Best practice electricity and gas networks safety frameworks in international jurisdictions

Report prepared for Department of Environment, Land, Water & Planning, Victoria
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1. Introduction

1.1 Background

Review of Victoria’s Electricity and Gas Network Safety Frameworks

The Victorian Government is currently undertaking an Independent Review of Victoria’s Electricity and Gas Network Safety Frameworks (the Review). The purpose of the Review is to assess the effectiveness of the safety frameworks applicable to electricity and gas transmission and distribution networks in Victoria in achieving desired safety outcomes. The design and adequacy of the safety regulatory obligations, incentives and other arrangements governing the safety of Victoria’s electricity and gas networks will also be reviewed.1

The Review commenced as a review of the framework applicable to electricity with an Issues Paper being published in April 2017,2 and has subsequently been expanded to include gas networks. A supplementary Issues Paper covering Victoria’s gas network safety frameworks was published in May 2017.3

The Issues Paper and Supplementary Issues Paper set out the initial scope and invite stakeholder to provide submissions issues for consideration. Importantly, the consideration covers the range of legislative instruments that provide the governance and administration of safety undertaken by various agencies, the capability to adequately promote safety considering emerging areas of changes, audit regimes and monitoring, including penalties for failures to comply with notices etc, and economic incentives, including the economic regulation of networks.

The Terms of Reference for the Review provide that the Chair has regard to best practice electricity and gas safety and risk management frameworks in other jurisdictions, including nationally and internationally.4 This report provides research material to support consideration international best practice safety frameworks.

1.2 Scope

Marsden Jacob Associates (Marsden Jacob) was engaged to undertake a comprehensive but rapid review of the safety and risk amendment frameworks applicable to gas and electricity networks in five international jurisdictions with similar regulatory or environmental settings to Victoria.

DELWP requested consideration be given to the following when summarising best practice:

- The effectiveness of the safety framework in achieving energy network safety outcomes.
- The regulatory obligations, incentives and other arrangements governing energy network businesses.
- The effectiveness of regulators in monitoring and enforcing compliance.

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The adaptability of safety frameworks to adjust to the widespread deployment of emerging technologies including renewable energy and battery storage.

**Defining electricity and gas networks**

For the purposes of the review, the scope was targeted to focus on life risks and with the scope of electricity and gas networks defined as follows:

- **Electricity networks**—transmission and distribution networks from the generation gate to the residential metre – e.g. poles and wires and substations.

- **Gas networks**—transmission pipelines and gas distribution networks to the residential metre excluding production (e.g. wells) and refining – but including storage facilities.

Due to the various forms of gas that are used internationally, we have considered a broad range of reticulated gas supplies including: methane, reticulated liquid petroleum gas and landfill gas.

**Types of risks considered**

In assessing the safety frameworks, we considered risks both to workers – occupational health and safety (OH&S) risks and risks to the broader community. These risks may have a detrimental outcome on people (resulting in injuries, illness or death) or on assets.

These risks are described further in the framework covered in Chapter 2.

**International jurisdictions covered**

The five international jurisdictions covered and rationale for selecting each jurisdiction is as follows:

- New Zealand - similar regulatory structure and market design.
- England & Wales - similar regulatory structure and legislative approach.
- Spain - similar climate / environment and risks.
- United States - California – similar climate/ environment and risks.
- United States - Texas - similar climate / environment and risks.

**1.3 Approach**

Our approach commenced with a literature review and desktop research. We used this research to complete a summary table for each of the jurisdictions for each of gas and electricity network safety regulation.

Where gaps reminded or the framework adopted required clarification, Marsden Jacob approached and sought to hold discussions with regulators in each international jurisdiction.
1.4 Structure of this report

The remainder of this report is structured as follows:

- Chapter 2 provides background on theory of best practices safety framework.
- Chapters 3 through 7 cover each of the international jurisdictions in turn:
  - Chapter 3: New Zealand
  - Chapter 4: England and Wales
  - Chapter 5: Spain
  - Chapter 6: California
  - Chapter 7: Texas
- Chapter 8 provides observations from the comparison of jurisdictions and a summary of the network characteristics of the jurisdictions covered.

One appendix also supports the report - Appendix A: Other learnings from the US
2. Theory on best practices safety frameworks

2.1 Overview

2.1.1 Types of risks

Energy networks such as electricity transmission and distribution and gas transmission and distribution include a broad range of safety risks that vary from occupational health and safety risks that would impact on an individual through to catastrophic risks that could result in multiple fatalities of members of the public.

Accordingly, safety frameworks for energy networks are required to oversee a large range of risk types. These are likely to include:

1. Occupational health and safety risks
   - Slips, trips and falls
   - Training, qualification related failures
2. Internal network failure risks
   - Infrastructure / product failure
   - Engineering / design failure
   - Maintenance related failures
3. External risks
   - Public risks – where the general public interacts with the infrastructure or service
   - Natural disaster risks – where the geological, climatic, or weather-related event is beyond design capabilities to withstand

2.1.2 Gap between legislative frameworks and safety outcomes

The focus of the review is on legislative frameworks and their use in controlling safety risks. However, it is important to note that the legislation alone does not determine each network organisation’s management of risks. Figure 1 illustrates that as well as the legislative framework (Acts, regulations, codes licensing requirements) the regulator’s enforcement style and the network organisations’ culture and capacity to manage risks impact on the management of risks.
2.2 Legislative frameworks

In Australia and other OECD countries, safety frameworks – have moved increasingly to outcome focussed or risk based legislation.

Risk based legislation contrasts with prescriptive legislation which specifies the actions that must be taken, typically with little or no scope for business to deviate from the requirements. The advantages of prescriptive legislation juxtapose with those of outcome-focused legislation. Prescription can create certainty for operators - by providing a step by step guide to meeting the legislative requirements. One of the key disadvantages of a prescriptive approach is that it does not allow for innovation or new technology and so it can create unnecessary red tape.

English speaking countries sometimes refer to outcome focussed safety legislation as ‘Robens style’ legislation as this form of legislation was proposed by the 1972 report by the Committee on Safety and Health at Work in Great Britain chaired by Lord Robens.5 One of the key statements from the report was:6

… the general principles of safety responsibility and safe working should be embodied in a statutory declaration which would set all of the detailed statutory and other provisions in clear perspective. We recommend, therefore, that the Act should begin by enunciating the basic and over-riding responsibilities of employers and employees. This central statement should spell out the basic duty of an employer to provide a safe working system including safe premises, a safe working

5 The Committee on Safety and Health at Work was formed in the years following the Aberfan disaster - when a landslide occurred on the waste rock dump from a coalmine in Wales after heavy rain resulting in the death of 116 children and 28 adults.

The advantages of risk based legislation compared to alternative forms of legislation when applied in a safety context include:

- Improved focus by business on the required outcomes – rather than focusing attention on activities that demonstrate compliance, for example.
- Freedom for businesses to innovate in their approach to achieving safety outcomes.
- Flexibly of the legislation to accommodate technological changes without requiring amendments.

Finally, risk based legislation is seen to have the advantage that it forces the industry to identify, consider and manage its own risks. When this risk management is incorporated into each organisation’s processes it can result in a safety culture within the organisation.

However, risk based legislation also has some disadvantages: its effective implementation and enforcement can impose costs on both the industry and the regulator and requires a reasonable level of competence to identify and assess risks.

Despite the movement away from prescription, many sets of safety legislation blend prescription with outcome focussed legislation. The appropriate approach depends on a range of factors many of which are unique to the industry, the characteristics of businesses that are required to comply with the legislation and the risks faced. For example, while outcome-focussed approach to safety has been adopted for networks in several the jurisdictions, many retain prescriptive regulations for clearance distances around electricity infrastructure. In this case, the approach adopted may reflect that there is limited scope for innovation in this area and a desire for a clear, consistent rule that can be easily monitored.

2.3 Risk-based safety frameworks

The fundamentals of risk management are outlined below. Subsequently, the expression of this approach within risk based legislation is outlined, and the implementation of standard frameworks such as ‘As Low As Reasonably Practicable’ (ALARP) and Frequency-Number diagrams are then described.

2.3.1 Risk management

The Australian Standards on Risk management – Principles and guidelines (AS/NZS ISO 31000:2009)\(^8\) defines risk as ‘the effect of uncertainty on objectives’\(^9\). The standard gives increasing weight to risk-based approaches to safety management and assessments.

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9 The previous definition of risk used in the 2004 version of the standards was ‘the chance of something happening that will have an impact on objectives’.
Fundamentals of a risk-based approaches

Underpinning all risk management (including risk-based approaches to safety) is the assessment of likelihood and consequences. Resulting risk levels can be described mathematically as a product of the two components as follows:

\[
\text{Risk level} = \text{Likelihood of event} \times \text{consequences of event}
\]

**Where:**

- **Likelihood** is the measure of chance that an event will occur in each year.
- **Consequences** are the unwanted outcome that would arise.\(^\text{10}\)

### 2.3.2 Risk-based approaches to safety

For legislation that imposes a duty of care it is necessary to specify the level of effort that is required to fulfill the duty. Several jurisdictions use the phrase *reasonably practicable* to specify the level of effort required.

#### Reasonably practicable in legislation

Several jurisdictions have adopted phrasing that includes the words ‘reasonably practicable’ in safety legislation where general broad duties of care on businesses are outlined to signal the use of a qualified risk-based safety framework approach.

A range of phases are used in Australia and international jurisdictions\(^\text{11}\) that include the term ‘reasonably practicable’. Most commonly recognizable examples are ‘As Low As Reasonably Practicable’ (ALARP) and ‘So Far As Is Reasonably Practicable’ (SFAIRP) provisions. A similar phrase, ‘As Low as Reasonably Achievable’ (ALARA), is also used in the United Kingdom and a recent development in managing positive risks is the concept of ‘As High As Reasonably Practicable’ (AHARP).\(^\text{12}\)

Regardless of the phasing, the term acts as a qualifier to avoid the imposition of duties that no one can fulfil – because absolute safety cannot be guaranteed and to ensure that preventive and protective actions are commensurate with the risks.\(^\text{13}\) Hence, for ease of reference, we refer to ALARP in this report as generally meaning the range of risk-based approaches safety legislation unless otherwise specified.

In Australia, the definition of reasonably practicable has its origin in English case law (or common law). The case of Edwards v. National Coal Board [1949] established the concept of reasonably practicable as distinguished from ‘physically possible’ as applied to risk mitigation measures\(^\text{14}\).

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\(^\text{11}\) Countries around the world that have employed elements of the ALARP framework either wholly or partially include Australia, Abu Dhabi, Belgium, Brazil, Denmark, Hong Kong, Ireland, Netherlands, Saudi Arabia, the U.S., and, of course, the U.K. See: Haine, Steven, P.E., *Safety and Enforcement Division Staff White Paper on As Low As Reasonably Practicable (ALARP) Risk-informed Decision Framework Applied to Public Utility Safety*, reported prepared on behalf of the California Public Utilities Commission, 24 December 2015, p 5


\(^\text{14}\) Asquith, Lord Justice, 1949, in Edwards v National Coal Board, 1 KB 704; 1949 1 All ER 743, a case on the interpretation of S 102 (8) of the Coal Mines Act, 1911. Refer to: [http://www.safetyphoto.co.uk/subsite/case%20e%20f%20g%20h/edwards_v_national_coal_board.htm](http://www.safetyphoto.co.uk/subsite/case%20e%20f%20g%20h/edwards_v_national_coal_board.htm)
“Reasonably practicable” is a narrower term than “physically possible” and seems to me to imply that a computation must be made by the owner, in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other; and that if it be shown that there is a gross disproportion between them - the risk being insignificant in relation to the sacrifice— the person upon whom the obligation is imposed discharges the onus which is upon him.

Thus, reasonably practicable or an ALARP approach sets the legislative boundaries around which risk levels are either acceptable or unacceptable on a conceptual level. The difficulty in this approach, compared to more prescriptive styles of legislation, is in defining where these limits may actually fall.

Individual and societal risks

For utilities and major hazard facilities it is necessary to consider both the impact on individuals and the risk of a catastrophic failure that could result in a large number of fatalities. These are often separated as individual risks and societal risks:

**Individual risks** are how individuals see the risk from a particular hazard affecting them and things they value personally. Though they may be prepared to engage voluntarily in activities that often involve high risks, people tend to be less tolerant of risks imposed on them and over which they have little control, unless they consider the risks as negligible. Moreover, though they may be willing to live with a risk that they do not regard as negligible, if it secures them or society certain benefits, they would want such risks to be kept low and clearly controlled.

**Societal risks** arise from the occurrence of multiple fatalities in a single event. Typical examples relate to nuclear power generation, railway travel, or the genetic modification of organisms. Societal risk, if realised, could have adverse repercussions for the institutions responsible for putting in place the provisions and arrangements for protecting people, eg Parliament or the Government of the day.

**ALARP in consideration of individual risks**

Individual risk is the risk to a single person. This individual may be a person who is a worker, who directly benefits from the activity and is aware of the associated hazards of the work, or a person who is a member of the general public. Limits that apply to a work may be different to the limits deemed as acceptable to individuals who are members of the public.\(^\text{15}\)

A common representation of an ALARP based approach is using a conceptual diagram like the one shown in below (Figure 2).

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Figure 2: ALARP triangle

Source: Based on Sample ALARP Risk Assessment Matrix by Risk Assessment Org

The diagram shows the increasing individual and societal concerns are conveyed along the vertical axis, with the increasing overall risk level that results being represented by the width of the diagram at each level.

Safety frameworks are generally shown as having two or three risk zones. In the case of Figure 2 three risk zones are shown with upper and lower thresholds identifiable. Some legislative frameworks do not have a “broadly acceptable” region and instead require ALARP to always be applied.

The most common threshold used in relation to individual risks is the probability of an individual’s risk of death per annum (IRPA) limits.

The Australian National Offshore Petroleum Safety and Environmental Management Authority’s (NOPSEMA’s) uses threshold IRPA limits in its roles as regulator of NOPSEMA use the following IRPA limits for workers:

- At or above likelihoods of $1 \times 10^{-3}$ (one in a thousand) the level of risk is unacceptable.
- Between $1 \times 10^{-3}$ (one in a thousand) and $1 \times 10^{-6}$ (one in a million) level the risk is acceptable if it is maintained As Low As Reasonably Practicable.
- Below $1 \times 10^{-6}$ (one in a million) the risk is acceptable.

It should be noted that the Health and Safety Executive suggest that, where risks are imposed on members of the general community “for the public good” a more stringent threshold of one in ten thousand is suggested.¹⁷

¹⁶ [https://www.risk-assessments.org/alarp.html](https://www.risk-assessments.org/alarp.html)
¹⁷ Health and Safety Executive, Reducing risks, HSE’s decision-making process, 2001
ALARP in consideration of societal risks

Frequency number curves (often shortened to F-N curves) are commonly used for societal risks because they enable a portfolio of risk where the consequence could be a single fatality or a number of fatalities (such as 10 to 100 people) to be captured.

The frequency number curve is a plot of the cumulative frequency (likelihood) of all events with N or more fatalities. The curve is typically plotted on a log-log scale as the frequency and number of fatalities can range by several orders of magnitude.\(^{18}\)

An example of a frequency number curve with ALARP diagram overlain is shown in Figure 3.

**Figure 3: Example of a frequency number curve**

![Frequency Number Curve Diagram](https://www.trafi.fi/filebank/a/1434377075/3ca313446052f4fe01a41ca2cecf6cfd/17853-L14_CER_ALARP.pdf)

**Source:** Safety and Enforcement Division Staff White Paper on As Low As Reasonably Practicable (ALARP) Risk-Informed Decision Framework Applied to Public Utility Safety By Steven Haine California Public Utilities Commission, December 2015

ALARP frameworks and expenditure decisions

In considering the activities to undertake to mitigate risks within an ALARP framework, it can be useful to consider this in terms of a cost benefit equation – if the risks are quantified.

Given that the case law definition of “reasonably practicable” states that the sacrifice should be grossly disproportionate to the risk it is not appropriate to merely compare costs to benefits.

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The UK Health and Safety Executive, has provided substantial guidance on the interpretation of the case law – but the approach set out below would also apply in Australia and other jurisdictions that use an ALARP approach.\textsuperscript{19}

Mathematically, the expenditure is not reasonable if:

\[
\frac{\text{Costs}}{\text{benefits}} > 1 \times \text{disproportion factor}
\]

The Health and Safety Executive provides guidance on the scale of the ‘disproportion factor’ that it is likely to (but not definitively) consider appropriate for various industries and risks with the onus on justifications for the relevant factor being provided by the operator. The Health and Safety Executive suggest that a disproportion factor is likely to be less than 10.\textsuperscript{20}

In Australia, the Commonwealth Office of Best Practice Regulation have suggested that the value of a statistical life is $4.2 million (in 2014 values).\textsuperscript{21} Using this value and a disproportion factor of 10 then the threshold cost of preventing a fatality would be $42 million.

\textsuperscript{19} Health and Safety Executive, ‘Cost Benefit Analysis (CBA) checklist’, 2016. Refer to: www.hse.gov.uk/risk/theory/alarpcheck.htm

\textsuperscript{20} Ibid

3. New Zealand

3.1 Overview of electricity sector

Consumers and generation

Total consumption of electricity in New Zealand was almost 39,000 GWh of electricity in 2014:

- 115,000 industrial consumers accounted for approximately 44% of demand
- 1.7 million residential properties accounted for 32% of the demand; and
- 166,000 commercial consumers (shops, businesses, office buildings, etc.) accounted for 24% of demand.  

Electricity supply comes from over 200 power stations in New Zealand. Five large generation companies together own 98 of the power stations and produce most of the New Zealand’s electricity. These companies also operate a further 81 power station on behalf of their owners. Other hydro, cogeneration and geothermal, and wind generation companies operate a further 40 plants. 

Hydro generation supplies most of electricity in New Zealand. Between 2011 and 2014 hydro represented 57% of generation, thermal and geothermal represented a further 21% and 15% respectively, with wind (5%) and cogeneration (3%) making up the balance. In 2014, around 90% of New Zealand’s generation output came from renewable energy sources. The Government’s Energy Strategy aims to lift this to 90% by 2025.

Transmission

The national grid is made up of 11,743 km of high-voltage transmission lines and more than 170 substations. The lines operate at between 220 kV and some as high as 400 kV, with lines carrying alternating current at either 110 kV or 220 kV. A high-voltage direct current cable connects the National Island and the South Island that also forms part of the national grid. The HVDC cable carries 350 kV of electricity in both direction but is predominately used to transport electricity from major generators in the South Island to the North Island.

National grid infrastructure is owned, operated, maintained and developed by the state-owned enterprise, Transpower. The network is shown in Figure 4 (below).

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22 Electricity Authority (NZ), Electricity in New Zealand, January 2016, p. 5. Available at: https://www.ea.govt.nz/about-us/media-and-publications/electricity-nz/


Distribution

The national grid is supported by 39 distribution (low voltage) distribution networks, largely owned by 29 local distribution businesses (or lines companies) in New Zealand. Some of the larger distribution companies listed on the stock exchange, but most are owned by trusts or local councils.

The larger electricity distribution companies by number of connections are Vector Lines, Powerco, Orion NZ and Wellington Electricity (Table 1).

Table 1: Electricity distribution businesses, New Zealand

<table>
<thead>
<tr>
<th>Distribution business</th>
<th>Line length (km)</th>
<th>No. of customer connections</th>
<th>% of customer connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector Lines</td>
<td>18,266</td>
<td>545,968</td>
<td>26%</td>
</tr>
<tr>
<td>Powerco</td>
<td>27,904</td>
<td>330,577</td>
<td>16%</td>
</tr>
<tr>
<td>Orion NZ</td>
<td>11,193</td>
<td>192,857</td>
<td>9%</td>
</tr>
<tr>
<td>Wellington Electricity</td>
<td>4,697</td>
<td>166,591</td>
<td>8%</td>
</tr>
<tr>
<td>Unison Networks</td>
<td>9,002</td>
<td>111,045</td>
<td>5%</td>
</tr>
<tr>
<td>WEL Networks</td>
<td>5,338</td>
<td>87,703</td>
<td>4%</td>
</tr>
<tr>
<td>Aurora Energy</td>
<td>5,878</td>
<td>85,966</td>
<td>4%</td>
</tr>
<tr>
<td>Northpower</td>
<td>5,939</td>
<td>57,247</td>
<td>3%</td>
</tr>
<tr>
<td>Other 21 distribution businesses (total)</td>
<td>63,930</td>
<td>488,175</td>
<td>24%</td>
</tr>
<tr>
<td>Total</td>
<td>152,148</td>
<td>2,066,129</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Commerce Commission of New Zealand, ‘Performance summaries for electricity distributors’ webpage, documents last updated 31 May 2017.27

26 Electricity Authority (NZ), Electricity in New Zealand, January 2016, p. 15. Available at: https://www.ea.govt.nz/about-us/media-and-publications/electricity-nz/

The distribution networks include sub-transmission lines and cables that operate at voltages such as 33 kV, 50 kV and 66 kV. They also include distribution line voltages that vary between 11 kV and 22 kV which are then converted for most consumers to receive voltages between 230 to 400 volts.\(^{28}\)

The *Electricity Reform Act 1998* broke up generation and distribution segments of the electricity industry. The *Electricity Industry Act 2010* has subsequently allowed distributors to enter retailing with some restriction.\(^{29}\)

Dedicated networks embedded within the regional network are also considered distribution or line companies. Embedded networks (sometimes also referred to as a secondary network) are owned by someone other than the local network owner. Embedded networks are typically used to serve customers in some commercial buildings, some apartment buildings, shopping malls, airports.\(^{30}\)

![Figure 5: Electricity distribution network regions, New Zealand](Source: Commerce Commission New Zealand, 2016\(^{31}\))

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3.2 Overview of gas sector

Consumers and supply sources

Natural gas is used by approximately 270,000 consumers in the North Island of New Zealand. Of which there are 260,000 residential consumers, 15,700 commercial and 400 industrial consumers.\(^{32}\) There is no reticulated natural gas in the South Island of New Zealand, however there are small LPG reticulation schemes in Christchurch, Dunedin, Wanaka, Arrowtown and Queenstown.\(^{33}\)

Gas supply comes from 15 gas fields within the Taranaki region, located onshore and offshore of the south west of the North Island with all supply going to the domestic market. This is the only basin currently producing gas.

Transmission

Natural gas in the North Island is delivered in New Zealand through 2,520 km of high pressure gas transmission pipelines and 17,844 km of regional gas distribution networks.

Figure 6: New Zealand Gas Transmission Pipeline System – North Island

Source: Gas Industry Company, 2016\(^{34}\)


As shown in Figure 6 (above), there are two major gas transmission pipelines on the North Island, both owned by First Gas:

- The ‘Maui pipeline’ (previously owned by Maui Development Limited until June 2016) extends for 309 km from South Taranaki north to Huntly. This pipeline carries gas from the Maui and other fields via six production stations to direct users (including Methanex and Huntly) and into the First Gas System at 13 interconnection points. One of these points (Frankley Road at New Plymouth) allows bidirectional flow and since the Kupe field has been in production, flow at this location has been into the Maui pipeline. In 2015 the Maui pipeline carried 78 per cent of total gas production.

- The First Gas System (previously the Vector Gas System until April 2016) is more extensive radiating out from the Maui pipeline and running for approximately 2,211 km through to most major centres in the North Island. This pipeline was originally built by the government to transport gas from Kapuni to Auckland and Wellington. However, several pipeline expansions undertaken in the 1980s now means the pipeline is now used to deliver gas to all the demand centres.

These two major gas transmission pipelines operate on open access arrangements, allowing all parties to ship gas through their pipelines. Under common ownership since early 2016, a process is now underway to simplify operating arrangements for gas users.

Under harsh climatic conditions and rugged terrain, New Zealand’s main gas transmission system has proven to be quite reliable over its 30 to 40 years of operation. There have however been five significant gas transmission pipelines outages, two of them caused by third parties (in 1985 and 2003), two by landslips (both events in 1977) and one by severe flooding (2004). The duration of one of 1977 outages is unknown but other outages have all been less than 6 days.  

**Distribution**

There are four main gas distribution network owners that distribute natural gas throughout the North Island under an open access regime: GasNet; First Gas; PowerCo; and Vector. Nova Energy has a small network of non-open access distribution pipelines. The network lengths and characteristics for all distribution networks are summarised in Table 2 (below).

**Table 2: Gas distribution network owners, New Zealand**

<table>
<thead>
<tr>
<th>Distributor</th>
<th>Total Length (km)</th>
<th>Region</th>
<th>Active Connections</th>
<th>% of total active connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector</td>
<td>5,900</td>
<td>Greater Auckland</td>
<td>103,044</td>
<td>37.2</td>
</tr>
<tr>
<td>First Gas</td>
<td>4,870</td>
<td>Northland, Waikato, Bay of Plenty (including Rotorua, Taupo), Gisborne, Kapiti</td>
<td>60,402</td>
<td>21.8</td>
</tr>
<tr>
<td>Powerco</td>
<td>6,315</td>
<td>Greater Wellington, Hawke’s Bay, Manawatu, Horowhenua, Taranaki</td>
<td>103,407</td>
<td>37.4</td>
</tr>
<tr>
<td>Gasnet</td>
<td>659</td>
<td>Wanganui, Rangitikei</td>
<td>9,682</td>
<td>3.5</td>
</tr>
<tr>
<td>Nova[a]</td>
<td>1001</td>
<td>Wellington, Porirua, Hutt Valley, Hastings, Hawera, Papakura, Manukau City</td>
<td>2262</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17,844</strong></td>
<td></td>
<td><strong>276,761</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

---


36 Ibid
Note: (a) Nova is not subject to statutory disclosure requirements. This figure is from the Commerce Commission Gas Industry Final Report in 2004.

Source: Gas Registry Information summarised in The Gas Industry Co’s Gas Industry Facts at a Glance, 201737

### 3.3 Research summary

<table>
<thead>
<tr>
<th>Network description</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area &amp; population</td>
<td>Natural gas is used by approximately 270,000 industrial, commercial, community and residential consumers in the North Island of New Zealand.</td>
<td>New Zealand electricity customers consumed almost 39,000 GWh of electricity in 2014 with consumption split between industrial (115,000 customers, 44% of demand), residential (1.7 million households, 32%), and commercial consumers (166,000 customers, 24% of demand)</td>
</tr>
<tr>
<td>Network operators</td>
<td>There is no distribution of reticulated natural gas in the South Island, but there are small LPG reticulation schemes in Christchurch, Dunedin, Wanaka, Arrowtown and Queenstown.</td>
<td>Power supply comes from over 200 power stations in New Zealand. Five large generation companies together own 98 of the power stations and produce most of the New Zealand’s electricity.</td>
</tr>
<tr>
<td>Other features</td>
<td>Gas supply comes from 15 gas fields within the Taranaki region, located onshore and offshore of the south west of the North Island with all supply going to the domestic market. This is the only basin currently producing gas.</td>
<td>Hydro generation output accounts for most of electricity in New Zealand (57%). Thermal (21%), geothermal (15%), wind (5%) and cogeneration (3%) make up the balance. In 2014, around 90% of New Zealand’s generation output came from renewable energy sources. The Government’s Energy Strategy aims to lift this to 90% by 2025.</td>
</tr>
<tr>
<td></td>
<td>Natural gas is delivered in New Zealand through 2,520 km of high pressure gas transmission pipelines and 17,844 km of regional gas distribution networks. There are four main companies which distribute natural gas through the North Island: GasNet; Nova Energy; PowerCo; and Vector.</td>
<td>The national grid is made up of 11,743 km of high-voltage transmission lines and more than 170 substations. There is a high-voltage direct current cable connects the National Island and the South Island that also forms part of the national grid.</td>
</tr>
<tr>
<td></td>
<td>The two major pipelines are:</td>
<td>National grid infrastructure is owned, operated, maintained and developed by Transpower, a state-owned enterprise.</td>
</tr>
<tr>
<td></td>
<td>– The First Gas Maui pipeline which extends for 309 km from South Taranaki north to Huntly. This pipeline carries gas from the Maui and other fields via six production stations to direct users (including Methanex and Huntly) and into the First Gas system at 13 interconnection points. In 2015 the Maui pipeline carried 78 per cent of total gas production.</td>
<td>39 distribution (low voltage) distribution networks support the national grid, largely owned by 29 local distribution businesses (or lines companies). Most are owned by trusts but some larger ones are exchange listed corporations, others are shareholder co-operatives, community trusts and local councils/ bodies.38</td>
</tr>
<tr>
<td></td>
<td>– The First Gas System (previously the Vector Gas System) which is more extensive, running for approximately 2,211 km through to most major centres in the North Island.</td>
<td>Dedicated networks embedded within the regional network are also considered distribution or line companies.</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Regulator roles:</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Regulator</td>
<td>- Energy Safety (within WorkSafe New Zealand)</td>
<td>- Energy Safety, part of WorkSafe New Zealand</td>
</tr>
<tr>
<td>Economic Regulator</td>
<td>- Energy Safety (within WorkSafe New Zealand) is the regulator for ensuring the safe supply and use of electricity and gas in New Zealand. WorkSafe is responsible for the administration and development of parts of the Gas Act 1992, and for regulations and Codes of Practice relating to safety, quality and measurement of gas.</td>
<td>- Energy Safety (within WorkSafe New Zealand) is the regulator for ensuring the safe supply and use of electricity and gas in New Zealand. WorkSafe is responsible for the administration and development of parts of the Electricity Act 1992, and for regulations and Codes of Practice relating to safety.</td>
</tr>
<tr>
<td>Network regulator</td>
<td>- Gas Industry Company (GIC)</td>
<td>- Electricity Authority</td>
</tr>
<tr>
<td>Market Operator</td>
<td>- A gas sector regulatory body, Gas Industry Company (GIC), was established in December 2004 as the ‘industry body’ under Part 4A of the Gas Act 1992, following the request by gas industry participants for industry self-regulation backed up by the force of law in 2003. The Company’s role as the industry body and co-regulator is to:</td>
<td>- The statutory objective of the Electricity Authority is to promote competition in, reliable supply by, and the efficient operation of, the New Zealand electricity industry for the long-term benefit of consumers.</td>
</tr>
<tr>
<td></td>
<td>- Develop arrangements, (including regulations) to improve the operation of gas markets, access to infrastructure, and consumer outcomes;</td>
<td>- The Electricity Authority are tasked with governing the electricity market under the Electricity Industry Act 2010. The Act authorises the making of regulations and the Electricity Industry Participation Code 2010. The Authority’s functions are to:</td>
</tr>
<tr>
<td></td>
<td>- Develop these arrangements with the principal objective to ensure that gas is delivered to existing and new customers in a safe, efficient, reliable, fair and environmentally sustainable manner; and</td>
<td>- Make and administer the Electricity Industry Participation Code 2010 (the Code)</td>
</tr>
<tr>
<td></td>
<td>- Oversee compliance with, and review such arrangements.</td>
<td>- market facilitation measures</td>
</tr>
<tr>
<td></td>
<td>- Ministry of Business, Innovation and Employment (MBIE)</td>
<td>- Monitoring industry and market performance</td>
</tr>
<tr>
<td></td>
<td>- MBIE has primary responsibility for advising the Minister (and the Government) on energy policy and an ongoing role in policy development and maintenance of the legislation to ensure it remains fit for purpose. In respect to gas, the MBIE is responsible for:</td>
<td>- Contracting and/or performing market operation services</td>
</tr>
<tr>
<td></td>
<td>- All gas governance and industry arrangements;</td>
<td>- Ministry of Business, Innovation and Employment (MBIE)</td>
</tr>
<tr>
<td></td>
<td>- The role of gas as a thermal fuel;</td>
<td>- MBIE advises the Minister on energy policy legislation. MBIE monitor and advise on electricity market, including monitoring the electricity market regulator, the Electricity Authority.</td>
</tr>
<tr>
<td></td>
<td>- Recommendations made by GIC; and</td>
<td>- There is a Memorandum of Understanding between the Electricity Authority and the MBIE with respect to provide a framework for the parties to work together, especially where there is the potential for overlap in their respective roles.</td>
</tr>
<tr>
<td></td>
<td>- The Crown Minerals Act 1991 and the Gas Act 1992.</td>
<td>- Other entities involved in electricity regulation include:</td>
</tr>
<tr>
<td></td>
<td>- Other entities involved in gas regulation include:</td>
<td>- Commerce Commission (comcom.govt.nz)</td>
</tr>
</tbody>
</table>

**Gas**

- Energy Safety (within WorkSafe New Zealand)
  - Energy Safety (within WorkSafe New Zealand) is the regulator for ensuring the safe supply and use of electricity and gas in New Zealand. WorkSafe is responsible for the administration and development of parts of the Gas Act 1992, and for regulations and Codes of Practice relating to safety, quality and measurement of gas.

- Gas Industry Company (GIC)
  - A gas sector regulatory body, Gas Industry Company (GIC), was established in December 2004 as the ‘industry body’ under Part 4A of the Gas Act 1992, following the request by gas industry participants for industry self-regulation backed up by the force of law in 2003. The Company’s role as the industry body and co-regulator is to:
    - Develop arrangements, (including regulations) to improve the operation of gas markets, access to infrastructure, and consumer outcomes;
    - Develop these arrangements with the principal objective to ensure that gas is delivered to existing and new customers in a safe, efficient, reliable, fair and environmentally sustainable manner; and
    - Oversee compliance with, and review such arrangements.

- Ministry of Business, Innovation and Employment (MBIE)
  - MBIE has primary responsibility for advising the Minister (and the Government) on energy policy and an ongoing role in policy development and maintenance of the legislation to ensure it remains fit for purpose. In respect to gas, the MBIE is responsible for:
    - All gas governance and industry arrangements;
    - The role of gas as a thermal fuel;
    - Recommendations made by GIC; and
  - Other entities involved in gas regulation include:

**Electricity**

- Energy Safety, part of WorkSafe New Zealand
  - Energy Safety (within WorkSafe New Zealand) is the regulator for ensuring the safe supply and use of electricity and gas in New Zealand. WorkSafe is responsible for the administration and development of parts of the Electricity Act 1992, and for regulations and Codes of Practice relating to safety.

- Electricity Authority
  - The statutory objective of the Electricity Authority is to promote competition in, reliable supply by, and the efficient operation of, the New Zealand electricity industry for the long-term benefit of consumers.

  The Electricity Authority are tasked with governing the electricity market under the Electricity Industry Act 2010. The Act authorises the making of regulations and the Electricity Industry Participation Code 2010. The Authority’s functions are to:
    - Make and administer the Electricity Industry Participation Code 2010 (the Code)
    - market facilitation measures
    - Monitoring industry and market performance
    - Contracting and/or performing market operation services

- Ministry of Business, Innovation and Employment (MBIE)
  - MBIE advises the Minister on energy policy legislation. MBIE monitor and advise on electricity market, including monitoring the electricity market regulator, the Electricity Authority.

  There is a Memorandum of Understanding between the Electricity Authority and the MBIE with respect to provide a framework for the parties to work together, especially where there is the potential for overlap in their respective roles.

- Other entities involved in electricity regulation include:
  - Commerce Commission (comcom.govt.nz)
### Relevant safety legislation

<table>
<thead>
<tr>
<th>Acts</th>
<th>Worker Safety is legislated under the Health and Safety at Work Act, 2015 - based on the Australian Model WHS Act (administered by WorkSafe NZ)</th>
</tr>
</thead>
</table>
| Regulations | **Gas Act 1992** (administered by the Ministry of Business, Innovation, and Employment and WorkSafe NZ)  
The Gas Act 1992 is the primary piece of legislation in respect of the regulation of gas in New Zealand. The objectives of the Gas Act are to:  
- provide for the regulation, supply, and use of gas in New Zealand;  
- protect the health and safety of members of the public in connection with the supply and use of gas; and  
- promote the prevention of damage to property in connection with the supply and use of gas.  
The Energy Safety part of Worksafe New Zealand has roles and responsibilities outlined in the Gas Act 1992. Worksafe’s role is focused on safeguarding people and property from the dangers of electricity and gas, and the safety issues around electrical and gas appliances, installations and electricity and gas supply generating systems. The key Regulation administered by Worksafe relevant to this study is the **Gas (Safety and Measurement) Regulations 2010**.  
- **Gas (Safety and Measurement) Regulations 2010** sets out:  
  - Requirements for distribution systems not covered by audited safety management systems  
  - Requirements for audited safety management systems |
| Codes etc. | **Electricity Act 1992** (administered by the Ministry of Business, Innovation, and Employment and WorkSafe NZ)  
The Electricity Act 1992 sets out the regulatory framework for the supply of electricity and the electricity industry, and for regulation and control of electrical workers. It covers:  
- Powers and duties of electricity operators and other owners of electricity works.  
- Electrical codes of practice.  
- Registration and licensing of electrical workers.  
- Restriction on electrical work.  
It also regulates fittings and electrical appliances that are, or may be, exported internationally.  
The Energy Safety part of Worksafe New Zealand also has roles and responsibilities outlined in the Electricity Act 1992. Worksafe’s role is focused on safeguarding people and property from the dangers of electricity and gas, and the safety issues around electrical and gas appliances, installations and electricity and gas supply generating systems. The key Regulation administered by Worksafe relevant to this study are the **Electricity (Safety) Regulations 2010** and the **Electricity (Hazards from Trees) Regulations 2010**.  
- **Electricity (Safety) Regulations 2010** promote the health and safety of members of the public relating to the supply and use of electricity in New Zealand, and promote the prevention of damage to property about the supply and use of electricity in New Zealand. The regulations: |
<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
</table>
| ▪ High pressure Natural Gas pipelines are in most cases regulated by WorkSafe NZ under the **Health and Safety in Employment (Pipelines) Regulations 1999**[^39] | – Provide for installations to be designed and installed under AS/NZS 3000; and  
– Define requirements relating to safety management systems.  
– Set out in schedules all the standards applicable to the regulations, with a focus on the adoption of international Standards.  
– Provide for offences including infringement offences.  
▪ The **Electricity Industry Act 2010** establishes the role of the Electricity Authority. The Act also authorises the making of the **Electricity Industry Participation Code 2010**[^40].  
– **Electricity Industry Participation Code 2010** refers generally to relevant standards for safety, health and safety and related to the integrity of equipment that must be considered by distribution, transmission, system operators and participants. |

**Legislative approach**  
(e.g. Prescriptive / outcome focussed / safety case etc.)  
Outcome focused – based on a duty of care “so far as is reasonably practicable”  
*Requires a safety management system - that prevents, so far as is reasonably practicable, the gas supply system from presenting a significant risk of—  
(a) serious harm to any member of the public; or  
(b) significant damage to property owned by a person other than the person that owns or operates the gas supply system.*  
Outcome focused – based on a duty of care “so far as is reasonably practicable” 61(A) of the Electricity Act states:  
Every ... electricity distributor ... must implement and maintain, in accordance with regulations made under section 169, a safety management system.  
The safety management system must prevent, so far as is reasonably practicable, the electricity supply system from presenting a significant risk of—  
(a) serious harm to any member of the public; or  
(b) significant damage to property owned by a person other than the electricity generator or electricity distributor. |

**Clarity & coordination of regulator roles**  
Gas pipeline companies are subject to information disclosure and default/customised price-quality regulation, by the Commerce Commission under the **Commerce Act 1986**.  
Suppliers of electricity lines services are subject to regulatory provisions by the Commerce Commission under Part 4 of the **Commerce Act 1986**. This

### Regulatory relationships

<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory relationships are set out in: <a href="https://www.worksafe.govt.nz/worksafe/information-guidance/legal-framework/enforcement-policy/regulatory-relationships-policy">https://www.worksafe.govt.nz/worksafe/information-guidance/legal-framework/enforcement-policy/regulatory-relationships-policy</a></td>
<td>role is predominately focused on the economic regulation of the networks. 41</td>
</tr>
</tbody>
</table>

Indication is that there is a tension – but share common objectives and have good communication.

### Safety approach / thresholds uses for different life risks:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duty of care to provide safe system – “so far as is reasonably practicable” Safety management systems – must either align with Standard (NZS 7901) or the regulations. Safety management systems must be audited regularly (every 5 years)</td>
<td>Duty of care to provide safe system – “so far as is reasonably practicable” Safety management systems – must either align with Standard (NZS 7901) or the regulations. Safety management systems must be audited regularly (every 5 years) Some prescriptive elements – such as the “tree regulations”</td>
</tr>
</tbody>
</table>

### Enforcement / compliance resourcing and policy

<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
</table>
| Energy safety may undertake planned audits – where warning is given ahead of time. The selection criteria are based on:  
- operator risk  
- installation or network risk  
- complaints, incidents and accidents  
- advice from other regulatory agencies  
- type of operator  
2013-14 Annual report states: In 2013-14 we completed 1,127 investigations of health and safety and/or hazardous substance incidents in workplaces, and 57 gas and electricity incidents  
The Statement of Intent forecasted 800-1,000 health and safety ... investigations and 65 investigations of significant gas and electrical ... incidents. | |

### Effectiveness measures published

<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
</table>
| Does not publish enforcement data.  
Accident data is published42  
Requirement to report:  
- Notifiable gas accident – that results in serious harm (including death); | Does not publish enforcement data.  
Accident data is published43  
Requirement to report Notifiable electrical accident – that results in serious harm (including death). |

---

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Futures issues</th>
<th>SWOT analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worker safety culture</td>
<td>No specific points identified.</td>
<td>Use of the duty of care – compels companies to identify, consider and manage emerging risks.</td>
</tr>
<tr>
<td>Community consultation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas appears to consider both individual &amp; societal risks. Emerging risks may not be apparent until they “bite”.</td>
</tr>
<tr>
<td>Energy Safety consider that they are quite risk mature</td>
<td></td>
<td>Use of the duty of care – compels companies to identify, consider and manage emerging risks but some prescription – such as for tree clearances. While electricity networks have the provision to consider societal risks no specific policy has been developed for this to be applied. The location of the Energy Safety group within the High hazards branch of workSafe NZ may encourage flow of practices from the other parts of the branch (such as Major Hazard Facilities) including the consideration of societal risks. Emergent risks may not be apparent until they “bite” – see a discussion in Chapter 8.</td>
</tr>
</tbody>
</table>

| Non-notifiable gas accident.         |                                        |               |
| Natural gas and liquefied petroleum gas (LPG) have different characteristics as fuels and differing distribution and utilisation patterns so they are recorded and analysed separately |                                        |               |
| Energy Safety does not, in general, conduct in depth investigations of electrically-caused fires unless there is evidence of equipment failure. This is because a significant number of fires that are related to the supply or use of electricity are either not reported or are not reported in a timely manner. |                                        |               |
3.4 Other insights

3.4.1 Natural disaster risks

In recent years New Zealand has had several natural disasters. This has increased awareness of these risks as well as risks driven by human or technology error. Risks include:

- geographical events - earthquakes, volcano, tsunami, landslides
- Weather events- coastal hazards, floods, severe weather
- Failure of infrastructure – e.g. telecommunications, power networks.

The Ministry of Civil Defence & Emergency Management is assigned a leadership role in reducing risks, being ready for, responding to and recovering from emergencies. It manages central government’s response and recovery functions for national emergencies, and supports the management of local and regional emergencies.

Under the Civil Defence Emergency Management (CDEM) Act 2002, the Ministry has developed a framework for managing and responding to these risks.

The relationship between the National CDEM Strategy, The National CDEM Plan, CDEM Group plans, the emergency plans of other agencies and other reduction mechanisms at the national and local level are critical to CDEM in New Zealand as illustrated in the diagram below.

The Ministry also publishes a range of ‘Best Practice Guidance’ for emergency management tailored to specific industries.

Figure 7: Linkage between national, regional, and local operational plans and arrangements and risk reduction policies and programmes

Source: Guide to the National Civil Defence Emergency Management Strategy 2015, Figure 1.1, p. 6
3.4.2 Electricity distribution performance summaries

The Commerce Commission of New Zealand collates performance summaries for electricity distributors based on information required to be publicly disclosed under Part 4 of the Commerce Act 1986.

The performance summaries provide high level statistics on each lines companies’ performance, including measures such as profitability, capital and operating expenditure, asset condition, line charge revenue and network reliability.44

The following is a screen shot of the type and form of information presented in the summaries. All supporting data is also made available in an accessible Excel format, including on a distribution business basis.

Figure 8: Performance summary reporting for electricity distribution networks in New Zealand


3.4.3 Other observations

New Zealand shares a similar regulatory approach to Australia – both in terms of safety legislation and in terms of competition regulation for natural monopolies such as electricity and gas networks.

Consistent with this, several the gas codes of practice and standards are shared between the two countries. A key difference in the transparency of this guidance material is that the New Zealand Government has a policy that if a standard is referred to in legislation it must be readily

accessible to the public. Hence, New Zealand standards tend to be available online. In contrast, many of the same standards are only available on purchase in Australia.


4. England and Wales

4.1 Overview of electricity sector

The electricity market in the United Kingdom is divided into two parts geographically. Great Britain has a single electricity market, while Northern Ireland forms an all-island electricity market with the Republic of Ireland.

The National Grid Electricity Transmission plc (NGET) is the sole system operator, responsible for ensuring that electricity supply and demand stay in balance and the system remains within safe technical and operating limits across Great Britain. NGET is part of National Grid which was listed on the London Stock Exchange in 1995. NGET has recently adopted new responsibilities with the commencement of the Capacity Market on 1 October 2016.

Transmission

NGET is also one of three regulated regional monopoly transmission operators (TOs) permitted to develop, operate and maintain the high voltage system within Great Britain and is responsible for developing and maintaining the transmission network in England and Wales. Two other transmission operations, Scottish Power Transmission Limited and Scottish Hydro Electric Transmission plc develop and maintain the network in southern Scotland and northern Scotland and the Scottish islands groups respectively (Figure 9, below).

Across England and Wales NGET’s network consists of approximately 8,700 km of high voltage transmission lines. Of these, there are approximately 7,200 km of overhead lines and 1,500 km of underground cables. The system also includes approximately 342 substations. NGET is listed on the New York Stock Exchange.

Distribution

Distribution Network Operators (DNOs) own and operate the distribution network in the UK. There are currently 14 licensed DNOs in Britain owned by six different groups. Figure 9 (below) shows the UK DNO regions, including operators in Ireland (ESB Networks, Northern Ireland Electricity Networks) and that do not form the focus of this report.

A 2011 survey of distribution systems in Europe estimated the distribution networks across the whole of the UK consisted of 837,156 km of distribution lines including 313,840 km of overhead lines and 523,316 km of underground cables. There are also 665,408 transformers and 637 interconnections between the transmission and distribution networks.

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Smaller low voltage networks owned and operated by Independent Network Operators (IDNOs) are located within the areas covered by the Distribution Network Operators (DNOs). These companies may facilitate the development and services for independent utility infrastructure networks across a range of services – such as gas, electricity, water and fibre to new housing and commercial developments. GTC, Energetics Limited, ESP Utilities Group and UK Power Distribution Limited are the current Independent Network Operators (IDNOs).  

All Distribution Networks Operators (DNOs) and Independent Networks Operators (IDNOs) must hold a licence to distribute electricity their network. The licences contain conditions which, among other things, limit the amount of revenue which these companies can recover from their customers.  

All licensed electricity distribution businesses, or Distribution Network Operators (DNOs) in Great Britain, are obliged under Condition 21 of their licences to maintain a Distribution Code detailing the technical parameters and considerations relating to connection to, and use of, their electrical networks. All Distribution Networks Operators (DNOs) currently operate under the

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52 Refer to the DCode website: http://www.dcode.org.uk/


54 DCode website: http://www.dcode.org.uk/
same version of the Code, and the Code is maintained by the Distribution Code Review Panel. All modifications to the Code must be approved by Ofgem.55

Interconnection

The British electricity system currently has around 4 GW of interconnection capacity:56

- The England-France Interconnector is a 2,000 MW HVDC connecting the British and French transmission systems that went into service in 1986.
- The Moyle Interconnector is 500 MW HVDC link between the Northern Irish and British transmission systems that commenced service in 2001.
- The BritNed Interconnector is a 1,000 MW HVDC submarine power cable connecting the Isle of Grain in Kent in the UK to the Netherlands which was commissioned in 2011.
- The East/West Interconnector is a 500 MW, 260 km HVDC submarine and subsoil power cable connecting the British and Irish electricity markets that commenced service in 2012.

Customers and generation

In December 2015, there were 27.8 million domestic electricity consumers in Great Britain.57 An International Energy Agency report on the UK from 2011 indicated that residential sector accounted for the highest proportion of electricity consumption, representing 36% of total demand. The industry sector accounted for 32% of total electricity demand, commercial and service sector (other) accounted for 29% and the remainder was consumed in the transport (1%) and agriculture and fishing sectors (1%).58

Most of the UK’s electricity comes from fossil fuel sources with around 30% of power being supplied by natural gas plants and a further 22% being supplied by coal generators in 2015. Nuclear reactors contributed around 21% and renewable energy sources account for the remaining domestic generation, contributing around 25% of electricity production for the year. Renewable energy sources include wind (12% of total), biomass and renewable wastes (9% of total), hydro (3% of total) and solar (2% of total).59

The interconnectors with France, the Netherlands and Ireland enables the UK to import or export electricity when it is most economical. Energy UK reports: “In 2015, the UK was a net importer from France and the Netherlands with net imports off 13.8 TWh and 8.0 TWh respectively which accounted for 5.8 per cent of electricity supplied in 2015. Total net exports to Ireland amounted to 0.9 TWh”60.

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55 A current copy of the code is available here: http://www.dcode.org.uk/the-gb-distribution-code/
56 Elexon, ‘Interconnectors’ webpage. Refer to: https://www.elexon.co.uk/reference/interconnectors/
58 International Energy Agency,
60 Energy UK, ‘Electricity Generation’ webpage. Refer to: http://www.energy-uk.org.uk/energy-industry/electricity-generation.html
4.2 Overview of gas sector

Transmission

Natural gas across the UK is supplied via the national transmission system (NTS). The NTS is owned and operated by National Transmission, the sole gas transmission asset owner in the UK. The NTS currently consists of 7,600 km of high pressure pipelines and leaves the system at 49 points across the UK.\textsuperscript{61}

Figure 10: Gas transmission networks, UK

\begin{center}
\includegraphics[width=\textwidth]{gas_transmission_map.png}
\end{center}

Source: Energy Networks Association (UK)\textsuperscript{62}

Distribution (including embedded networks)

From the NTS, gas is delivered to the gas distribution networks. There are eight gas distribution networks (GDNs) in Great Britain (England, Wales and Scotland), four of the networks are owned (or previously owned) by National Grid (61\% was sold to a consortium of investors on 31 March 2017), and other four are owned by Scotland Gas Networks, Northern Gas Networks, Wales & West Utilities and Southern Gas Networks.\textsuperscript{63} Each independent DSO owns and operates several relatively small networks at various geographical locations.

\begin{itemize}
\item \textsuperscript{61} National Grid, ‘What we do in the Gas Industry’ webpage. Refer to: \url{http://www2.nationalgrid.com/UK/Our-company/Gas/}
\item \textsuperscript{62} Available at: \url{http://www.energynetworks.org/info/faqs/gas-transmission-map.html}
\item \textsuperscript{63} National Grid, ‘What we do in the Gas Industry’ webpage. Refer to: \url{http://www2.nationalgrid.com/UK/Our-company/Gas/}
\end{itemize}
In addition to the National Transmission System and the major gas distribution networks there are six independent gas transporters (IGTs) operating in the UK. Independent gas transporters deliver gas to around one million customers – particularly in rural and remote areas.

There are also fifteen independent (embedded) gas distribution system operators. Embedded gas distribution system operators as of 2015 included: Energetics Gas Ltd, ES Pipelines Ltd, ESP Connections Ltd, ESP Networks Ltd, ESP Pipelines Ltd, Fulcrum Pipelines Ltd, GTC Pipelines Ltd, Independent Pipelines Ltd, Quadrant Pipelines Ltd, Indigo Pipelines Ltd, Severn Gas Transportation Ltd, Greenpark Energy Transportation Ltd, SP Gas Transportation Cockenzie Ltd, SP Gas Transportation Hatfield Limited and Energy Asset Pipelines Ltd.

Interconnectors and gas storage

There are currently three gas interconnectors which connect to the National Transmission System:

- IUK interconnector to Belgium

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64 Available at: [http://www.energynetworks.org/info/faqs/gas-distribution-map.html](http://www.energynetworks.org/info/faqs/gas-distribution-map.html)


Balgzand to Bacton Line (BBL) to the Netherlands
Moffat to the Republic of Ireland interconnector

There are three types of gas storage: long-range storage, medium-range storage (typically salt caverns, such as Aldbrough and depleted fields, such as Hatfield Moor) and short-range storage (peak LNG plants). Long-range storage is typically used for seasonal variations. Rough, the only such facility in the United Kingdom currently, represents three-quarters of the country’s storage capacity. It is owned and operated by former incumbent Centrica Storage.\(^69\) Operating gas storage facilities are listed in Table 3 (below).

**Table 3: Details of gas storage facilities in the UK**

<table>
<thead>
<tr>
<th>Name</th>
<th>Owner</th>
<th>Type</th>
<th>Location</th>
<th>Maximum technical capacity (millions cubic metres)</th>
<th>Operational timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough</td>
<td>Centrica</td>
<td>Offshore depleted gas field</td>
<td>Offshore</td>
<td>3,716</td>
<td>Pre 2000</td>
</tr>
<tr>
<td>Stublach</td>
<td>Storengy</td>
<td>Salt cavern</td>
<td>On shore</td>
<td>400</td>
<td>2018</td>
</tr>
<tr>
<td>Holford</td>
<td>EoN</td>
<td>Salt cavern</td>
<td>On shore</td>
<td>160</td>
<td>2013</td>
</tr>
<tr>
<td>Aldbrough</td>
<td>SSEHL &amp; Statoil UK</td>
<td>Salt cavern</td>
<td>On shore</td>
<td>268.5</td>
<td>2009</td>
</tr>
<tr>
<td>Hornsea</td>
<td>SSEHL</td>
<td>Salt cavern</td>
<td>On shore</td>
<td>257</td>
<td>Pre 2000</td>
</tr>
<tr>
<td>Hilltop</td>
<td>EDF</td>
<td>Salt cavern</td>
<td>On shore</td>
<td>98</td>
<td>2016</td>
</tr>
<tr>
<td>Holehouse</td>
<td>EDF</td>
<td>Salt cavern</td>
<td>On shore</td>
<td>48</td>
<td>2016</td>
</tr>
<tr>
<td>Humbly Grove</td>
<td>Petronas</td>
<td>Depleted field</td>
<td>On shore</td>
<td>259</td>
<td>2005</td>
</tr>
<tr>
<td>Hatfield</td>
<td>SP</td>
<td>Sandstone</td>
<td>On shore</td>
<td>115</td>
<td>2000</td>
</tr>
</tbody>
</table>

*Source: SSE Gas Storage - SSE Hornsea Limited Application for an Exemption under Section 85 of the Gas Act, 2015*

**Customers and supply sources**

There are currently an estimated 10.8 million gas customers in the UK.\(^70\) In 2010, the largest gas consuming sectors are power generation and households, each accounting for slightly more than a third of the total gas consumption. The rest was consumed in industry (12%), commercial and public services (6%) and the energy sector (6%). Because of the high share of gas use for heating, total gas demand varies according to temperature.\(^71\)

The UK currently produces enough gas to meet around 45% of demand. The majority of UK gas production comes from offshore fields (99%), mostly from the North Sea with some coming from the East Irish Sea\(^72\). The remainder of gas is imported via pipelines from Europe and Norway (38%), and via tankers in the form of Liquefied Natural Gas (LNG) (17%).\(^73\)

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\(^70\) National Grid, ‘What we do in the Gas Industry’ webpage. Refer to: [http://www2.nationalgrid.com/UK/Our-company/Gas/](http://www2.nationalgrid.com/UK/Our-company/Gas/)
4.3 Research summary

<table>
<thead>
<tr>
<th>Network description</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area &amp; population</td>
<td>National Grid owns and operates the natural gas transmission system in the UK (referred to as the National Transmission System or NTS).</td>
<td>There are currently three transmission operators (TOs) that own and maintain the transmission networks in the UK:</td>
</tr>
<tr>
<td></td>
<td>The NTS consists of 7,660 km of pipelines with 49 exit points.74</td>
<td>– National Grid Electricity Transmission plc (NGET) for England and Wales</td>
</tr>
<tr>
<td></td>
<td>There are around 9 natural gas storage facilities (including salt caverns such as Aldbrough and depleted fields such as Hatfield Moor)</td>
<td>– Scottish Power Transmission Limited for southern Scotland and</td>
</tr>
<tr>
<td>Network operators</td>
<td>The UK distribution network consists of approximately 17,560 km of pipelines.</td>
<td>– Scottish Hydro Electric Transmission plc for northern Scotland and</td>
</tr>
<tr>
<td>Other features</td>
<td>There are eight gas distribution networks (GDNs) in Great Britain (Northern Ireland is part of the Irish gas market), four of the networks are owned by National Grid, and other four are owned by Scotia Gas Networks, Northern Gas Networks, Wales &amp; West Utilities and Southern Gas Networks.75</td>
<td>the Scottish islands groups.77</td>
</tr>
<tr>
<td></td>
<td>There are fifteen independent (embedded) gas distribution system operators (DSO). Each independent DSO owns and operates several relatively small networks at various geographical locations76</td>
<td>The transmission system is operated by a single System Operator, NGET, who are responsible for ensuring the stable and secure operation of the whole transmission system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Britain’s electricity market currently has 4GW of interconnector capacity (2GW to France, 1GW to the Netherlands, 500MW to Northern Ireland 500MW to the Republic of Ireland.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>There are 14 licensed distribution network operators (DNOs) in Britain and each is responsible for a regional distribution services area. The 14 DNOs are owned by six different groups. )78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>There are four independent network operators within distribution areas.</td>
</tr>
</tbody>
</table>

74 [http://www2.nationalgrid.com/UK/Our-company/Gas/](http://www2.nationalgrid.com/UK/Our-company/Gas/)


<table>
<thead>
<tr>
<th>Regulator roles:</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Regulator</td>
<td>The Office of Gas and Electricity Markets (Ofgem) regulates the gas and electricity networks and the competitive markets in gas and electricity supply and retail. The protection of consumer interests lies at the heart of the regulator’s role, including those interests in reducing greenhouse gas emissions and security of supply. The regulator is independent from the government, accountable instead to Parliament, to separate regulatory decisions from political control and so provide greater long-term regulatory certainty and to encourage market entry and investment.</td>
<td></td>
</tr>
<tr>
<td>Economic Regulator</td>
<td>The Health and Safety Executive (HSE) is the national regulator for work-related health and safety in Great Britain. It has statutory responsibility for making sure there is adequate health and safety regulation across most industry sectors, including the UK nuclear industry. HSE is responsible for administration and development of gas regulations including several gas safety regulations and historically has had oversight of the safety cases for the industry. In electricity, the HSE administers the Electricity at Work Regulations 1989. HSE is an executive non-departmental public body, sponsored by the Department for Work and Pensions.</td>
<td></td>
</tr>
<tr>
<td>Network regulator</td>
<td>The Department for Business, Energy &amp; Industrial Strategy (previously the Department of Energy &amp; Climate Change) works to make sure the UK has secure, clean, affordable energy supplies and promote international action to mitigate climate change.</td>
<td></td>
</tr>
<tr>
<td>Market Operator</td>
<td>The Oil &amp; Gas Authority covers offshore and production facilities. This includes offshore storage – such as the Rough facility.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relevant safety legislation</th>
<th>The Health and Safety at Work Act 1974 is the primary legislation covering occupational health and safety in Great Britain (Administered by HSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acts</td>
<td>The Gas Act 1986 is the main piece of onshore gas market legislation. It includes the licensing regime for industry members and sets out the economic regulation framework. (Administered by OFGEM)</td>
</tr>
<tr>
<td>Regulations</td>
<td>There are several bits of Gas safety legislation. The most important are:</td>
</tr>
<tr>
<td>Codes etc.</td>
<td>- The Gas Act 1986 apply to the conveyance of natural gas through a network and sets out a duty to minimise the risk of a gas supply emergency; arrangements for dealing with supply emergencies and has composition.</td>
</tr>
<tr>
<td></td>
<td>- Pipeline Safety Regulations 1996 (PSR) are principally concerned with pipeline integrity and aimed at securing safety in the design,</td>
</tr>
<tr>
<td></td>
<td>The Electricity Act 1989 sets out the legislative framework for participants and the licensing requirement. Ofgem administers the electricity licences and which include conditions such as becoming a party to, and complying with, industry codes and standards. (Administered by OFGEM)</td>
</tr>
<tr>
<td></td>
<td>- Industry codes establish market rules. Each code has its own Code Administrator and website. Relevant Codes are:</td>
</tr>
<tr>
<td></td>
<td>- Distribution Code covers the technical aspects around connection and use of the electricity distribution networks.</td>
</tr>
<tr>
<td></td>
<td>- Grid Code covers technical aspects around connections and use of the national electricity transmission system</td>
</tr>
</tbody>
</table>

---

79 Oil & Gas Authority, OGA Overview 2017, London, UK, 2017. Available at: https://www.ogauthority.co.uk/media/3598/oga_overview_april_2017.pdf
81 https://www.ofgem.gov.uk/licences-industry-codes-and-standards
82 https://www.ofgem.gov.uk/licences-industry-codes-and-standards/industry-codes
<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
</table>
| construction, installation, operation, maintenance and decommissioning of pipelines.  
  - Gas Safety (Rights of Entry) Regulations 1996  
  - Gas Safety (Installation and Use) Regulations 1998  
  - Control of Major Accident Hazards (COMAH) 2015 | Licensees are also required to comply with several technical codes and standards relating to transmission and distribution networks: 83  
Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR) 84 require the DNOs to ensure their equipment is safe and protected, and that the public are aware of any dangers. (Administered by Department for Business, Energy and Industrial Strategy)  
  - wiring regulations (BS7671) 85  
  - Electricity at Work Regulations 1989  
  - Electrical standards and approved codes of practice are available on the Health and Safety Executive website 86. There are 15 Electrical and Power related standards. |

**Legislative approach**  
(e.g. Prescriptive / outcome focussed / safety case etc.)  
Outcome focused Safety Management Systems and Safety Cases 87  
Specific Safety Management System for pipelines, elements required are:  
- Review and audit  
- Monitoring  
- Written documentation  
Other elements required:  
- Risk based management using duty of care and so far as is reasonably practicable  
- Some prescription in elements of the Electricity Safety, Quality and Continuity Regulations 2002.  
- Links to the licensing system  
  - Driven by a self-regulated approach via licencing system

---

86 [http://www.hse.gov.uk/electricity/standards.htm](http://www.hse.gov.uk/electricity/standards.htm)  
<table>
<thead>
<tr>
<th><strong>Gas</strong></th>
<th><strong>Electricity</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Hazard identification and risk assessment, however this does not prescribe mandatory qualitative description or quantitative scenario analysis (though both may be acceptable)</td>
<td>▪ Distribution business design and adopt an approved Distribution Code (currently all use the same Code)</td>
</tr>
</tbody>
</table>

**Clarity & coordination of regulator roles**  
(e.g. Does economic regulator create barriers for safety)

HSE and Ofgem meet regularly. Indicate that there is a high-level coordination and roles are clear  
In 2013, Ofgem introduced a regulatory framework called RIIO (revenue = incentives + innovation + outputs)  
The output measures are Safety, Reliability (and availability), Environmental impact, Customer / stakeholder satisfaction and Customer connections.\(^88\)  

| The RIIO reports for 2015/16 are available for gas transmission\(^89\) and gas distribution report\(^90\) | The RIIO reports for 2015/16 is electricity transmission\(^91\) and electricity distribution\(^92\) available. |

**Safety approach / thresholds uses for different life risks:**  
Employees  
Individual public risks  
Societal risks  
(e.g. ALARP, F-N Curve)

Employees are covered in the Safety Management System  
Public risks consider both individual and societal risks  
Apply

| Public risk are covered in the Safety Management System focus is on low electrical lines and fallen lines / disturbance of underground lines  
More relevant to individual risk / limited consideration of societal risks | |

**Enforcement / compliance resourcing and**

Responsive enforcement. Prosecution focus with limited data available on other types of compliance and enforcement \(^93\)

| Normally responsive enforcement – investigate complaints, concerns and incidents.\(^94\) | |

---


\(^93\) [http://www.hse.gov.uk/gas/supply/programme-of-work.htm](http://www.hse.gov.uk/gas/supply/programme-of-work.htm)

\(^94\) [http://www.hse.gov.uk/electricity/how.htm](http://www.hse.gov.uk/electricity/how.htm)
<table>
<thead>
<tr>
<th>Policy</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>The regulator does not appear to undertake regular inspections, rather</td>
<td>The regulator does not appear to undertake regular inspections, rather these are undertaken by the networks with the regulator reviewing these reports. The inspector plans for the Transmission and Distribution</td>
<td>Currently campaign checking the competency of Snr authorised people.</td>
</tr>
<tr>
<td>these are undertaken by the networks with the regulator reviewing these</td>
<td>Networks are published. The inspector plans for Networks Plan for 2005 to 2010 is here.</td>
<td></td>
</tr>
<tr>
<td>reports. The inspector plans for the Transmission and Distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Networks are published. The inspector plans for Networks Plan for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005 to 2010 is here.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness measures used</td>
<td>HSE publish data on incidents here</td>
<td>HSE publish data on incidents here</td>
</tr>
<tr>
<td>Leading indicators</td>
<td>Under RIIO gas distribution networks report on:</td>
<td>Under RIIO electricity distribution networks report on:</td>
</tr>
<tr>
<td>Lagging indicators</td>
<td>• length of mains off risk (km)</td>
<td>• compliance with the relevant legislation</td>
</tr>
<tr>
<td>Major incidents</td>
<td>• numbers of pipe fractures and corrosion failures from iron mains</td>
<td>• secondary deliverables to support reliability. These include health, criticality and monetised risk, and a load index (LI).</td>
</tr>
<tr>
<td></td>
<td>• number of occurrences of ‘gas in buildings’ events caused by iron mains</td>
<td>Under RIIO National Grid reports on compliance with safety obligations set by the HSE. It also reports on Secondary deliverables related to asset health, condition, criticality etc. are assessed through Network Output Measures (NOMs). These are related to network:</td>
</tr>
<tr>
<td></td>
<td>• number of incidents</td>
<td>• assets condition measure</td>
</tr>
<tr>
<td></td>
<td>• number of steel service pipes decommissioned.</td>
<td>• risk measure</td>
</tr>
<tr>
<td></td>
<td>Under RIIO the NTS reports on compliance with legal safety requirements, Network Output Measures (NOMs) and compliance with government</td>
<td>• performance measure</td>
</tr>
<tr>
<td></td>
<td>requirements for critical sites</td>
<td>• capability measure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Replacement Outputs</td>
</tr>
<tr>
<td>Future issues</td>
<td>See section 4.4</td>
<td>Recognise moving to a Smart grid with local generation and solutions as well as battery storage. Mostly monitoring at the moment.</td>
</tr>
<tr>
<td>Anticipated future issues</td>
<td></td>
<td>See also section 4.4</td>
</tr>
<tr>
<td>SWOT analysis</td>
<td>Risk based regulation</td>
<td>Risk based regulation – with some prescription</td>
</tr>
<tr>
<td>Summary SWOT analysis</td>
<td>Safety Management System requires companies to identify risks. Good coordination between HSE &amp; Ofgem</td>
<td>Safety Management System requires companies to identify risks. Good coordination between HSE &amp; Ofgem</td>
</tr>
<tr>
<td>Strengths</td>
<td>Separation of gas from electricity may result in divergence of approaches If HSE is not proactive then emergent risks may not be identified until they “bite”</td>
<td>Separation of gas from electricity may result in divergence of approaches If HSE is not proactive then emergent risks may not be identified until they “bite”</td>
</tr>
<tr>
<td>Weakness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opportunity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threats</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWOT analysis</td>
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<td>Risk based regulation – with some prescription</td>
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<tr>
<td>Weakness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opportunity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threats</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.4 Other insights

Iron mains risk reduction program

The Iron Mains Replacement Programme was introduced in 2002 to address ‘societal concern’ regarding the potential for failure of cast iron gas mains and the consequent incidents.\textsuperscript{95}

*In Great Britain gas is distributed through a network of around 275 000 km of cast iron, ductile iron, steel and polyethylene pipes. Iron pipes (which include cast iron, spun iron and ductile iron) are known to be at risk of failure through fracture and corrosion and this can result in serious gas explosions. Iron pipes within 30 m of buildings present the greatest hazard and are referred to as ‘at-risk’ pipes. The major gas distribution network operators have designed successive decommissioning programmes to manage the risk from their at-risk iron pipes.*\textsuperscript{96}

The Iron Mains Risk Reduction Programme (IMRRP) addresses the failure of ‘at risk’ iron gas mains (i.e. those pipes within 30 metres of buildings) and the consequent risk of injuries, fatalities and damage to buildings.\textsuperscript{97}

The program was developed after the introduction of regulation 13A of the Pipelines Safety Regulations 1996. Regulation 13A requires the HSE to approve iron mains replacement programmes submitted by the gas Distribution Network operations if they are judged by HSE to be ‘suitable and sufficient’.\textsuperscript{98}

Iron Mains Replacement is now incorporated as a measure under Ofgem’s RIIO price method (discussed below).

Network transformation

Ofgem have introduced the RIIO (*Revenue = Incentives + Innovation + Outputs*) approach to price control to incentivize investment in energy networks as they transform to a low carbon economy. For example, energy networks will have to become smarter to meet the following challenges:\textsuperscript{99}

- connecting more home-based microgeneration, i.e. solar panels and small scale renewable generation
- connecting more small-scale renewables and Combined Heat and Power to the low voltage distribution network
- extending the high voltage transmission grid to connect renewable generation, often located in remote regions or offshore


\textsuperscript{98} Health and Safety Executive, ‘Progress with the iron mains replacement programme at 31 March 2013’, [undated]. Refer to: http://www.hse.gov.uk/gas/supply/mainsreplacement/progress1213.htm

- balancing the electricity network to manage large amounts of renewable generation which by its nature is intermittent
- coping with the predicted increase in generation needed to deliver the electrification of transport and heat
- gas networks will face further growth in the use of Liquefied Natural Gas and carbon capture and storage facilities at power stations, and
- in the long term with the electrification of heat, the level of demand for gas is uncertain.

**Small generation**

Generators rated at up to 50 MW are exempted from licensing under the *Utilities Act* in the UK, so micro-generators are not covered by the usual licensing conditions.

Electricity Safety First, an independent charity committed to reducing deaths and injuries through electrical accidents at home and work, has published best practice guidance on “Connecting a microgeneration system to a domestic or similar electrical installation (in parallel with the mains supply)” (November 2015).  

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5. Spain

5.1 Overview of the electricity sector

Portugal and Spain have integrated their electricity markets into a single Iberian Electricity Market, (Mercado Ibérico de Electricidad – MIBEL) created in 2007 and the countries share a common spot market operator (Operador del Mercado Ibérico – OMIE). Both are owned 50/50 by the Spain and Portuguese wholesale market operators from pre-MIBEL times.\(^\text{101}\)

Transmission

The Spanish high-voltage transmission network in Spain is owned and operated by Red Eléctrica de España (REE). Red Eléctrica de España is a publicly listed entity. Law 3/2012 limits share ownership of the company, with the State maintaining ownership of 10% of shares and other entities able to hold (either directly or indirectly) no more than 5% of share capital or to use more than 3% of voting rights.\(^\text{102}\)

In 2016, the transmission network had a total length of 43,000 km, of which 20,641 km is at 400 kV. The network also includes 5,216 substations with a transformer capacity of 80,695 megavolt-amperes. These numbers include both peninsular and extra-peninsular networks in the islands.\(^\text{103}\)

There are interconnectors with Portugal (multiple), Morocco (undersea HVDC) and France.

Distribution

The distribution network consists of an estimated 695,427 km of lines including 475,323 km of overhead lines, 220,104 km of underground cables, 289,671 transformers, and 776 distribution to transmission interconnection points.\(^\text{104}\)

Spain has five major distribution companies, all originally subsidiaries of the companies involved also in power generation and supply: Endesa, Iberdrola, Gas Natural Fenosa, E.ON and HC Energia-EDP. Aligned with EU Directives, the electricity and gas DSOs are legally and functionally unbundled. In addition, there are more than 300 small distribution companies, however these are not legally required to unbundle. A map of the key network features is shown in Figure 12.

---


Consumers and generation

In 2014, there were just under 28 million domestic electricity customers in Spain and a further 849,000 non-domestic customers.\(^ {106} \)

Electricity comes from a balanced mix of generation sources within Spain. Nuclear supplies around 20.9% of total generation, natural gas accounts 17.2% and coal a further 16.3%. Most of Spain’s power generation however comes from renewable generation sources: wind 19.1%, hydro 14.3%, solar 5%, biofuels and waste 2%. Oil accounts for a small proportion, 5.2%.\(^ {107} \)

5.2 Overview of the gas sector

Like the situation in electricity, the Spanish and Portuguese natural gas markets are interlinked and together form the Iberian natural gas market. Neither Spain nor Portugal have significant gas production of their own.\(^ {108} \)


Customers and supply sources

There are an estimated 7.585 million gas customers with 76% of the population connected to gas and around 6,000 industrial facilities connected. By consumption households represent 16.3%, electricity generation 17.6%, Industrial 64.8%, and non-energetic use account for an additional 1.8%.

Spain imports most of the gas it consumes as domestic production is negligible. There are interconnector pipelines with Morocco, Algeria, Portugal, and France. The interconnectors with France and Portugal are bi-directional, while the interconnectors with Algeria and Morocco are used to import natural gas to Spain.\(^\text{109}\) The three main supplier countries are Algeria (42.4%), Nigeria (15.4%) and Qatar (11.6%)\(^\text{110}\), and up to eighteen companies inject gas into the system (in 2012). There are four underground storage facilities covering around 9.1% of the demand.\(^\text{111}\)

Transmission

Enagas Transporte, S.A.U. owns and operates more than 95% of gas transport pipelines, it is also the system operator for other companies' pipelines. The Engas Transporte network consists of more than 11,000 km of pipelines, six LNG terminals, three of the strategic storage facilities in Spain, six international connections, and 18 compressor stations\(^\text{112}\). Their pipeline network is listed as being covered by polyethylene sheet that prevents direct contact of the steel with the ground and therefore protects from corrosion.\(^\text{113}\)

A map of the key natural gas network features is shown in Figure 13 (below). The map includes interconnectors to Morocco and Algeria in the South, with France in the North East, and with Portugal to the West.


Figure 13: Natural gas infrastructure, Spain


Distribution

In 2007, there were 53,795 km of distribution pipelines in Spain. Since 2007, the distribution network has grown to over 72,830 km in 2015.

The main distribution operators are Grupo Gas Natural Fenosa (69% of connections), EDP (12%), Madrilena Red de Gas (11%), Redexis (7%), Gas Extremadura (1%).

5.3 Research summary

<table>
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<tr>
<th>Network description</th>
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<th>Electricity</th>
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</thead>
<tbody>
<tr>
<td>Area &amp; population</td>
<td>Spain imports most of the gas it consumes, since its gas production is minimal. There are three main supplier countries: Algeria (42.4%), Nigeria (15.4%) and Qatar (11.6%), and up to eighteen companies injecting gas in the system (in 2012)</td>
<td>Portugal and Spain have integrated to create a single Iberian Electricity Market, (Mercado Ibérico de Electricidad – MIBEL) created in 2007 and the countries share a common spot market operator (Operador del Mercado Ibérico – OMIE). Both are owned 50/50 by the Spain and Portuguese wholesale market operators from pre-MIBEL times.119</td>
</tr>
<tr>
<td>Network operators</td>
<td>Enagas Transporte, S.A.U. owns and operates more than 95% of gas transport pipelines, it is the system operator for other companies' pipelines. The Engas Transporte network consists of 11,000 km of pipelines and 18 compressor stations118</td>
<td>The transmission network in Spain is owned and operated by Red Eléctrica de España (REE) (publicly listed entity, State owns 10% holding by other entities is limited by law)</td>
</tr>
<tr>
<td>Other features</td>
<td>4 underground storage facilities</td>
<td>The transmission network consists of 43,000 km of lines, 5,216 substations.120</td>
</tr>
<tr>
<td></td>
<td>There are 53,795 km (2007) of distribution pipelines.</td>
<td>There are interconnectors with Portugal (multiple), Morocco (undersea HVDC), France</td>
</tr>
<tr>
<td></td>
<td>The main distribution operators are Grupo Gas Natural Fenosa (69% of connections), EDP (12%), Madrileña Red de Gas (11%), Redexis (7%), Gas Extremadura (1%). (2015 National Report to EU)</td>
<td>695,427 km including 475,323 km overhead and 220,104 km underground, 289,671 transformers, and 776 Transmission-Distribution interconnection points (2011)</td>
</tr>
<tr>
<td></td>
<td>7.585 million gas customers with 76% of the population connected to gas and around 6,000 industrial facilities connected</td>
<td>Spain has five major distribution companies, all originally subsidiaries of the companies involved also in power generation and supply: Endesa, Iberdrola, Gas Natural Fenosa, E.ON and HC Energia-EDP. Since recent EU Directives, the electricity and gas DSOs are legally and functionally unbundled.</td>
</tr>
<tr>
<td></td>
<td>By consumption households represent 16.3%, electricity generation 17.6%, Industrial 64.8%, and non-energetic use account for an additional 1.8%.</td>
<td>There are also more than 300 small distribution companies.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulator roles:</strong></td>
<td><strong>The main regulatory authorities include:</strong></td>
</tr>
<tr>
<td>Safety Regulator</td>
<td>Ministry of Industry, Energy and Tourism <em>(Ministerio de Industria, Energía y Turismo)</em>: Responsible for setting Spanish energy policy and its implementation, including the development of regulatory proposals and, among other things, approvals of tariff structures, energy product prices, network access tolls and electricity charges in accordance with current legislation. It also has duties in relation to the licensing of facilities, alongside those of the autonomous communities (regions).</td>
</tr>
<tr>
<td>Economic Regulator</td>
<td>National Markets and Competition Commission <em>(Comisión Nacional de los Mercados y la Competencia - CNMC)</em>. This is the regulatory body, under the Ministry of Economy and Competitiveness, for the energy sector. Its primary duty (in the electricity sector) is to supervise and control the correct operation of the electricity market. It issues circulars in relation to the electricity sector, and oversees the development and enforcement of rules in the context of energy legislation, supervising the obligations of players in the electricity market and the proper operation of the energy system such as network capacity, unbundling of activities, economic competition, tariffs, energy auctions</td>
</tr>
<tr>
<td>Network regulator</td>
<td>Worker safety regulator is the National Institute for Safety and Health at Work <em>(Instituto Nacional de Seguridad e Higiene en el Trabajo)</em></td>
</tr>
<tr>
<td>Market Operator</td>
<td>Ministry of Agriculture, Food and Environment <em>(Ministerio de Agricultura, Alimentación y Medio Ambiente)</em>. This proposes and implements government policy in relation to climate change and environmental protection (among other things), without prejudice to the role of regional bodies which have related duties in their corresponding regions.</td>
</tr>
<tr>
<td>Refer to agencies list in appendix for detailed description.</td>
<td>Each of the autonomous communities has regulatory authorities with responsibilities for electricity activities carried out in their territory, typically regional departments for industry or energy.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relevant safety legislation</th>
<th>Key Occupational Health and Safety legislation (administered by Instituto Nacional de Seguridad e Higiene en el Trabajo) are:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Codes etc.</td>
<td>The main legislation regulating the Spanish gas system (most of which is administered by Ministerio de Industria, Energía y Turismo) is as follows:<strong>122</strong>: <em>Hydrocarbons Sector Law 34/1998</em> of 7 October 1998</td>
</tr>
</tbody>
</table>

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121 [https://uk.practicallaw.thomsonreuters.com/4-529-8116?__lrTS=2017040918235156&transitionType=Default&contextData=(sc.Default)&firstPage=true&bhcp=1#co_anchor_a997019](https://uk.practicallaw.thomsonreuters.com/4-529-8116?__lrTS=2017040918235156&transitionType=Default&contextData=(sc.Default)&firstPage=true&bhcp=1#co_anchor_a997019)

<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Royal Decree-Law 6/1999 of 16 April 1999</td>
<td>▪ of this service and the lowest possible cost. 125 The Act is administered by Ministerio de Industria, Energía y Turismo.</td>
</tr>
<tr>
<td>▪ Royal Decree-Law 6/2000 of 23 June 2000</td>
<td>▪ The new Electricity Sector Act 24/2013 (administered by Ministerio de Industria, Energía y Turismo) aims to ensure that consumers with distributed generation contribute to the costs of the electricity system under the same conditions as other customers. Red Eléctrica de España’s (REE) role as the electricity system operator and sole transmission company for Spain on an exclusive basis is also outlined. REE is also the owner of pumping facilities in non-mainland electricity systems responsible for security of supply, system security and integration of renewable energy as set out in Law 17/2013. 126</td>
</tr>
<tr>
<td>▪ Royal Decree 949/2001 of 3 August 2001</td>
<td>▪ 2001-06-08 (ESP-2001-R-102133) Royal Decree no. 614/2001 on minimum requirements for the protection of the health and safety of workers against electrical hazards. Administered by Instituto Nacional de Seguridad e Higiene en el Trabajo) – Note this is in workplaces and not networks.</td>
</tr>
<tr>
<td>▪ Planning and development of electricity and gas transmission networks of September 2002: Scope 2002-2011</td>
<td>▪</td>
</tr>
<tr>
<td>▪ Royal Decree 1434/2002 of 27 December 2002</td>
<td>▪</td>
</tr>
<tr>
<td>▪ Royal Decree 942/2005 of 3 August 2005</td>
<td>▪</td>
</tr>
<tr>
<td>▪ Ministry of Industry, Tourism and Trade Order 3126/2005 of 5 October 2005 (NGTS)</td>
<td>▪</td>
</tr>
<tr>
<td>▪ Ministry of Industry, Tourism and Trade Order 3354/2010 of 29 December 2010</td>
<td>▪</td>
</tr>
<tr>
<td>▪ Ministry of Industry, Energy and Tourism Order 849/2012 of 26 April 2012</td>
<td>▪</td>
</tr>
</tbody>
</table>

*Technical Management Standards* that seek to guarantee functioning of the gas system as well as the continuity, quality and safety of natural gas supply are provided on the Ministerio de Energía Turismo y agenda digital website 123. The *Gas Code* is also publicly available. 124

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123 Refer to: [http://www.minetad.gob.es/energia/gas/NGTS/Paginas/NGTS.aspx](http://www.minetad.gob.es/energia/gas/NGTS/Paginas/NGTS.aspx)


126 Refer to: [https://uk.practicallaw.thomsonreuters.com/4-529-81167__lRTS=20170409182335156&transitionType=Default&contextData=(sc.Default)&firstPage=true&bhcp=1&bhhash=1#co_anchor_a997019](https://uk.practicallaw.thomsonreuters.com/4-529-81167__lRTS=20170409182335156&transitionType=Default&contextData=(sc.Default)&firstPage=true&bhcp=1&bhhash=1#co_anchor_a997019)
<table>
<thead>
<tr>
<th><strong>Legislative approach</strong> (e.g. Prescriptive / outcome focussed / safety case etc.)</th>
<th><strong>Gas</strong></th>
<th><strong>Electricity</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome focussed - Requires safety management system</td>
<td></td>
<td>Outcome focussed - Transmission network - Red Eléctrica de España uses a risk based approach.</td>
</tr>
</tbody>
</table>

| **Clarity & coordination of regulator roles** | Reported the national bodies – the Ministry of Industry, Energy and Tourism (Ministerio de Industria, Energía y Turismo) and the National Institute for Safety and Health at Work (Instituto Nacional de Seguridad e Higiene en el Trabajo) align and coordinate roles well | Reported the national bodies – the Ministry of Industry, Energy and Tourism (Ministerio de Industria, Energía y Turismo) and the National Institute for Safety and Health at Work (Instituto Nacional de Seguridad e Higiene en el Trabajo) align and coordinate roles well. Some issues arise between the national bodies and the regulatory authority in each of the autonomous communities which apply the legislation in their territory. |

| **Safety approach / thresholds uses for different life risks:** | Safety Management System used submitted every 3 to 5 years. Elements required include:  
- Review and audit  
- Monitoring  
- Written documentation | Risk based approach is applied. Safety Management System – submitted every 3 to 5 years. |
| Employees  
Individual public risks  
Societal risks (e.g. ALARP, F-N Curve) | Enrollment / compliance resourcing & policy | Periodic reviews inspections on an ad hoc basis. However, the responsibility is placed on the companies. |
| **Enforcement / compliance resourcing & policy** | Periodic reviews inspections on an ad hoc basis. However, the responsibility is placed on the companies. | Periodic reviews inspections on an ad hoc basis. However, the responsibility is placed on the companies. |

| **Effectiveness measures used**  
Leading indicators  
Lagging indicators  
Major incidents | National Institute for Safety and Health at Work (Instituto Nacional de Seguridad e Higiene en el Trabajo) publishes data on fatalities | Transmission network operator- Red Eléctrica de España (REE) publishes data on both leading indicators (e.g. training undertaken, risks assessed) and lagging indicators (Lost time injuries etc.) National Institute for Safety and Health at Work (Instituto Nacional de Seguridad e Higiene en el Trabajo) publishes data on fatalities. |

| **Outcomes**  
Worker safety culture | No information identified on this topic | Transmission network operator uses a risk based approach to Occupational health and safety and social risks. |

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<table>
<thead>
<tr>
<th>Community consultation</th>
<th>Gas</th>
<th>Electricity</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Transmission network operator publishes many corporate plans(^{128}) – which appear to show a risk culture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Future issues</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticipated future issues</td>
<td>No specific issues are identified</td>
<td>Red Eléctrica de España identify:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Integration of renewables into transmission network</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Nature exacerbated by climate change (floods, lightning, wind)(^{129})</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>SWOT analysis</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary SWOT analysis</td>
<td>Safety Management System used requiring utilities to identify and manage all risks.</td>
<td>Safety Management System used requiring utilities to identify and manage all risks.</td>
</tr>
<tr>
<td></td>
<td>Publication of enforcement and incident information is limited.</td>
<td>Some coordination and consistency issues due to national/state differences and inconsistent approaches.</td>
</tr>
<tr>
<td></td>
<td>Limited evidence of focus on identifying future issues.</td>
<td>Publication of enforcement and incident information is limited.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited evidence of focus on identifying future issues.</td>
</tr>
</tbody>
</table>


5.4 Other insights

5.4.1 EU involvement in Spanish and UK legislation

A (current) members of the European Union the member states commit to implementing a range of EU Directives. Accordingly, it is worth noting the influence these directives have on member states such as Spain and the UK.

Safety of gas pipelines and electricity networks are not directly regulated by any EU directives; however, some analysts have considered whether this would be beneficial.\textsuperscript{130}

Two EU directives have some tangential impact on the regulation of gas pipeline safety.

- The EU Directive 2012/18/EU on the control of major-accident hazards involving dangerous substances, (often referred to as Seveso-III) covers (to use the Australian phase) “major hazard facilities” – but specifically excludes gas pipelines;
- Directive 2009/73/EC concerning common rules for the internal market in natural gas sets out the competition framework and requires unbundling of services; and the corresponding

5.4.2 Forest break grazing programmes in Spain

A few innovative approaches to managed prevention of wildfires has been widely applied in the south-eastern France over the part 25-years. Spanish regions with similar Mediterranean climates have increasingly been adopting these techniques via regional and specific welfare prevention programmes in response to recent increased in the frequency and impact of wildfires.\textsuperscript{131}

The programmes operate on the understanding that, when adequately managed, most types of grazing livestock can assist wildfire prevention. Sheep and goat systems appear to be particularly well-suited to this objective. Currently, fire break grazing programs are mostly funded directly by the forest services of the Spanish regional government.

A study on the environmental benefits of extensive livestock grazing by Ruiz-Mirazo,\textsuperscript{132} explains the concept and provides some example programme statistics:

\begin{quote}
Habitually, farmers that take part in wildfire prevention programmes make their livestock graze intensively in the fuelbreak areas defined by forest services and, thus, vegetation fuel loads are reduced. In the event of wildfire, this would facilitate that fire brigades gained control of the wildfire. In exchange for this service, livestock farmers receive money and/or in-kind remuneration, which can consist on animal housing, fences or water troughs.
\end{quote}

The report identifies prices paid vary between € 20 to € 90 per hectare per year – depending on the grazing difficulty (steepness, type of vegetation and distance to animal housing) associated to the fuelbreaks.

\textsuperscript{130}http://ec.europa.eu/environment/seveso/pdf/study_report.pdf


However, another report\textsuperscript{133} noted that this approach may impact on biodiversity and commented that: “…the selective effect of feeding has a negative impact on biodiversity and may compact the soil if the carrying capacity is exceeded. For this reason, it is not ranking in the top of the best preventive actions.”

\textsuperscript{133} Carreiras, Manuela et al. \textit{Comparative analysis of policies to deal with wildfire risk}.
http://www.ingentaconnect.com/content/bpl/ldr/2014/00000025/00000001/art00009
6. California

6.1 Overview of the electricity sector

Federal oversight

In the US, the electricity industry is subject to a complex series of regulatory regimes at municipal, state and federal levels, with some exemptions. The Constitution allows federal regulation of utilities only where interstate commerce is involved. Accordingly, intrastate activities are subject to regulation by state regulatory commissions, which approve the construction of generating plants and transmission lines, while all states approve retail prices for their jurisdictional electric utilities.\(^\text{134}\)

In the United States, local electricity grids (within each state) are interconnected to form larger networks for reliability and commercial purposes. There are three main interconnections, which operate largely independently from one another with limited transfers of electricity between them:

- The Eastern Interconnection encompasses the area east of the Rocky Mountains and a portion of the Texas panhandle.
- The Western Interconnection encompasses the area from the Rockies west.
- The Electric Reliability Council of Texas (ERCOT) covers most of Texas.

The geographic coverage of each of the interconnections are shown in Figure 14. The Eastern and Western Interconnections are linked with each other and are each connected with Canada. ERCOT is not linked to either of the other interconnections, except via certain direct current lines, however it links with parts of Mexico. The Western Interconnection also has links with Mexico.\(^\text{135}\)

**Figure 14: US electric power regions**

Source: U.S. Energy Information Administration

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The regional operation of the electricity system is managed by balancing authorities, also called independent system operators (ISO) and regional transmission organisations (RTOs).

The Federal Energy Regulatory Commission (FERC) is an independent agency that regulators the interstate transmission of electricity, natural gas, and oil. One of the FERC’s statutory responsibilities is to ensure that prices, terms and conditions for wholesale sales and transmission of electric energy are reasonable and not unduly discriminatory or preferential.

Outside of the FERC’s jurisdictional responsibility that are dealt with by State Public Utilities Commissions are matters including reliability problems related to failures of local distribution facilities; and tree trimmings near local distribution power lines in residential neighbourhoods.  

State-based regulators

The California ISO manages most of California’s electricity transmission system (Figure 15). Within the California ISO areas there is 71,740 MW of generation capacity, 26,000 miles of transmission lines (41,843 km), and the population served is approximately 30 million.  

The California Public Utilities Commission (CPUC) regulates investor-owned utilities (IOUs) - both electric and natural gas - operating in California. Public own utilities (POUs) are subject to local and public control and regulation. 

The California PUC derives its powers from the California state constitution. The CPUC has plenary authority over the operations of the electric and gas investor-owned utilities (IOUs). It sets retail rates through traditional General Rate Cases (GRCs) as well as by allocating costs among utility customers in other types of proceedings. 

The CPUC regulates seven investor-owned electricity utilities. These include three major utilities: Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas and Electric Company (SDG&E). Smaller utilities are also included: Sierra Pacific Power Company, Pacific Power & Light and Bear Valley Electric Services.

CPUC coverage includes:

- 4 million electric poles;

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139 A summary of the differences between IOUs and PUOs is set out on the California Energy Commission website. Refer to: http://www.energy.ca.gov/pou_reporting/background/difference_pou_iou.html

- Over 300,000 miles of lines including 200,000 miles of above ground lines and 77,000 miles of underground lines; and
- Over 2,200 substations.

The CPUC is also responsible for monitoring and enforcing safety standards in the industry. It undertakes environmental assessments of proposed transmission lines, power plants or other major facilities.

Publicly Owned Utilities (POUs) are organized in various forms including municipal districts, city departments, irrigation districts, or rural cooperatives. There are 44 Publicly Owned Utilities (POUs) in the state that account for approximately a quarter of electricity supply in California. Most Publicly Owned Utilities (POUs) are smaller than Investor Owned Utilities (IOUs) by electricity sales and the number of customer accounts.

### Generation

There are over 760 power plants which offer 60 gigawatts (GW) of capacity within the California ISO area. California is a net importer of electricity, with more than one-fourth (25%) of California's electricity supply coming from facilities outside the state.

#### 6.2 Overview of the gas sector

**Federal oversight**

Like the federal based oversight for interstate electricity transmission networks federal agencies in the U.S. also have oversight and regulatory responsibilities in relation to interstate natural gas pipeline systems.

- The independent Federal Energy Regulatory Commission (FERC) regulates the interstate transmission of electricity, natural gas, and oil. For natural gas pipelines, the FERC regulates the transmission and sale of natural gas for resale in interstate commerce. It also monitors and investigates energy markets; enforces FERC regulatory requirements through imposition of civil penalties and other means; and oversees environmental matters related to natural gas and hydroelectricity projects and other matters.

- Another federal agency, the Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) administers the Department's national regulatory program to assure the safe transportation of natural gas, petroleum, and other hazardous materials by pipeline. The PHMSA is responsible for setting safety standards,
procedures, and development and expansion of any pipeline system for both interstate and intrastate pipelines and is the default regulator for safety matters.\textsuperscript{145}

US Pipeline safety statues allow States to assume safety authority over intrastate gas pipelines through Certification and Agreements with the PHMSA under Chapter 601, Title 49 of the U.S. Code of Federal Regulations.\textsuperscript{146} Subchapter D covers the minimum pipeline safety regulations.\textsuperscript{147} States must adopt these standards at a minimum to participate, but may adopt more stringent standards.

States participating in the pipeline safety program are able to receive grants from PHMSA to reimburse up to 80 percent of the total cost of the personnel, equipment, and activities reasonably required by the State agency for conducting its pipeline safety program during a given calendar year.\textsuperscript{148} California participates in the program and has adopted more stringent requirements.\textsuperscript{149} Hence, the majority of regulatory and safety oversight and on-the-ground activities in relation to pipelines within the state is undertaken by the state-based regulator, the California Public Utilities Commission (discussed further below).

\textbf{State-based regulators}

The \textbf{California Public Utilities Commission (CPUC)} regulates the California utilities' natural gas rates and natural gas services, including in-state transportation over the utilities' transmission and distribution pipeline systems, storage, procurement, metering and billing.

General Rate Case regulation by the CPUC covers investor-owned natural gas utilities. These companies’ service approximately 10.8 million customers and include:\textsuperscript{150}

- Pacific Gas and Electric (PG&E)
- Southern California Gas (SoCalGas)
- San Diego Gas & Electric (SDG&E)
- Southwest Gas, and
- Several smaller natural gas utilities

The CPUC also regulates independent storage operators Lodi Gas Storage, Wild Goose Storage, Central Valley Storage and Gill Ranch Storage.

The CPUC regulates the safety of both privately and publicly owned utilities. As part of the safety role, the CPUC enforces natural gas and LPG safety regulations; inspects construction, operation, and maintenance activities; and makes necessary amendments to regulations to protect and promote the safety of the public, the utility employees that work on the gas pipeline systems,


\textsuperscript{147} U.S. Government Publishing Office, ‘Electronic Code of Federal Regulations’, e-CFR data current as of 23 June 2017. Refer to: https://www.ecfr.gov/cgi-bin/text-idx?SID=3ff5aaeec01ded1ec2e0ca1b5a77ae23&mc=true&tpl=/ecfrbrowse/Title49/49CisubchapD.tpl

\textsuperscript{148} Pipeline and Hazardous Materials Safety Administration, ‘State Programs’, [undated], accessed June 2017. Refer to: https://www.phmsa.dot.gov/pipeline/state-programs

\textsuperscript{149} https://primis.phmsa.dot.gov/comm/States.htm?nocache=7867

\textsuperscript{150} California Public Utilities Commission, ‘Natural Gas and California’, [undated]. Refer to: http://www.cpuc.ca.gov/general.aspx?id=4802
and the environment. CPUC gas safety engineers are trained and qualified by the federal government.\textsuperscript{151}

Within California there are 12,388 miles of transmission pipelines, including 1,163 miles of interstate pipelines and 11,225 miles of intrastate pipelines\textsuperscript{152}. A map of the major natural gas transmission pipelines is shown in Figure 16.

The distribution network consists of 105,709 miles of mains pipelines and approximately 94,294 miles of service lines\textsuperscript{153}. Operating the distribution networks are 18 distribution operation and 12 local distribution companies.

\textbf{Figure 16: California natural gas infrastructure}

\begin{center}
\includegraphics[width=\textwidth]{Figure16.png}
\end{center}

\textit{Source: U.S. Energy Information Administration}

Customers and supply sources

The majority of California’s natural gas customers are residential and small commercial customers, with two thirds of California households using natural gas for home heating. However larger consumers, like electric generators and industrial customers account for most

\begin{itemize}
  \item \textsuperscript{151} California Public Utilities Commission, ‘Pipeline Safety’, [undated]. Refer to: \url{http://www.cpuc.ca.gov/general.aspx?id=6762}
  \item \textsuperscript{152} Based on 2016 data from the Pipeline and Hazardous Materials Safety Administration pipeline infrastructure database. Accessible via: \url{https://www.phmsa.dot.gov/pipeline/library/data-stats/pipelinemileagefacilities}
  \item \textsuperscript{153} Based on 2016 data from the Pipeline and Hazardous Materials Safety Administration pipeline infrastructure database. Accessible via: \url{https://www.phmsa.dot.gov/pipeline/library/data-stats/pipelinemileagefacilities}
\end{itemize}
of natural gas consumed. Currently about three fifths of California’s net electricity generation is fuelled by natural gas.\textsuperscript{154}

Natural gas production within the State has declined over the past three decades, resulting in most of the gas needed to meet demand needing to be piped from out-of-state gas basins via the interstate natural gas pipeline system. Major interstate pipelines that deliver out-of-state natural gas to California consumers are:\textsuperscript{155}

- the Gas Transmission Northwest Pipeline
- Kern River Pipeline
- Transwestern Pipeline
- El Paso Pipeline
- the Ruby Pipeline
- Questar Southern Trails and Mojave Pipeline

Another pipeline, the North Baja – Baja Norte Pipeline, takes gas off the El Paso Pipeline at the California/Arizona border, and delivers that gas through California into Mexico. The pipelines are shown in Figure 16.

California also has 14 natural gas storage fields that help stabilize supply. Together the gas fields have a storage capacity of about 600 billion cubic feet of natural gas and a typical working natural gas capacity of about 375 billion cubic feet.\textsuperscript{156}

\textsuperscript{154} U.S. Energy Information Administration, \textit{California State Energy Profile}, last updated 20 October 2016, access 8 June 2017.


### 6.3 Research summary

<table>
<thead>
<tr>
<th>Network description</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
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<tbody>
<tr>
<td>Area &amp; population</td>
<td>The majority of California’s natural gas customers are residential and small commercial customers, however larger consumers, like electric generators and industrial customers account for most of natural gas consumed. Two thirds of California households use natural gas for home heating and about three fifths of California’s net electricity generation if fuelled by natural gas.</td>
<td>CPUC coverage includes:</td>
</tr>
<tr>
<td>Network operators</td>
<td>Most of the gas supply comes from out-of-state gas basins and is delivered into California via the interstate natural gas pipeline system. Natural gas production within the State have declined over the past three decades. Natural gas fields are primarily located in geologic basins in the northern portion of the Central Valley.</td>
<td>– 4 million electric poles</td>
</tr>
<tr>
<td>Types of risks</td>
<td>Major interstate pipelines that deliver out-of-state neutral gas to California consumers are:</td>
<td>– Over 300,000 miles of lines including 200,000 miles of above ground lines and 77,000 miles of underground lines</td>
</tr>
<tr>
<td>Other features</td>
<td>▪ The Gas Transmission Northwest Pipeline</td>
<td>– Over 2,200 substations</td>
</tr>
<tr>
<td></td>
<td>▪ Kern River Pipeline</td>
<td>There are seven investor-owned electricity utilities operating under CPUC jurisdiction:</td>
</tr>
<tr>
<td></td>
<td>▪ Transwestern Pipeline</td>
<td>▪ Three major utilities are: Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas and Electric Company (SDG&amp;E).</td>
</tr>
<tr>
<td></td>
<td>▪ El Paso Pipeline</td>
<td>▪ Smaller utilities are: Sierra Pacific Power Company, Pacific Power &amp; Light and Bear Valley Electric Services.</td>
</tr>
<tr>
<td></td>
<td>▪ the Ruby Pipeline</td>
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</tbody>
</table>
### Regulator roles:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
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<tbody>
<tr>
<td>natural gas and a typical working natural gas capacity of about 375 billion cubic feet.</td>
<td>The Federal Energy Regulatory Commission (FERC) regulates the interstate transmission of electricity, natural gas, and oil.</td>
</tr>
<tr>
<td>▪ There are 42,290 miles of gas distribution pipelines providing services to 2,747,225 customers</td>
<td>▪ The California Public Utilities Commission (CPUC) regulates: regulates privately owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation companies, in addition to authorizing video franchises.</td>
</tr>
<tr>
<td>Regulator roles: Safety Regulator, Economic Regulator, Network regulator, Market Operator</td>
<td>– The CPUC role incorporates both economic and technical safety regulation (and enforcement) of networks</td>
</tr>
<tr>
<td></td>
<td>– The CPUC regulates natural gas rates and natural gas services, including in-state transportation over the utilities’ transmission and distribution pipeline systems, storage, procurement, metering and billing.</td>
</tr>
<tr>
<td></td>
<td>– The CPUC role includes ensuring safe, reliable utility service and infrastructure at just and reasonable rates, with environmental enhancement and a healthy economy.</td>
</tr>
<tr>
<td></td>
<td>▪ Occupational Safety &amp; Health Administration within the Department of Labor are responsible for administering the Occupational Safety and Health Act of 1970. The OSH Act covers most private sector employers and their workers, in addition to some public-sector employers and workers in the 50 states and certain territories and jurisdictions under federal authority (California is not one of those jurisdictions).</td>
</tr>
<tr>
<td></td>
<td>▪ California Energy Commission is the State’s primary energy policy and planning agency. Roles include certifications of power plants (&gt;50MW), developing the state’s energy emergency response plan and contingency programs, offering incentives for low-carbon technology and fuels, setting and updating energy efficiency standards for buildings and appliances.(^{157})</td>
</tr>
<tr>
<td></td>
<td>▪ The Federal Department of Transportation’s Pipeline and Hazardous Material Safety Administration (PHMSA) is responsible for safety standards, procedures, and development and expansion of any pipeline system.</td>
</tr>
<tr>
<td></td>
<td>▪ The US Coast Guard and the states are responsible for the planning and safety regulation of LNG terminals and their connection points onshore.</td>
</tr>
<tr>
<td>Relevant safety legislation Acts</td>
<td>California Public Utilities Code is enacted through the California Constitution. The Code sets California Public Utilities Commissions’ role as the regulator and the limits around that role for types of utilities (including both IOUs and POUs). It also includes provisions for specific named utilities.</td>
</tr>
</tbody>
</table>

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\(^{157}\) California Energy Commission, Core Responsibilities, January 2015. Available at: [http://www.energy.ca.gov/commission/fact_sheets/documents/core/CEC-Core_Responsibilities.pdf](http://www.energy.ca.gov/commission/fact_sheets/documents/core/CEC-Core_Responsibilities.pdf)
Gas
Under the Code, the California Public Utilities Commission can make General Orders to set standards, procedures, or guidelines applicable to a class of utilities, as distinguished from a decision affecting only a single utility. A list of General Orders can be found here.
- For infrastructure upgrades and maintenance, General Order (GO) 165 established minimum requirements for electric distribution facilities regarding inspection (including maximum allowable inspection cycle lengths), condition rating, scheduling and performance of corrective action, record-keeping, and reporting, to ensure safe and high-quality electric service.
- Other general orders adopted by the Commission that establish rules and standards for safe and reliable utility operations include GO 95 and GO 128.
- Natural gas operations have their own rules, including GO 112, which sets forth rules governing the design, construction, testing, operation, and maintenance of gas gathering, transmission, and distribution pipelines.

Electricity
Under the Occupational Safety and Health Act, employers are responsible for providing a safe and healthful workplace. The U.S. Occupational Health and Safety Administration’s (OSHA) mission is to assure safe and healthful workplaces by setting and enforcing standards and by providing training, outreach, education and assistance.


Electric Power Generation, Transmission and Distribution Standard, administered by the U.S. Occupational Health and Safety Administration sets out the construction standard for electric power line work.

Legislative approach (e.g. Prescriptive / outcome focussed / safety case etc.)
The California Public Utilities Code requires utilities to furnish and maintain adequate, efficient, just, reasonable service and facilities. The law specifically cites the necessity to promote “safety, health, comfort and convenience” of utility patrons, employees, and the public.
The law also authorizes the Commission to order infrastructure improvements needed to “secure adequate service and facilities”. Major investor-owned utilities – both electric and gas - submit Safety Model Assessment Proceedings (S-MAP) to the CPUC for approval. These are based on an ALARP concept for safety cost/benefit analysis.

Clarity & coordination of regulator roles
Clear roles and good coordination as California Public Utilities Commission undertakes both economic and safety regulation

---

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161 PUC Section 451, Chapter 3, Article 1, enacted by Statutes 1951, amended 1977.
<table>
<thead>
<tr>
<th>Safety approach / thresholds uses for different life risks:</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees</td>
<td>State requirements include:</td>
<td>Safety Model Assessments (based on ALARP concept)</td>
</tr>
<tr>
<td>Individual public risks</td>
<td>Natural Gas Safety Action Plan</td>
<td>Annual audit regime of required plans and procedures</td>
</tr>
<tr>
<td>Societal risks (e.g. ALARP, F-N Curve)</td>
<td>Annual audit regime of required plans and procedures</td>
<td>Incident reporting and “near miss” incident reporting</td>
</tr>
</tbody>
</table>

**Federal driven requirements:**
- Inspections during construction of new pipelines and of ongoing maintenance and operating phases including assessing emergency response safety regulations
- Numerous annual reporting obligations including on incidents, networks characteristics such as mileage and materials used

**Enforcement / compliance resourcing and policy**
- Federally there is a national pipeline inspection and enforcement program in place. The Department of Transport’s PHMSA employees around 600 employees. Of these:
  - **208 federal inspection and enforcement staff** and **345 state inspectors** are responsible for regulating nearly 3,000 companies that operate 2.7 million miles of pipelines, 148 liquefied natural gas plants, and 7,571 hazardous liquid breakout tanks.
  - PHMSA pipeline safety personnel spent 71 percent of their time conducting safety-related activities, including inspections and incident investigations on the ground, in the lab, and at the office, as well as enforcement and public outreach.
  - In 2016, PHMSA pipeline safety personnel initiated 1,175 inspections of pipeline operators. Pipeline safety personnel worked a total of 21,545 days: 10,416 days in the office and 11,129 days out of the office. These

A complete listing of gas and electric safety incidents for the year are included in the CPUC Annual Report. The report identifies the incident ID, facility owner, reason for investigation (e.g. operator judgement, interruption, injury, gas loses, media coverage, vegetation etc), facility type, a brief description of the incident, and the current status (open or closed). The information gives a rich understanding of the causes and nature of incidents across the sectors. 164

29 audits/inspections held or planned for 2015.

Incident investigations (2014) included: 165
- 182 electric facility incidents
- 2 generation incidents

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Key work streams for the Pipeline Safety Enforcement Program include:

- Corrosion enforcement
- Operator Qualification enforcement
- Gas integrity management enforcement
- Gas Distribution Pipeline Integrity Management enforcement
- Public awareness enforcement
- Hazardous liquid Integrity Management enforcement
- Operations & Maintenance enforcement

Guidance manuals are published for each with provide detailed information on the relevant code references and include examples of evidence (where appropriate).

**State-based**

- The CPUC regularly performs field and headquarter inspections and audits of practices and procedures developed by these gas utilities.
- The utilities also perform audits and report to the CPUC on an ongoing basis their practices, procedures, and progress on a variety of issues.

**Effectiveness measures used**

<table>
<thead>
<tr>
<th>Leading indicators</th>
<th>OHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagging indicators</td>
<td>Workplace fatalities</td>
</tr>
<tr>
<td>Major incidents</td>
<td>Serious non-fatal work-related injuries</td>
</tr>
</tbody>
</table>

**Compliance action reporting**

- Compliance actions taken
- Number of penalties assessed

---

<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Dollars assessed and dollars of penalties</td>
<td></td>
</tr>
<tr>
<td><strong>Probable violation reporting</strong></td>
<td></td>
</tr>
<tr>
<td>▪ Number found</td>
<td></td>
</tr>
<tr>
<td>▪ Number submitted to DOT for action</td>
<td></td>
</tr>
<tr>
<td>Number corrected during year</td>
<td></td>
</tr>
<tr>
<td>Outcomes</td>
<td>The CPUC actively investigates safety culture and management practices at regulated utilities. RASA is currently investigating this at Pacific Gas and Electric Company and PG&amp;E Corp.166</td>
</tr>
<tr>
<td>No information was identified</td>
<td></td>
</tr>
<tr>
<td>Future issues</td>
<td>Cyber security is an identified issue</td>
</tr>
<tr>
<td>SWOT analysis</td>
<td>Outcome focussed regulation using an ALARP approach</td>
</tr>
<tr>
<td>CPUC being responsible for safety and economic/market regulation provides a single expert regulator</td>
<td></td>
</tr>
<tr>
<td>CPUC run a very open process – akin to a public review being undertaken all the time</td>
<td></td>
</tr>
<tr>
<td>CPUC appear to be developing new policy material &amp; the “en Banc” and related processes appear a fast way to react</td>
<td></td>
</tr>
<tr>
<td>The State /federal split appears confusing and may result in gaps or overlaps</td>
<td></td>
</tr>
</tbody>
</table>

6.4 Other insights

6.4.1 Combined economic and technical safety regulator

The CPUC is both the economic and technical safety regulator for electricity and gas networks in California. Following the making of a RISK OIR in 2013, rate cases submitted by investor-owned utilities are required to include a Utility Risk Assessment.

Purpose of RISK OIR\(^{167}\) was to incorporate a risk-based decision-making framework into the Rate Case Plan for the energy utilities’ General Rate Cases. Two new procedures were established to feed into GRC applications in which utilities request funding for safety-related activities:

- May 2015 filing of Application in Safety Model Assessment Proceeding (S-MAP); and
- Risk Assessment Mitigation Phase (RAMP) filing into a new Order Instituting Investigation (OII) (in connection with GRC application) based on format approved in S-MAP proceeding.\(^ {168}\)

6.4.2 En Banc hearings for emerging issues

CPUC uses En Banc hearing as a rapid consultation and workshop process that involves other government agencies as well as interested stakeholders.

The term ‘En Banc’ (French for “in bench”) is commonly used in law to mean a session in which a case is heard before a panel of judges. An ‘En Banc’ review is often used for usually complex cases or cases considered to be of greater importance.

Each En Banc hearing will assemble a diverse panel of experts to consider these and related issues. An agenda and a staff issue paper will be available before the En Banc hearing.

The CPUC Safety En Banc’s consider emerging issues – for example where regulator coverage or responsibilities are unclear – or for more complex matters.

In 2016, En Banc’s have included\(^ {169}\):

- **En Banc on utility pole safety** (28 April 2016) held in response to the rising number of blackouts and wildfires associated with utility poles.

- **Safety En Banc on Interconnected Infrastructure** (19 October 2016) focussed on the nature of interconnected critical infrastructure (gas, electric, communications, transportation, and water) and the risk that a disruption in one infrastructure may have cascading adverse effects on others.

Other work streams related to utility poles and fire risks include:

- A current review of the status of databases and database applications in California regarding pole and conduit information; including location, attachments, material, ownership, and management, as well as the implications of such data management for

\(^{167}\) Risk OIR, R.13-11-006, Order Instituting Rulemaking to Develop a Risk-Based Decision-Making Framework to Evaluate Safety and Reliability Improvements and Revise the Rate Case Plan for Energy Utilities


safety and access. Refer to the Pole and Conduit Database Application webpage for further details.

- Information about historical safety incidents either exasperated or sparked by utility pole failures contained in Mulqueen, A., Zarfar, M., A Brief Introduction to Utilities Poles, report prepared for the California Public Utilities Commission, 31 July 2014.\(^{170}\)

7. Texas

7.1 Overview of the electricity

As highlighted in Chapter 4 (on California) the US electricity transmission networks are interconnected to form three main interconnected systems that operate largely independently from one another.

The Electric Reliability Council of Texas (ERCOT) covers most of Texas. It is not linked to either of the other interconnections, except via certain direct current lines, and instead links with parts of Mexico.

ERCOT is unique in that it fulfils multiple roles as the balancing authority, interconnection, and the regional transmission organization.\(^ {171}\) According to the ISO/RTO Council, ERCOT’s region includes more than 46,500 miles of transmission lines, more than 550 generating units, and serves electricity to a population of 24 million.\(^ {172}\)

The Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil.\(^ {173}\) One of the FERC’s statutory responsibilities is to ensure that rates, terms and conditions for wholesale sales and transmission of electric energy are just, reasonable and not unduly discriminatory or preferential. Importantly FERC has a limited role in networks that operate entirely within one state.

Within Texas, there are three types of transmission and distribution utilities (TDUs):

- **Investor owned utilities** (IOUs) cover approximately 85% of the population in Texas, and the retail electricity market within their service areas has been opened to competition. The Public Utility Commission of Texas regulates the rates and services offered by the five Investor owned utilities in Texas:
  - AEP Texas
  - CenterPoint Energy
  - Oncor
  - Sharyland Utilities
  - Texas New Mexico Power
  - Exel Energy\(^ {174}\)

- **Municipal utilities** are owned and operated by the cities they serve. They are not directly owned by the inhabitants of the area, but the members of the council can be elected by the inhabitants. Most municipal utilities (although not all) haven't been subjected to deregulation laws, therefore consumers in these areas usually cannot choose their retail energy provider.\(^ {175}\)

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\(^{171}\) [https://www.eia.gov/energyexplained/index.cfm?page=electricity_delivery](https://www.eia.gov/energyexplained/index.cfm?page=electricity_delivery)

\(^{172}\) [http://www.isorto.org/About/Members/ERCOT](http://www.isorto.org/About/Members/ERCOT)

\(^{173}\) [https://www.ferc.gov/about/ferc-does.asp](https://www.ferc.gov/about/ferc-does.asp)


A utility cooperative is a not-for-profit company owned by its customers. Co-ops were not included in the energy deregulation laws since they are already considered as a democratic system of power and gas supply. This system tends to exist in rural areas with low population density - in bigger cities, where population density is greater, the complexity of the system would be difficult to handle by this type of structure.\textsuperscript{176}

There are approximately 118 Municipal Utilities and Utility Cooperatives in Texas.\textsuperscript{177} Like the situation in California, the rates and services policies for these networks are set by the local entities and not regulated by the state utility commission.

Figure 17: Electric infrastructure overview, Texas

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{electric_infrastructure_overview_texas.png}
\caption{Electric infrastructure overview, Texas}
\label{fig:electric_infrastructure_overview_texas}
\end{figure}

\textit{Source: U.S. Department of Energy, State of Texas Energy Sector Risk Profile, p. 2}\textsuperscript{178}

7.2 Overview of the gas sector

In the U.S. the Federal Energy Regulatory Commission (FERC) regulates the interstate natural gas transmission network. Another federal agency, the Department of Transportation’s Pipeline and Hazardous Materials Safety Administration (PHMSA) is responsible for safety standards, procedures, and development and expansion of any pipeline system (both interstate and intrastate).

\textsuperscript{176} Call Me Power, ‘Utilities Companies in Texas’, last updated 11/12/2014, \url{http://callmepower.com/tx/utility}

\textsuperscript{177} Call Me Power, ‘Utilities Companies in Texas’, last updated 11/12/2014, \url{http://callmepower.com/tx/utility}

\textsuperscript{178} \url{https://energy.gov/oe/mission/energy-infrastructure-modeling-analysis/state-and-regional-energy-risk-assessment-initiative}
Within Texas, the Railroad Commission of Texas (RRC) regulates intrastate natural gas pipelines. These regulatory powers differ between investor-owned utilities and municipally owned utilities. The RRC has jurisdiction over the rates, operations and services of investor owned gas utilities\textsuperscript{179}. In contrast, there is no similar authority provided for where the utility is municipally-owned and the services are being provided within the municipality’s boundaries.\textsuperscript{180}

Regardless of the ownership structure, the Railroad Commission of Texas is the relevant State-based pipeline safety regulator.

There are currently 114 local distribution companies in Texas. Of these:

- 30 are investor-owned and
- 84 are municipally-owned.

Investor-owned distribution utilities currently provide natural gas services to most customers - approximately 4.3 million connections or 89.9\% of the customer base.

The municipally owned utilities provide services for the remaining 10.2\% of customers (488,300 connections). The largest of which is CPS Energy with 338,700 customers.\textsuperscript{181}

\textbf{Figure 18: Natural gas infrastructure overview, Texas}

\begin{center}
\includegraphics[width=\textwidth]{natural_gas_overview.png}
\end{center}

\textit{Source: U.S. Department of Energy, State of Texas Energy Sector Risk Profile, p. 6\textsuperscript{182}}

\begin{itemize}
\item \textsuperscript{179} http://www.rrc.state.tx.us/about-us/resource-center/faqs/gas-services-faqs/faq-natural-gas-prices/
\item \textsuperscript{180} http://www.rrc.state.tx.us/about-us/resource-center/faqs/gas-services-faqs/faq-texas-natural-gas-rates/
\item \textsuperscript{181} http://www.rrc.state.tx.us/media/38358/industry-statistics-at-a-glance.pdf
\item \textsuperscript{182} https://energy.gov/oe/mission/energy-infrastructure-modeling-analysis/state-and-regional-energy-risk-assessment-initiative
\end{itemize}
### Research summary

<table>
<thead>
<tr>
<th>Network description</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area &amp; population</strong></td>
<td>The gas transmission network is the most extensive in the US. It consists of an estimate 45,219 miles of pipelines including 13,413 miles (interstate), 31,807 miles (intrastate), 37 natural gas storage fields (22 reservoirs and 18 salt caverns)</td>
<td>The transmission network consists of approximately 41,843 km (26,000 miles) of networks and 2,200 substations</td>
</tr>
<tr>
<td><strong>Network operators</strong></td>
<td>The distribution pipeline network consists of approximately 102,039 miles of mains, 45,951 miles of service lines and 183 miles of master meter systems</td>
<td>Electric Reliability Council of Texas (ERCOT) covers most of Texas ERCOT is unique in that it is the balancing authority, interconnection, and the regional transmission organization are all the same entity and physical system.</td>
</tr>
<tr>
<td><strong>Other features</strong></td>
<td>Of the investor owned utilities, Atoms Energy Mid-Texas Division is the largest with 1.6 million customers, CenterPoint Energy Entex has 1.6 million, Texas gas services Company has 629,822.</td>
<td>There are three other transmission network operators within the state Electric Transmission Texas (joint venture between AEP and Berkshire Hathaway), AEP Texas (part of AEP), SWEPCO.</td>
</tr>
<tr>
<td></td>
<td>There are an estimated 4.84 million gas customers in Texas, of these:</td>
<td>Six investor owned utilities are regulated by the Public Utilities Commission of Texas cover 85% of the State (AEP Texas, CenterPoint Energy, Oncor, Sharyland Utilities, TNMP, and Exel Energy)</td>
</tr>
<tr>
<td></td>
<td>- 4.3 million are supplied by investor owned distribution utilities and 488,258 are supplied by municipally-owned utilities</td>
<td>118 Municipal Utilities and Utility Cooperatives services their local populations. Rates and services are not overseen by a regulator.</td>
</tr>
<tr>
<td></td>
<td>- The numbers of customers by type are: Residential 4.2 million, Small Commercial &amp; Industrial 290,356, Large Com &amp; Industrial 795, Other 350,602</td>
<td>Population: 26.45 million, housing units: 10.26 million, businesses: 0.54 million</td>
</tr>
</tbody>
</table>

| Regulator roles: | The **Railroad Commission of Texas** (the RRC) regulates intrastate natural gas transmission and requires gas utilities to file their rates with the Commission. The Pipeline Safety department within the RRC ensures that the pipelines in Texas’ pipeline infrastructure are designed, constructed, operated and maintained safely. | The **Public Utility Commission of Texas** is the state agency that regulates electric, telephone and water utilities for the state of Texas. Its mission is to protect customers, foster competition and promote high quality infrastructure. In other words, the PUC writes and enforces the rules by which utilities abide. |
| Safety Regulator | | |
| Economic Regulator | | |
| Network regulator | | |
| Market Operator | | |

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184 A master metered system is a pipeline system, other than one designated as a local distribution system, for distributing natural gas ...where the operator purchases metered gas from an outside source for resale through a gas distribution pipeline system. [http://www.rrc.state.tx.us/pipeline-safety/reports/texas-pipeline-system-mileage/](http://www.rrc.state.tx.us/pipeline-safety/reports/texas-pipeline-system-mileage/)

185 [http://www.rrc.state.tx.us/media/38358/industry-statistics-at-a-glance.pdf](http://www.rrc.state.tx.us/media/38358/industry-statistics-at-a-glance.pdf)

<table>
<thead>
<tr>
<th><strong>Gas</strong></th>
<th><strong>Electricity</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The Pipeline Safety department is delegated to enforces compliance by intrastate pipeline operators with federal and state laws and regulations and promotes public safety.</td>
<td>▪ The <strong>Electric Reliability Council of Texas (ERCOT)</strong> manages the flow of electric power to 22 million Texas customers. This represents 85 percent of the state’s electric load and 75 percent of the Texas land area. ERCOT is the independent system operator (ISO) for the region. The Texas Reliability Entity, Inc. (Texas RE) is delegated by the North American Electric Reliability Corporation (NERC) to develop, monitor, assess, and enforce compliance with NERC Reliability Standards within the geographic boundaries of the ERCOT region. In addition, Texas RE is authorized by the Public Utility Commission of Texas (PUC) and by NERC to investigate compliance with the ERCOT Protocols and Operating Guides, working with PUC staff regarding any potential protocol violations. Other agencies include: ▪ State Energy Conservation Office - <a href="http://seco.cpa.state.tx.us/">http://seco.cpa.state.tx.us/</a> ▪ Office of Public Utility Counsel - <a href="http://www.opuc.texas.gov/">http://www.opuc.texas.gov/</a></td>
</tr>
</tbody>
</table>

**Relevant safety legislation**

**Acts**

**Regulations**

**Codes etc.**

▪ The **Utilities Code** is a Texan statute under the Texan Constitution. The Code sets the roles of the regulators of utilities industries and general provisions for regulation and service delivery of electric and gas utilities. Relevant Titles, Subtitles, and Chapters are as follows:
  - Title 2. Public Utility Regulatory Act including Subtitle A. Provisions Applicable to All Utilities; and Subtitle B. Electric Utilities
  - Title 3. Gas Regulation including Subtitle A. Gas Utility Regulatory Act, and Subtitle B. Regulation of Transportation and Use
  - Title 4. Delivery of Utility Services including Subtitle A. Utility Corporation and other Providers, and Subtitle B. Provisions and Regulating Delivery of Services

▪ The **Texan Administrative Code** is a compilation of all state agency rules in Texas. [Title 16: Economic Regulation](http://www.sos.state.tx.us/tac/index.shtml) provides the complied rules and regulations developed by the RRC and the PUC.\(^\text{187}\)

**Part 1. Railroad Commission of Texas**

  - Chapter 8 - Pipeline Safety Regulations
  - Chapter 18 - Underground Pipeline Damage Prevention
  - Chapter 2 - Informal Complaint Procedures

### Gas

- Chapter 7 - Gas Services Division
- Part 2. Public Utility Commission of Texas

### Electricity

- Chapter 25 - Substantive Rules Applicable to Electric Service Providers

#### The Texas Electrical Safety and Licensing Act

The **Texas Electrical Safety and Licensing Act** under the Occupations Code statute requires the Texas Department of Licensing and Regulation (TDLR) to adopt the revised National Electrical Safety Code (NESC) as the electrical code that establishes the “minimum standard” for all electrical work in Texas. The NESC is revised every 5 years to keep the Code up-to-date with changes in the industry and technology. It is not a federal law, rather it is adopted individually by states and municipalities. The Code is published exclusively by IEEE.

Note: Texas is not a "state-plan" state; that is, it does not have its own occupational safety and health regulatory program. The federal rules govern workplace safety and health in private sector workplaces (private businesses and non-profit organizations).

The **Health and Safety Code** is also a Texan Statute under the Texan Constitution. Title 9. Safety includes Subtitles Public Safety and Emergencies.

US Pipeline safety statues allow States to assume safety authority over intrastate gas pipelines through Certification and Agreements with the PHMSA. To participate States must adopt minimum standards: **Title 49: Transportation Code, Subtitle B Ch1 SubChapter D**

**Legislative approach**
(e.g. Prescriptive / outcome focussed / safety case etc.)

- Highlly prescriptive.
- Proactive approach to enforcement (albeit subject to resource availability – some penalties appear to have been issued number of years after the infringement or period of infringemen has ended). Frequent penalties – but relatively small amounts. Information on penalties issued available and easily accessible online here.
- Very prescriptive. Well supported by active enforcement via audits and incident investigations.
- Relatively high number of penalties given for infringement for a range of issues including many minor non-incident related activities. Refer to the list in Appendix 1 and to: [http://www.rrc.state.tx.us/pipeline-safety/enforcement/](http://www.rrc.state.tx.us/pipeline-safety/enforcement/)

#### Clarity & coordination of regulator roles

- No information was identified on this topic

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188 [https://www.tdlr.texas.gov/electricians/elec.htm](https://www.tdlr.texas.gov/electricians/elec.htm)
189 [http://standards.ieee.org/about/nesc/](http://standards.ieee.org/about/nesc/)
<table>
<thead>
<tr>
<th>(e.g. Does economic regulator create barriers for safety)</th>
<th></th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enforcement / compliance resourcing and policy</strong></td>
<td></td>
<td>Appears to be limited data on enforcement</td>
</tr>
<tr>
<td><strong>Texan enforcement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Pipeline Safety department with the Railroad Commission of Texas works to enforce compliance with federal and state laws and regulations by pipeline operators.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Staff located across seven regional offices throughout the state.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Pipeline Safety conducts approximately 2,850 inspections per year using a risk-based evaluation model as well as specialized inspections.(^{190})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additionally, staff investigates accidents and complaints involving pipeline facilities.(^{191})</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Effectiveness measures used</strong></td>
<td></td>
<td>Appears to be limited data on enforcement</td>
</tr>
<tr>
<td>Leading indicators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Pipeline operators must report incidents or accidents on intrastate gas systems involving:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– a fatality or injuries;</td>
<td></td>
<td></td>
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<tr>
<td>– $50,000 property damage; and</td>
<td></td>
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<tr>
<td>– gas loss of three million cubic feet or more, or that the operator judges significant.</td>
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<td></td>
</tr>
<tr>
<td>Operators must make the report by telephone within two hours and must file the written report within thirty (30) days.</td>
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<td></td>
</tr>
<tr>
<td>▪ All underground pipeline damages must be reported by the pipeline operator and the excavator involved. The report should be filed through the Commission’s online reporting system.(^{192})</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Outcomes</strong></td>
<td></td>
<td>No information was identified on this topic</td>
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<tr>
<td>Worker safety culture</td>
<td>Worker safety culture appears based on compliance</td>
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</table>


### Community consultation

<table>
<thead>
<tr>
<th>Gas</th>
<th>Electricity</th>
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<tr>
<td>No information was identified on this topic</td>
<td>No information was identified on this topic</td>
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### Future issues

#### Anticipated future issues

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<tr>
<th>Gas</th>
<th>Electricity</th>
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<tr>
<td>No information was identified on this topic</td>
<td>No information was identified on this topic</td>
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### SWOT analysis

#### Summary SWOT analysis

| Strengths | There is lack of information on electricity network safety in Texas. |
| Weakness | Prescriptive legislation will require the regulator to identify new issues and the solution. |
| Opportunity | The gas market is unique as it appears to have many small suppliers. |
| Threats | Uses a prescriptive approach and compliance is based on a large number of small penalty notices |

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*Draft Report*  
*Best practice electricity and gas networks safety frameworks*
8. Observations on comparison of jurisdictions

8.1 Common themes identified

Regulatory approach
All the jurisdictions except Texas gas regulation use an outcome focussed approach to regulation of safety for energy networks.

The prescriptive approach to regulation of gas in Texas may be reflective of the large number of small operators in the area (analogous to small prospecting in remote areas of Australia).

All other jurisdictions use a Safety Management System and through this process energy network managers are required to identify and manage all relevant risks. Ensuring that Safety Management Systems are a true reflection of the all the risks requires a high level of knowledge and experience in the network utility – and in the regulator too. If this does not occur it is likely that some risks will be overlooked by both the utility and the regulator and they would not be identified until the risks manifest themselves (or “bite”).

Inspections and enforcement
There are mix of inspection and enforcement processes adopted by the jurisdictions. Inspections are usually undertaken primarily by the network operators – either by requirement through regulations or as a reflection of good safety management practices (often outlined in operational processes and plans). The regulators all have the right to undertake inspections, however the exercise of these rights varies between jurisdictions:

- Regulators in Texas (for gas) and California (all networks) undertake inspections as part of regulator audit processes as well as in response to incidents.
- Available information for the UK and New Zealand suggests proactive inspection by regulators is less frequent, the onus being on the network operators to report results from inspections with the regulator reviewing those reports.
- Limited evidence of inspections by regulators was uncovered for Spain, however, as each of the autonomous communities has regulatory authorities with responsibilities for activities carried out in their territory, lack of data is potentially a reflection of a division of roles rather than an indication inspections are not occurring. It is noted that a number of the network operators in Spain are multi-national enterprises that own and operate networks in other Countries. Some companies appear to have adopted international based reporting and likely adopt a standard approach across jurisdictions that may be above the regulator requirements for any individual country they operate in.

Reported incidents are investigated in all jurisdictions with regulators using a combination of in-house and external resources. The jurisdictions with higher emphasis on proactive inspections (Texas and California) appear to undertake more of these activities internally.

The differences in enforcement and issuance of penalties or prosecutions is most apparent in a comparison of California outcome-focussed regulation of natural gas and Texan prescriptive based regulation of natural gas. Californian prosecutions tend to be infrequent with penalty values tending to be very high, in contrast Texas has a higher number of prosecutions with the average penalty being lower. Further detail comparing Californian and Texan penalties is provided in Appendix 1.
Treatment of individual and societal risks

The details of the outcome focussed approach varies from one jurisdiction to another but all rely on a duty of care and either a Safety Management System or a Safety Case.

- All jurisdictions (excluding Texas that rely on duty of care) appear to consider both individual and societal risks for gas pipelines.
- The consideration of societal risks for electricity networks appears to be relatively undeveloped in all jurisdictions.

Public reporting of safety performance

There does not appear to be a common approach to reporting on safety performance. Various regulators publicise data on incidents, and prosecutions.

The objective of publicising prosecutions appears to be a deterrent to “poor behaviour” by utility managers. In contrast, publication of basic incidents data is to ensure transparency.

Good practice in safety regulation appears to be to share information on past incidents as a learning opportunity for other regulated entities. While this practice was not identified in the international jurisdictions – it used in Australian safety regulators, particularly in mining and resource safety.

A significant level of detail on the nature of prosecutions, penalties and incidents is made publicly available in the US jurisdictions. Less detailed information was available or able to be found for the other jurisdictions. In the UK, publicly available data appeared included prosecutions and numbers of incidents however causes of incidents that would enable shared learnings specific to energy networks was not uncovered through the course of this project. We note it is possible a subscription based approach to release of this type information is adopted such as mentioned occurs in Australia by mine safety regulators.

Emergent risks

Each jurisdiction has different perceptions of new and emergent risks. As each regulator is likely to focus on the key risk in their area, there is to opportunity to share knowledge between jurisdictions.

In the US, where federal and state based reporting systems are more developed, the focus has shifted, consistent with a wider societal focus, to high impact, low frequency safety risks resulting from cyber-attacks, for example. Other jurisdictions appear to be still working to develop smarter, more accessible and updated databases on infrastructure types and then addressing the risks (via programs and incentives) that access this type of data affords regulators.

It is noted that both Spain and the UK can benefit and /or influence the European Commission’s work on energy safety. The requirement to report on regulatory developments each year and to progress country policies in line with EU Directives, which tend to focus on intercountry risks, has possibly resulted in a heavier focus on gas and associated pipeline safety and nuclear safety over electricity networks.

Limited information uncovered on risks from distributed generation uptake

Finally, limited evidence or data on safety issues arising from increased renewable or distributed generation has been uncovered. The primary concerns with increased distributed generation, in particular, is the increasing difficulty presented by this form of generation in managing system
reliability (i.e. balancing supply and demand to avoid outages). Some incident reporting has been uncovered, particularly from fire departments as the first respondents, in relation to solar panels and battery storage, however the damage from these incidents tend to be localised and therefore not extend beyond the meter to the wider networks.
### 8.2 Summary of key agencies

A summary of the key agencies and their role in each jurisdiction is set out in the following table.

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<tr>
<th>Jurisdiction</th>
<th>Agency</th>
<th>Role</th>
<th>Sector(s)</th>
<th>Primary focus area(s)</th>
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</table>
| New Zealand  | WorkSafe New Zealand        | WorkSafe New Zealand is the work health and safety regulator. Primary responsibilities are set out in the Health and Safety at Work Act (HSWA). Within WorkSafe, the Energy Safety division is the regulator for ensuring the safe supply and use of electricity and gas in New Zealand. WorkSafe is responsible for the administration and development of parts of the Gas Act 1992, and for regulations and Codes of Practice relating to safety, quality and measurement of gas. Energy Safety are responsible for:  
  - safeguarding people and property from the dangers of gas and electricity  
  - the safety of gas and electrical appliances and installations  
  - the safety of gas supply & electricity supply, and transmission generating systems  
  - the quality and measurement of gas and electricity. | Healthcare, OHS regulator, administration of selected electricity and gas regulations related to work safety. |                                                                                                   |
|              | Electricity Authority       | The Electricity Authority is the regulator of the electricity industry tasked with governing the electricity market under the Electricity Industry Act 2010. The Act also authorises the making of regulations and the Electricity Industry Participation Code 2010. The Electricity Authority develop, administer and enforce the market rules that govern nearly every aspect of New Zealand’s electricity industry including generation, transmission, system operation, security of supply, market arrangements, metering, distribution and retail. They also contract service providers to operate the electricity market and system, analyse and monitor the performance of the market and the electricity industry and make the information available on the Electricity Market Information (EMI) website.  
  The Electricity Authority’s statutory objective is to promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers.  
  The Electricity Authority is an Independent Crown Entity. The Cabinet Minister responsible for the Electricity Authority is the Minister of energy and Resources. The Ministry of Business, Innovation and Employment (MBIE) monitors the Authority on behalf of the Minister, carrying out the role set out in section 27A of the Crown Entities Act.  
  Board members are appointed by nomination, in their official capacity however do not represent the interest of any participation group and act independently.  
  The Authority is funded through appropriation approved by Parliament each financial year, with the government being reimbursed for the cost of funding the Authority appropriations through a levy on | Economic regulator                                                                                                           |
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|              | The Gas Industry Company  
http://gasindustry.co.nz/ | The **Gas Industry Company** is a gas sector regulatory body, established under Part 4A of the Gas Act 1992, following the request by gas industry participants for industry self-regulation. The Company’s role as the industry body and co-regulator is to:  
- the operation of gas markets, access to infrastructure, and consumer outcomes;  
- ensure that gas is delivered in a safe, efficient, reliable, fair and sustainable manner; and  
- Oversee compliance with, and review such arrangements.  
Under the **Gas Act 1992**, the Gas Industry Co reports to the Minister of Energy and Resources on a range of matters. The Gas Industry Co is a limited liability company registered under the **Companies Act 1993** and is owned by industry participant shareholders. There are currently 13 shareholders and any industry participant is entitled to become a shareholder on application and payment of a $1 fee. Each shareholder holds a $1 share which is redeemable at the option of the shareholder.  
The Board comprises seven Director, four of whom are independent and three are associated with industry stakeholders (usually senior executives of industry participants).  
The Gas Industry Company has **three sources of funding**:  
- The Gas Act provides for a levy on industry participants with the levy covering the cost of policy work and market administration, excluding external server providers and some consultants  
- Market Fees levied under section 43S of the **Gas Act** provides for industry governance regulation or rules to be funded by industry participants.  
- Shareholders are required to pay an annual fee to the Company. The fee is $2,000 (plus GST) per shareholder in 2017. | Economic and technical safety regulator |
|              | Ministry of Business, Innovation and Employment  
http://www.mbie.govt.nz/ | The Ministry of Business, Innovation and Employment (MBIE) has primary responsibility for advising the Minister (and the Government) on energy policy and an ongoing role in policy development and maintenance of the legislation to ensure it remains fit for purpose. Monitors both the electricity and gas markets and oversees the regulators.  
|              | Ministry of Civil Defence & Emergency Management (CDEM)  
http://www.civildefence.govt.nz/ | Assigned a leadership role in reducing risks, being ready for, responding to and recovering from emergencies. New Zealand is vulnerable to a number of natural disaster type risks as well as risks driven by human or technology error. Risks include: Geographical events (earthquakes, volcano, tsunami), | Emergency planning and management |
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<tr>
<td>United Kingdom</td>
<td>Office of Gas and Electricity Markets (Ofgem) [<a href="https://www.ofgem.gov.uk/">https://www.ofgem.gov.uk/</a>]</td>
<td>The <strong>Office of Gas and Electricity Markets</strong> (Ofgem) regulates the gas and electricity networks and the competitive markets in gas and electricity supply and retail. The protection of consumer interests lies at the heart of the regulator’s role, including those interests in reducing greenhouse gas emissions and security of supply. The regulator is independent from the government, accountable instead to Parliament, to separate regulatory decisions from political control and so provide greater long-term regulatory certainty and to encourage market entry and investment. Ofgem is a non-ministerial department. Ofgem is funded by a licence fee levied on the energy industry. Fines imposed on industry by Ofgem are not used to fund Ofgem, but rather are paid directly to Treasury.</td>
<td>Economic regulator, electricity and gas licence requirements, oversight of various energy utility Codes (but not enforcement)</td>
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<td></td>
<td>The Health and Safety Executive [<a href="http://www.hse.gov.uk/index.htm">http://www.hse.gov.uk/index.htm</a>]</td>
<td>The <strong>Health and Safety Executive</strong> (HSE) is the independent national regulator for work-related health and safety in Great Britain. It has statutory responsibility for making sure there is adequate health and safety regulation across most industry sectors, including the UK nuclear industry. In electricity, the HSE administers the <strong>Electricity at Work Regulations 1989</strong>. HSE is an executive non-departmental public body, sponsored by the Department for Work and Pensions. Income generated by HSE including money from fees and licensing contribute to the agency’s annual budget, with the Department contributing to cover shortfalls. The Board of the HSE is comprised of three layers – the HSE Board (members appointed following consultation), the Management Board (comprising the most senior executives in HSE), and the Extended Management Board (including divisional directors from the HSE).</td>
<td>OHS regulator, administration of selected electricity and gas regulations related to work safety.</td>
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<td>Department for Business, Energy &amp; Industrial Strategy [<a href="https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy">https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy</a>]</td>
<td>The <strong>Department for Business, Energy &amp; Industrial Strategy</strong> (previously the Department of Energy &amp; Climate Change) works to make sure the UK has secure, clean, affordable energy supplies and promote international action to mitigate climate change. The department brings together responsibilities for business, industrial strategy, science, innovation, energy, and climate change. The BEIS is a ministerial department, supported by 46 agencies and public bodies.</td>
<td>Climate change and environmental policy. Licensing and some involvement in licence conditions. Prosecutions.</td>
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<td></td>
<td>Oil and Gas Authority [<a href="https://www.ogauthority.co.uk/">https://www.ogauthority.co.uk/</a>]</td>
<td>An independent Government Company as of 2016, the <strong>Oil and Gas Authority</strong>’s role is to regulate, influence and promote the UK oil and gas industry in order to maximise the economic recovery of the UK’s oil and gas resources.</td>
<td>Monitoring of offshore oil and gas industry and natural gas licensing.</td>
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<tr>
<td>Jurisdiction</td>
<td>Agency</td>
<td>Role</td>
<td>Sector(s)</td>
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<tr>
<td>Spain</td>
<td>National Commission of Markets and Competition (Comisión Nacional de los Mercados y la Competencia)</td>
<td>The <strong>National Commission of Markets and Competition</strong> (CNMC) is an independent organisation that ensures fair competition and regulates markets and all productive sectors of the Spanish economy in order to protect consumers. The CNMC performs the role of the National Energy Regulator, responsible for overseeing all economic aspects of the energy markets, as well as some technical management of the system, including licencing. Formed in October 2013, the CNMC is the result of a merger of the previous antitrust authority with six regulatory agencies (responsible for telecom and audiovisual, electricity and natural gas markets, postal sector, airport and certain aspects of the railway sector). The main objective of the CNMC is to guarantee, preserve and promote the proper functioning, transparency and existence of effective competition in all markets and productive sectors, to the benefit of consumers and users. The CNMC is a public entity with its own autonomous legal status. It is independent from Spain’s ventral government but is subject to parliamentary control. The CNMC exercises its functions through two governing bodies: the Council and the President, which is also its Council. The Council is composed of ten members appointed by the Government, at the proposal of the Minister of Economy and Competitiveness, among persons of recognized prestige and professional competence within the scope of the Commission.</td>
<td>Economic regulator and system operator</td>
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<td></td>
<td>Ministry of Industry, Energy and Tourism (Ministerio de Industria, Energía y Turismo)</td>
<td>The <strong>Ministry of Industry, Energy and Tourism</strong> is responsible for setting Spanish energy policy and its implementation, including the development of regulatory proposals and, among other things, approvals of tariff structures, energy product prices, network access tolls and electricity charges in accordance with current legislation. The government sets the tariffs for network access on the basis of the CNMC methodology. It also approves the CNMC methodology for calculating the charges of the electricity system and sets the level of these charges. System charges are used to cover system costs (including the remuneration for renewable generation).</td>
<td>Policy and oversight of economic regulator roles</td>
<td></td>
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<tr>
<td>Jurisdiction</td>
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<tr>
<td>Ministry of Agriculture, Food and Environment (Ministerio de Agricultura, Alimentación y Medio Ambiente)</td>
<td>The Ministry of Agriculture, Food and Environment is responsible for proposing and implementing government policy in relation to climate change and environmental protection (among other things), without prejudice to the role of regional bodies which have related duties in their corresponding regions.</td>
<td>Climate change and environmental policy</td>
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<tr>
<td>Other</td>
<td>Each of the autonomous communities has regulatory authorities with responsibilities for electricity activities carried out in their territory, typically regional departments for industry or energy.</td>
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<tr>
<td>National Institute for Safety and Health at Work (Instituto Nacional de Seguridad e Higiene en el Trabajo)</td>
<td>The National Institute for Safety and Health at Work is the main body concerned with occupational safety and health (OSH) The autonomous regions have certain competencies in OSH matters that are carried out by the regional labour authorities and the regional OSH centres or institutes. Resides within the Ministry of Employment and Social Security (Ministerio de Empleo y Seguridad Social).</td>
<td>Worker safety regulator</td>
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<tr>
<td>U.S. Federal Agencies</td>
<td>Federal Energy Regulatory Commission (FERC)</td>
<td>The Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of electricity, natural gas and oil. A primary function of FERC is to “assist consumers in obtaining reliable, efficient and sustainable energy services at a reasonable cost through appropriate regulatory and market means”. One of the FERC’s fundamental statutory responsibilities is to ensure that rates, terms and conditions for wholesale sales and transmission of electric energy are just and reasonable and not unduly discriminatory or preferential. The FERC is also responsible for the regulation of the interstate gas industry, including LNG import terminals. Note: The Constitution allows federal regulation of utilities only where interstate commerce is involved.</td>
<td>Policy and planning. Economic regulator for interstate networks (but not intrastate networks).</td>
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<td>The Office of Energy Infrastructure Security provides expertise and assistance to FERC to identify, communicate and seek solutions to potential risks to FERC-jurisdictional energy facilities from cyber-attacks and physical threats such as electromagnetic pulses, including voluntary efforts beyond Reliability Standard compliance.</td>
<td>Investigation and strategic oversight of high impact, low frequency events safety risks</td>
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<td>The Department of Transportation’s Pipeline and Hazardous Materials Safety Administration (PHMSA) ensures the safe transportation of natural gas, petroleum, and other hazardous materials by pipeline. The PHMSA is also the default regulator for safety matters. States are able to participate in their own state based pipeline safety program and receive up to 80% of funding to undertake duties each year from the Federal government. To participate in the pipeline safety program States must adopt the minimum pipeline safety regulations; however, States may pass more stringent regulations for pipeline safety through their State Legislatures. If States did not participate in the pipeline safety program, intrastate pipeline facilities would be PHMSA’s responsibility. Both California and Texas has developed and assumed responsibility for their own State based programs.</td>
<td>Technical safety standards development, monitoring and enforcement. Sets minimum standards. Primary regulator for interstate pipelines and intrastate pipelines in the absence of a State safety program.</td>
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<td>Jurisdiction</td>
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<td>Occupational Safety &amp; Health Administration within the Department of Labor</td>
<td>Responsible for administering the <em>Occupational Safety and Health Act of 1970</em>. The OSH Act covers most private sector employers and their workers, in addition to some public sector employers and workers in the 50 states and certain territories and jurisdictions under federal authority (California is not one of those jurisdictions but Texas is). California has developed its own State Plan. This has been reviewed as adopting safety and health standards which are at least as effective as Federal OSHA standards. It includes a number of additional / unique provisions the State has adopted.</td>
<td>OHS regulator, development of selected electricity and gas regulations related to work safety. (Primary role is setting minimum standards)</td>
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<tr>
<td>U.S. Department of Energy, Electricity delivery &amp; energy reliability</td>
<td>The Office of Electricity Delivery and Energy Reliability (OE) provides national leadership to ensure that the Nation’s energy delivery system is secure, resilient and reliable. OE works to develop new technologies to improve the infrastructure that brings electricity into our homes, offices, and factories, and the federal and state electricity policies and programs that shape electricity system planning and market operations. OE also works to bolster the resiliency of the electric grid and assists with restoration when major energy supply interruptions occur.</td>
<td>Research, policy, development of national level strategies</td>
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| California | California Public Utilities Commission (CPUC) [http://www.cpuc.ca.gov/](http://www.cpuc.ca.gov/) | The **California Public Utilities Commission** (CPUC) regulates privately owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation companies. The CPUC serves the public interest by protecting consumers and ensuring the provision of safe, reliable utility service and infrastructure at just and reasonable rates, with a commitment to environmental enhancement and a healthy California economy. The CPUC was established by Constitutional Amendment with it’s role outlined in the Public Utilities Act. The Governor of California appoints five Commissioners for six year terms to the CPUC, including designating one as president. The CPUC meets publicly to carry out the business of the agency, which may include the adoption of utility rate changes, rules on safety and service standards, implementation of conservation programs, investigation into unlawful or anticompetitive practices by regulated utilities and intervention into federal proceedings which affect California ratepayers. The role of two of relevant divisions within the CPUC are:  
- The Energy Division, which assists Commission activities in the electricity, natural gas, steam, and petroleum pipeline industries with administration of legal matters, court proceeding, and regulation of investor owned utilities in the State. This division focuses primarily on economic and legal matters.  
- The Safety and Enforcement Division has safety oversight of a range of industries. Its role is to ensure that regulated services are delivered in a safe, reliable manner. This division has investigative and enforcement roles to ensure consumers’ rights are protected in transactions with regulated utilities. CPUC employs 1,000 including judges, engineers, analysts, lawyers, auditors, and support. | Economic, legal, technical safety compliance, monitoring and enforcement |
<p>| California | California Energy Commission <a href="http://www.energy.ca.gov/">http://www.energy.ca.gov/</a> | The <strong>California Energy Commission</strong> is the State’s primary energy policy and planning agency. | Policy and planning |</p>
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| Cal/OSHA within the Department of Industrial Relations (DIR)  
https://www.dir.ca.gov/ | The Department of Industrial Relations in California administers legislation in relation to workers' compensation, workplace safety, labour law, apprenticeships as well as development related policy. The Division of Occupational Safety and Health (Cal/OSHA) within the Department implements and administers the California State Plan, including being responsible for enforcement and consultation on changes. Cal/OSHA utilizes the Division of Labor Standards Enforcement (DLSE)'s Policies and Interpretations Manual to provide guidance for the enforcement program. Compliance officers inspect workplaces for hazardous conditions and issue citations and orders where violations are identified. Inspections may be the result of regular scheduling, imminent danger reports, fatalities, and worker complaints or referrals. DLSE enforces the law prohibiting retaliation for occupational safety or health activity. | | OHS regulator, administration and development of selected electricity and gas regulations related to work safety. |
| Texas | The Public Utility Commission (PUC) is the state agency that regulates electric, telephone and water utilities for the state of Texas. Its mission is to protect customers, foster competition and promote high quality infrastructure. In other words, the PUC writes and enforces the rules by which utilities abide. | | Economic regulator for electricity. Writes and enforces the operating rules alongside ERCOT. |
| Electric Reliability Council of Texas  
http://www.ercot.com/ | The Electric Reliability Council of Texas (ERCOT) manages the flow of electric power to 22 million Texas customers. This represents 85 percent of the state's electric load and 75 percent of the Texas land area. ERCOT is the independent system operator (ISO) for the region and also manages financial settlement for the competitive wholesale bulk-power market and administers consumer switching in competitive choice areas. The Texas Reliability Entity, Inc. (Texas RE) performs the regional entity functions described in the Energy Policy Act of 2005 for the ERCOT region, as mandated by the delegation agreement with the North American Electric Reliability Corporation (NERC). The delegation agreement was approved by the Federal Energy Regulatory Commission. ERCOT is also authorized by the Public Utility Commission of Texas (PUC) and is permitted by NERC to investigate compliance with the ERCOT Protocols and Operating Guides, working with PUC staff regarding any potential protocol violations. Texas RE is independent of all users, owners, and operators of the bulk-power system. | | Electricity system operator. Role in investigation and enforcement alongside the PUO, however role not entirely clear. |
| Texas Energy Reliability Council  
http://www.rrc.state.tx.us/gas-services/natural-gas-reliability/texas-energy-reliability-council/ | The Texas Energy Reliability Council (TERC) was formed in the early 1970's. Members of the council have made a commitment to do their best by working with other members to avoid interruption of high priority gas deliverables. The organization has no employees, no budget, no staff and no mandate other than to foster communication among its members to help assure that high priority gas needs are met. | | Voluntary council responsible for gas reliability |
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<tbody>
<tr>
<td>Railroad Commission of Texas (RRC)</td>
<td><a href="http://www.rrc.state.tx.us/pipeline-safety/">http://www.rrc.state.tx.us/pipeline-safety/</a></td>
<td>Process to enact the role as a statutory authority for apportioning gas to avoid high priority curtailments previously considered however, voluntary agreement and commitment by heads of major pipelines being reached and agreed to by RCC made this unnecessary at time. In addition to gas industry members the council includes representatives from electric utilities, Electric Reliability Council of Texas (ERCOT) and Public Utility Commission (PUC).</td>
<td></td>
<td>Primary pipeline safety regulator and compliance enforcement agency Economic regulator for interstate gas transmission</td>
</tr>
<tr>
<td>Railroad Commission of Texas (the RRC)</td>
<td><a href="http://www.rrc.state.tx.us/about-us/organization-activities/divisions-of-the-rrc/oversight-safety-division/">http://www.rrc.state.tx.us/about-us/organization-activities/divisions-of-the-rrc/oversight-safety-division/</a></td>
<td>The Railroad Commission of Texas (the RRC) regulates intrastate natural gas transmission pipelines in Texas and requires gas utilities to file their rates with the Commission. The Pipeline Safety department within the RRC ensures that the pipelines in Texas’ pipeline infrastructure are designed, constructed, operated and maintained safely. The Pipeline Safety department also enforces compliance by intrastate pipeline operators with federal and state laws and regulations and promotes public safety and awareness through the pipeline damage prevention program for Texas. With staff located in seven regional offices throughout the state, Pipeline Safety conducts approximately 2,850 inspections per year using a risk-based evaluation model as well as specialized inspections. Additionally, staff investigates accidents and complaints involving pipeline facilities. The RRC is authorized by the Texas Utilities Code and Texas Natural Resources Code to regulate the safety of intrastate gas, hazardous liquid and CO2 pipelines in the state. It is also certified by the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration for the enforcement of federal pipeline safety regulations for intrastate pipeline facilities under the federal Pipeline Safety Act. The RCC employed slightly less than 680 FTE as at December 2016. It is funded by the Texas Legislature. Grants are available from the U.S. FERC in relation to the state pipeline safety program. Three independent Commissioners.</td>
<td></td>
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<tr>
<td>State Energy Conservation Office</td>
<td><a href="http://seco.cpa.state.tx.us/">http://seco.cpa.state.tx.us/</a></td>
<td>SECO partners with Texas consumers, businesses, educators and local governments to reduce energy costs and maximize efficiency.</td>
<td></td>
<td>Policy</td>
</tr>
</tbody>
</table>
## 8.3 Summary of network characteristics

A summary of the electricity and gas network characteristics in each jurisdiction is set out in the following table.

<table>
<thead>
<tr>
<th>Country</th>
<th>New Zealand</th>
<th>England and Wales</th>
<th>Spain</th>
<th>California</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electricity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power generation mix</td>
<td>44.2 TWh (Hydro 55.5%, geothermal 17.8%, natural gas 15.5%, wind 5.3%, coal 4.3%, biofuels and waste 1.4%, solar 0.2%)</td>
<td>339 TWh (Natural gas 30%, coal 22%, nuclear 21%, wind 12%, biomass and waste 9%, hydro 3%, solar 2% (all UK))</td>
<td>273.9 TWh (Nuclear 20.9%, wind 19.1%, natural gas 17.2%, coal 16.3%, hydro 14.3%, oil 5.2%, solar 5%, biofuels and waste 2%)</td>
<td>199.5 TWh (Coal &lt;1%; petroleum &lt;1%, natural gas 60%, nuclear 9%, hydro: 27.4 TWh, 14%, other renewables 5%)</td>
<td>429.8 TWh (Coal 32%, petroleum &lt;1%, natural gas 50%, nuclear 9%, hydro &lt;1%, other renewables 7%)</td>
</tr>
</tbody>
</table>
| Transmission network | 11,743 km (170 substations One HVDC cable) | 8,700 km
7,200 km overhead lines,
1,500 km underground cables,
342 substations
4 interconnectors | 40,000 km
5,216 substations
3 interconnectors (Portugal, Morocco, France) | 26,000 miles of transmission in California ISO area | 41,843 km (26,000 miles)
2,200 substations
8,736 miles (AP Texas only) |
| Transmission operator(s) | Transpower (state-owned enterprise) | 3 operators across the UK. National Grid Electricity Transmission (NGET) owns and operates the network in England and Wales (listed on the NY Stock Exchange) | Red Eléctrica de España (REE) (publicly listed entity, State owns 10% of shares and other entities can hold no more than 5% of share capital or 3% of voting rights) | Investor-owned electricity utilities (regulated by the CPUC) are: Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas and Electric Company (SDG&E) own both transmission and distribution assets. | Electric Transmission Texas (joint venture between AEP and Berkshire Hathaway), AEP Texas (part of AEP), SWEPCO |
| Distribution network | 152,148 km | 837,156 km including 313,840 km overhead and 523,316 km underground
665,408 transformers
637 DSO-DTO interconnection points | 695,427 km including 475,323 km overhead and 220,104 km underground
289,671 transformers
776 DSO-DTO interconnection points | Over 300,000 miles of lines including 200,000 miles of above ground lines and 77,000 miles of underground lines; over 2,200 substations, and 4 million electric poles within CPUC regulation area | 200,000 miles above ground, 77,000 miles underground
42,691 miles (AEP Texas only) |
<p>| Distribution operator(s) | 39 distribution networks owned by 29 local distribution businesses (most are owned by trusts but some larger ones are exchange listed corporations, others are shareholder co- | 14 operators owned by six different groups across the UK. Electricity North West, Northern Powergrid, UK Power Networks, and Western Power Distribution | The electricity and gas DSOs are legally and functionally unbundled. More than 300 small companies. | Seven electricity investor-owned utilities (IOUs) are regulated. These include three major utilities: Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas and | Six investor owned utilities are regulated by the Public Utilities Commission of Texas cover 85% of the State (AEP Texas, CenterPoint Energy, Oncor, |</p>
<table>
<thead>
<tr>
<th>Country</th>
<th>New Zealand</th>
<th>England and Wales</th>
<th>Spain</th>
<th>California</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>operatives, community trusts and local councils/bodies. Largest distribution businesses are Vector Lines (26% of connections), Powerco (16%) and Orion NZ (9%).</td>
<td>are the largest in England &amp; Wales.</td>
<td></td>
<td>Electric Company (SDG&amp;E). Smaller utilities include: Sierra Pacific Power Company, Pacific Power &amp; Light and Bear Valley Electric Services.</td>
<td>Sharyland Utilities, TNMP, and Exel Energy)</td>
</tr>
<tr>
<td>Other</td>
<td>4 independent distribution network operators own and operate networks within distribution areas. GTC, Energetics Limited, ESP Utilities Group and UK Power Distribution Limited</td>
<td>44 Public Owned Utilities (PUOs) in the state are subject to local and public control and regulation.</td>
<td></td>
<td>118 Municipal Utilities and Utility Cooperatives services their local populations. Rates and services are not overseen by a regulator.</td>
<td></td>
</tr>
<tr>
<td>Customer base</td>
<td>1.98 million 115,000 industrial (44% of consumption), 1.7 million residential (32%), 166,000 commercial (24%)</td>
<td>27.8 million domestic consumers (2015) In 2010, the residential sector represented 36% of total demand, industry was 32%, commercial and services sector (other) was 29%, transport (1%), agriculture and fishing (1%)</td>
<td>28 million domestic and 849,000 non-domestic customers.</td>
<td>Population: 38.33 million Housing units: 13.79 million Businesses: 0.86 million 30 million customers</td>
<td>Population: 26.45 million Housing units: 10.26 million Businesses: 0.54 million</td>
</tr>
<tr>
<td>Natural Gas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission pipelines</td>
<td>2,520 km One underground storage facility</td>
<td>7,660 km (2017) 10 storage facilities</td>
<td>9,540 km 18 compressor stations 4 underground storage facilities</td>
<td>12,388 miles including 1,163 miles (interstate), 11,225 miles (intrastate) 14 natural gas storage fields</td>
<td>45,219 miles including 13,413 miles (interstate), 31,807 miles (intrastate) 37 natural gas storage fields (22 reservoirs and 18 salt caverns)</td>
</tr>
<tr>
<td>Transmission operator(s)</td>
<td>First Gas owned both major gas transmission pipelines. National Grid is the sole operator and owner</td>
<td>Enagas Transporte, S.A.U. owns and operates more than 95% of gas transport pipelines, it is the system operator for other companies’ pipelines.</td>
<td>Investor owned utilities regulated by the CPUC include: Pacific Gas and Electric (PG&amp;E), Southern California Gas (SoCalGas), San Diego Gas &amp; Electric (SDG&amp;E), Southwest Gas, and several smaller natural gas utilities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Draft Report
Best practice electricity and gas networks safety frameworks
<table>
<thead>
<tr>
<th>Country</th>
<th>New Zealand</th>
<th>England and Wales</th>
<th>Spain</th>
<th>California</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution</td>
<td>17,844 km</td>
<td>131,000 km (2017)</td>
<td>53,795 km (2007)</td>
<td>105,709 miles of mains, 94,294 miles of service lines</td>
<td>102,039 miles of mains, 45,951 miles of service lines</td>
</tr>
<tr>
<td>pipelines</td>
<td></td>
<td></td>
<td></td>
<td>402 miles of master meter systems&lt;sup&gt;193&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td>GasNet; First Gas, PowerCo; and Vector (open access pipelines). Nova Energy has a small network of non-open access distribution pipelines.</td>
<td>National Grid sold 61% to a consortium of investors on 31 Mar 2017.</td>
<td>The main distribution operators are Grupo Gas Natural Fenosa (69% of connections), EDP (12%), Madrileña Red de Gas (11%), Redexis (7%), Gas Extremadura (1%)</td>
<td>12 local distribution companies 18 distribution operators</td>
<td>114 local distribution companies including 30 investor-owned and 84 municipally-owned distribution utilities Of the investor owned utilities, Atoms Energy Mid-Texas Division is the largest with 1.6 million customers, CenterPoint Energy Entex has 1.6 million, Texas gas services Company has 629,822.</td>
</tr>
<tr>
<td>operator(s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of customers</td>
<td>270,000 customers (North Island only) (260,000 Residential customers, 15,700 commercial, 400 industrial)</td>
<td>10.9 million (National Grid)</td>
<td>7.585 million customers Households (16.3% of consumption), electricity generation (17.6%), Industrial (64.8%), Non-energetic use (1.8%) 76% of population, connected, 6,000 industrial facilities</td>
<td>10.8 million customers (investor owned utilities only)</td>
<td>4.84 million customers 4.3 million (investor owned distribution utilities) and 488,258 (municipally-owned) Residential 4.2 million, Small Commercial &amp; Industrial 290,356, Large Com &amp; Industrial 795, Other 350,602</td>
</tr>
<tr>
<td>(distribution)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
(a) England and Wales only
(b) Includes transmission and distribution assets

<sup>193</sup> A master metered system is a pipeline system, other than one designated as a local distribution system, for distributing natural gas within but not limited to a definable area, such as a mobile home park, housing project, or apartment complex, where the operator purchases metered gas from an outside source for resale through a gas distribution pipeline system.
Appendix A: Other insights from the United States

Comparison of the enforcement regimes in California and Texas

Comparison of the frequency and scale of penalties

The frequency and the scale of the penalties arising from enforcement actions in California and Texas are set out in Table 4. The data suggests California uses enforcement actions sparingly and that around 2011, the approach to penalty setting changed significantly. In contrast, Texas appears to use enforcement actions more frequently, but the penalties are lower.

Table 4: Gas Compliance Actions: 2001-2015

<table>
<thead>
<tr>
<th>Year</th>
<th>California</th>
<th></th>
<th></th>
<th>Texas</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Penalties Collected</td>
<td>Dollars of Penalties Collected</td>
<td>Average penalty value</td>
<td>Number of Penalties Collected</td>
<td>Dollars of Penalties Collected</td>
<td>Average penalty value</td>
</tr>
<tr>
<td>2001</td>
<td>17</td>
<td>$8,000</td>
<td>$471</td>
<td>13</td>
<td>$267,750</td>
<td>$20,596</td>
</tr>
<tr>
<td>2002</td>
<td>8</td>
<td>$6,000</td>
<td>$750</td>
<td>11</td>
<td>$77,150</td>
<td>$7,014</td>
</tr>
<tr>
<td>2003</td>
<td>0</td>
<td>$0</td>
<td>$0</td>
<td>8</td>
<td>$15,000</td>
<td>$1,875</td>
</tr>
<tr>
<td>2004</td>
<td>0</td>
<td>$0</td>
<td>$0</td>
<td>2</td>
<td>$17,500</td>
<td>$8,750</td>
</tr>
<tr>
<td>2005</td>
<td>0</td>
<td>$0</td>
<td>$0</td>
<td>4</td>
<td>$29,500</td>
<td>$7,375</td>
</tr>
<tr>
<td>2006</td>
<td>0</td>
<td>$0</td>
<td>$0</td>
<td>5</td>
<td>$42,250</td>
<td>$8,450</td>
</tr>
<tr>
<td>2007</td>
<td>1</td>
<td>$850</td>
<td>$850</td>
<td>9</td>
<td>$164,415</td>
<td>$18,268</td>
</tr>
<tr>
<td>2008</td>
<td>0</td>
<td>$0</td>
<td>$0</td>
<td>10</td>
<td>$39,225</td>
<td>$3,923</td>
</tr>
<tr>
<td>2009</td>
<td>1</td>
<td>$750</td>
<td>$750</td>
<td>17</td>
<td>$94,656</td>
<td>$5,568</td>
</tr>
<tr>
<td>2010</td>
<td>1</td>
<td>$2,250</td>
<td>$2,250</td>
<td>7</td>
<td>$37,900</td>
<td>$5,414</td>
</tr>
<tr>
<td>2011</td>
<td>1</td>
<td>$38,000,000</td>
<td>$38,000,000</td>
<td>16</td>
<td>$60,500</td>
<td>$3,781</td>
</tr>
<tr>
<td>2012</td>
<td>1</td>
<td>$16,760,000</td>
<td>$16,760,000</td>
<td>9</td>
<td>$168,500</td>
<td>$18,722</td>
</tr>
<tr>
<td>2013</td>
<td>4</td>
<td>$8,450,000</td>
<td>$2,112,500</td>
<td>11</td>
<td>$51,500</td>
<td>$4,682</td>
</tr>
<tr>
<td>2014</td>
<td>0</td>
<td>$0</td>
<td>$0</td>
<td>15</td>
<td>$392,750</td>
<td>$26,183</td>
</tr>
<tr>
<td>2015</td>
<td>8</td>
<td>$300,995,000</td>
<td>$37,624,375</td>
<td>21</td>
<td>$304,250</td>
<td>$14,488</td>
</tr>
</tbody>
</table>


Natural gas penalties in Texas

The Railroad Commission of Texas’ approach to gas pipeline safety regulation relies heavily on prescriptive standards and codes of practice set out predominately by the FERC. The approach to enforcement appears to rely heavily on the use of many small penalties.

Analysis of the penalties issued in Texas since 2011 shows that they range from $500 through to $150,000 – but as shown in Figure 19, there are a small number of large fines and a long tail of relatively small fines (valued at $5,000 or less).
The Railroad Commission of Texas has recently implemented an ‘improved enforcement process for pipeline safety’. This appears to have expedited the use of penalties and increased the value of penalties. 194

A full list of the pipeline safety enforcement cases is available on the RRC’s website going back to 2011. 195 A subset of the cases including details on the penalty amount collection and the infringement have been provided in Appendix 1.

A consequence of the highly prescriptive, penalties based approach is that enforcement activities are more extensive in comparison to other, less prescriptive approaches, such as in California.

The PHMSA pipeline safety performance metrics (outlined below) includes inspection activity, demonstrate the relative level of enforcement and inspective actives. The number of inspection days per 1,000 miles of pipeline is almost four times that of California: ~25 days in Texas compared to ~7 days in California in 2015.

**PHMSA pipeline safety performance metrics**

The PHMSA evaluates each state pipeline safety regulatory program. Part of the evaluation looks at state program performance in six areas:

- Damage Prevention Program
- Inspection Activity
- Inspector Qualification

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- Leak Management
- Enforcement
- Incident Investigation

In California, the California Public Utility Commission provides oversight of intrastate gas that are public utilities through certification by PHMSA. In Texas, the same role is undertaken by Texas Railroad Commission in relation to intrastate gas pipelines in Texas.\(^{196,197}\)

Figure 20 provides a snapshot comparison of the metrics for the two states. In comparing the graphs—care should be taken to note the values on the Y axis, as these are not consistent. Key differences to note are:

- the higher number of inspection days per 1,000 miles in Texas;
- the lower levels of core training for pipeline inspectors in Texas; and
- the higher number of leaks of all kinds in Texas.

**Figure 20: PHMSA pipeline performance metrics, Texas and California**


\(^{197}\) Texas data: [https://primis.phmsa.dot.gov/comm/StateProgramMetrics/StateProgramMetrics_TX.htm?nocache=6428](https://primis.phmsa.dot.gov/comm/StateProgramMetrics/StateProgramMetrics_TX.htm?nocache=6428)
Sources: California data: https://primis.phmsa.dot.gov/comm/StateProgramMetrics/StateProgramMetrics_CA.htm?nocache=8085
Texas data: https://primis.phmsa.dot.gov/comm/StateProgramMetrics/StateProgramMetrics_TX.htm?nocache=6428

State energy risk assessment initiative

The Office of Electricity Delivery and Energy Reliability (part of the Federal Department of Energy) has developed a State Energy Risk Assessment Initiative.\(^\text{198}\)

The initiative has developed State Energy Risk Profiles for each US State with the aim that the States better understand risks to their energy infrastructure and can be better prepared to make informed investment decisions.

The Risk Profiles identify likelihood and severity of the key risks in each jurisdiction. The Risk Profile highlights risk considerations relating to the electric, petroleum and natural gas infrastructures to become more aware of risks to these energy systems and assets.\(^\text{199}\) Example charts for Texas\(^\text{200}\) and California\(^\text{201}\) are provided below.

Natural Hazards overview

The natural hazards overview for California is provided in Figure 21 below. It can be seen that wildfire is relatively infrequent (averaging 32 events per year) but results in the largest annualized property loss.

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\(^{198}\) https://www.energy.gov/sites/prod/files/2015/04/f21/Creating%20a%20Culture%20of%20Risk%20Assessment%20brochure.pdf


Natural gas transportation

The frequency and value of events affecting natural gas transmission and distribution in Texas are set out in Figure 22. It can be seen that in transmission gas pipelines Corrosion and outside forces are the most frequent and largest value events. In gas distribution, Miscellaneous/unknown and outside forces are the most frequent and largest value events.

Electricity distribution

The frequency of the key causes of electricity outages are identified in Figure 23. It can be seen that Weather/falling trees and then Faulty equipment / human error are the two largest causes of outages.
Figure 23: Causes of electric-utility reported outages (2008–2013)

Source: Texas State energy risk profile

Useful data sources

Sources of electrical distribution related fires

The National Fire Protection Association (NFPA) collates data from fire departments and state through the National Fire Incident Reporting System (NFIRS). A 2017 research report collates data collected over the period 2010 to 2014 with information presented representing annual averages. The data collected by the NFPA is a rich source of information for policy makers to draw insights from.

Overall findings and a sample of data from the 2017 report is provided below which draws from the “Non-home Fires involving electricity distribution or lighting equipment” category follows:

- U.S. fire departments responded to an estimated annual average of 31,960 non-confined home structure fires involving electrical distribution or lighting equipment in 2010-2014.
- An estimated annual average of 14,760 non-confined and non-home fires involving electrical distribution and lighting equipment resulted in 20 civilian deaths, 190 civilian injuries, and $659 million in direct property damage each year.

Table 5: Non-home fires involving electrical distribution or lighting equipment, by type of equipment (2010-2014 annual averages) –

<table>
<thead>
<tr>
<th>Type of Equipment</th>
<th>Fires</th>
<th>Civilian Deaths</th>
<th>Civilian Injuries</th>
<th>Direct Property Damage (in $US Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiring and related equipment</td>
<td>8,670</td>
<td>(59%)</td>
<td>10 (49%)</td>
<td>100 (53%)</td>
</tr>
<tr>
<td>Unclassified electrical wiring</td>
<td>3,700</td>
<td>(25%)</td>
<td>10 (49%)</td>
<td>40 (21%)</td>
</tr>
<tr>
<td>Electrical power (utility) line</td>
<td>1,110</td>
<td>(8%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Equipment</th>
<th>Fires</th>
<th>Civilian Deaths</th>
<th>Civilian Injuries</th>
<th>Direct Property Damage (in $US Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet or receptacle</td>
<td>1,000</td>
<td>0</td>
<td>10</td>
<td>$39</td>
</tr>
<tr>
<td>Electrical service supply wires from utility</td>
<td>770</td>
<td>0</td>
<td>10</td>
<td>$14</td>
</tr>
<tr>
<td>Panel board, switchboard or circuit breaker board</td>
<td>720</td>
<td>0</td>
<td>20</td>
<td>$33</td>
</tr>
<tr>
<td>Electrical branch circuit</td>
<td>670</td>
<td>0</td>
<td>10</td>
<td>$36</td>
</tr>
<tr>
<td>Lamp, bulb or lighting</td>
<td>3,280</td>
<td>0</td>
<td>50</td>
<td>$111</td>
</tr>
<tr>
<td>Fluorescent lighting fixture or ballast</td>
<td>880</td>
<td>0</td>
<td>10</td>
<td>$29</td>
</tr>
<tr>
<td>Unclassified lamp or lighting</td>
<td>800</td>
<td>0</td>
<td>0</td>
<td>$29</td>
</tr>
<tr>
<td>Sign</td>
<td>340</td>
<td>0</td>
<td>0</td>
<td>$5</td>
</tr>
<tr>
<td>Transformers and power supplies</td>
<td>1,870</td>
<td>0</td>
<td>20</td>
<td>$215</td>
</tr>
<tr>
<td>Distribution type transformer</td>
<td>700</td>
<td>0</td>
<td>0</td>
<td>$47</td>
</tr>
<tr>
<td>Generator</td>
<td>400</td>
<td>0</td>
<td>10</td>
<td>$87</td>
</tr>
<tr>
<td>Cord or plug</td>
<td>910</td>
<td>0</td>
<td>20</td>
<td>$26</td>
</tr>
<tr>
<td>Total</td>
<td>14,760</td>
<td>20</td>
<td>190</td>
<td>$659</td>
</tr>
</tbody>
</table>

Note: Figures exclude confined fires. Figures reflect a proportional share of home fires with equipment involved in ignition unknown or reported as electrical distribution or lighting equipment of undetermined type. Fires deaths, and injuries are rounded to the nearest ten and direct property damage to the nearest million dollars. Totals may not equal sums because of rounding error.

Original source: Data from NFIRS Version 5.0 and NFPA Experience Survey.
Source: National Fire Protection Association (NFPA), Electrical Fires Research, report developed by Richard Campbell, March 2017, Table 8.1, pp. 101-102

Gas pipeline infrastructure data
The Federal Pipeline and Hazardous Materials Safety Administration (PHMSA) - within the Department of Transport, collects pipeline infrastructure data from operators.


Interactive map of reportable pipeline incidents caused by excavation damage
The Federal Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) provides an interactive map of reportable pipeline incidents caused by excavation damage. The map can depict the locations of individual incidents as well as produce "heat maps" that show where incidents are concentrated.203

203 http://phmsa.maps.arcgis.com/apps/MapTools/index.html?appid=8ac9d9ea06674f3a91f9a9e2bb0b4c64
Figure 24: Heat map of reportable pipeline incidents caused by excavation damage


Key and emerging risks

Repair, rehabilitation, and replacement of the highest-risk pipeline infrastructure

In 2011, following major natural gas pipeline incidents, the Federal Pipeline and Hazardous Materials Safety Administration (PHMSA) issued a “Call to Action” to accelerate the repair, rehabilitation, and replacement of the highest-risk pipeline infrastructure. This has targeted:

- Aging pipelines;
- Cast and wrought iron pipeline inventory; and
- Bare steel pipelines inventory;

More information is available here: https://opsweb.phmsa.dot.gov/pipeline_replacement/

Increased prevalence of renewable electricity sources

Increased penetration of renewables imposes emerging risks on distribution networks. The key issues arise from renewables having lower reliability and increased intermittency. This can result in difficulties with local grid load/demand levelling and inconsistent quality regarding voltage, frequency, and total harmonic distortion.\(^\text{204}\) Research indicates that California and Germany have high penetration of distributed generation assets.

Global installed capacity of solar photovoltaics was expected to have reached around 200 GW by the end of 2014 with the largest growth markets in China, Japan, and the USA.\(^\text{205}\)

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IEA-ETSAP and IRENA© Technology Brief E15 –
Advanced forms of renewable technology – such as Building Integrated Photovoltaic (BIPV) modules and reduced renewables costs are likely to increase penetration of renewables. 206

High Impact, Low Frequency events and the National Infrastructure Protection Plan

Energy Sector-Specific Plan, An Annex to the 2010 National Infrastructure Protection Plan207, introduced several new topics including pandemic events and highlights cybersecurity activities.

The Energy Sector has long prepared for all hazards, and natural disasters have been a key focus of sector efforts. The 2010 plan introduces several new topics including pandemic events and highlights cybersecurity activities. The Energy SSP is structured around the risk management framework defined in the National Infrastructure Protection Plan (NIPP).
