Gas infrastructure: international comparisons

Prepared for
Infrastructure Victoria

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Accenture Strategy
### Executive summary

**Introduction**

**Victoria’s gas challenge**

Victoria’s emissions from gas will need to decline to meet the state’s net zero target.

Gas plays a major role in Victoria’s energy mix. Historically an exporter of gas to other states, Victoria’s production is forecast to decline. Emissions from gas will need to decline to meet Victoria’s net zero target.

**Global policy comparison**

**Five jurisdictions**

We examined five jurisdictions that rely on gas and are taking policy actions for reducing emissions: the **United Kingdom**, the **Netherlands**, **Canada’s western provinces**, **Japan** and **other Australian jurisdictions**.

**Policy approaches**

**‘No-regrets’ and ‘creating options’**

Governments are taking ‘no-regrets’ measures and investing in options.

There is significant uncertainty about the role of gas in the future global energy mix. Comparison jurisdictions are taking a range of no-regrets measures and investing in alternatives for the future.

**Policy levers**

**Efficiency and electrification, CCS, and substituting gas with hydrogen and biomethane**

Increasing efficiency and supporting electrification are clear priorities; jurisdictions are also investing in CCS and hydrogen to create options.

**Energy efficiency** is a widely adopted no-regrets measure.

**Electrification** is a clear pathway to replace gas use, and countries are actively encouraging this transition.

**Carbon capture and storage** is seen as a feasible pathway for gas decarbonisation but it takes significant policy support and government action.

**Hydrogen** is being considered as a low-carbon alternative for natural gas, but its future role in the energy mix is unclear.

**Biomethane** is an option where feedstock is available at low cost close to the gas network.

**Policy alignment**

**Testing investments against net zero**

Assets should align with net zero pathways.

Aligning policies and regulation across government provides a strong framework to deliver net zero targets. Changing rules and shifting gas consumption patterns takes time.

Infrastructure and network investment decisions should be tested for compatibility with pathways to net zero.

**Impacts and trade-offs**

Policies affect the whole gas value chain.

The policy levers for reducing emissions from gas have diverse impacts across the gas value chain. Policy options involve different trade-offs between emissions reductions, complexity and costs.
Gas plays a major role in Victoria’s energy mix

Gas makes up 22% of Victoria’s primary energy use. Victoria has relatively high gas use due to historically abundant and low-cost supply from onshore and offshore gas fields.

Gas plays an important role in residential and commercial buildings. There are **over 2 million residential and commercial customer gas connections** in Victoria. More than 80% of residential properties in Victoria have a gas connection.

Gas is used for heat in industry, for electricity generation and in transport. Gas is also used as a feedstock for manufacturing processes including ammonia and polyethylene production.

The Victorian gas network extends across the state and has **nearly 34,000 km of pipelines and an asset base of A$6 billion**.

**Sources:** BP data (2019), Accenture analysis

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**Victoria’s gas consumption per capita is relatively high compared to other jurisdictions**

<table>
<thead>
<tr>
<th>Comparator country</th>
<th>Cubic metres, per capita (2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Australia</td>
<td>6,500</td>
</tr>
<tr>
<td>Canada</td>
<td>3,000</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2,500</td>
</tr>
<tr>
<td>Victoria</td>
<td>2,000</td>
</tr>
<tr>
<td>South Australia</td>
<td>1,500</td>
</tr>
<tr>
<td>OECD</td>
<td>1,000</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>500</td>
</tr>
<tr>
<td>Japan</td>
<td>0</td>
</tr>
<tr>
<td>Queensland</td>
<td>0</td>
</tr>
<tr>
<td>Tasmania</td>
<td>0</td>
</tr>
<tr>
<td>New South Wales</td>
<td>0</td>
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</tbody>
</table>

Victoria ranks second in Australia for gas use per capita and is one of the highest users of gas in the world.
Historically an exporter of gas to other states, Victoria’s production is forecast to decline

Victoria’s gas regions have seen lower levels of investment in recent years, owing to perceptions of policy uncertainty and limits on exploration. At the same time, production from the state’s largest offshore field in Gippsland is declining.

Recent forecasts from the Australian Energy Market Operator indicate that in the absence of increased supply within the state, Victoria may need gas from New South Wales to meet peak day demand by 2023.

AEMO forecasts are a market signal to ensure supply is adequate to meet expected demand. Earlier projections of declining Victorian supply have seen proposals for LNG import terminals and expansion of interstate gas transmission in response.

Victorian gas demand is also forecast to decline. AEMO forecasts a 13% decline in Victoria’s gas consumption over the next five years, driven by higher levels of renewables and new and existing energy efficiency and electrification measures.

Note: Actual total gas production and consumption is shown for 2019 and 2020
Sources: AEMO, (GSOO 2020, VGPR 2021), AEMO Gas Bulletin Board data, Accenture analysis
Emissions from gas will need to decline to meet Victoria’s net zero target

Victoria’s emissions from natural gas were ~17.4 Mt CO$_2$e in 2018, representing 17% of the state’s 102.2 Mt CO$_2$e total emissions.

The largest source of the state’s natural gas emissions is direct combustion, which includes burning gas for heat, steam and pressure for industrial operations and for space heating, hot water and cooking. The second largest source is fugitive emissions from leaks or venting of gas in exploration, processing, storage, transmission and distribution.

In 2017 the Victorian Government committed to net zero emissions by 2050. The role of gas should be considered in the context of the state’s overall energy mix during the transition to net zero emissions, including the potential role of negative emissions technologies. A full assessment of the future role of gas in the Victorian energy mix is beyond the scope of this report.

But natural gas is a significant part of the state’s emissions profile today, and emissions from natural gas will need to decline significantly to meet the net zero 2050 target.

We studied five comparison jurisdictions, based on their reliance on gas and use of relevant policy levers for reducing emissions

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Role of gas</th>
<th>Reason for selection</th>
<th>Case studies/deep dives</th>
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<tbody>
<tr>
<td><strong>Deep dive jurisdictions</strong></td>
<td></td>
<td></td>
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<tr>
<td>United Kingdom</td>
<td></td>
<td>Policy targets for green industrial revolution, reliance on gas</td>
<td>Extensive policy architecture for emissions reduction</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2,155</td>
<td>Planned exit from gas production and use</td>
<td>Porthos CCS project</td>
</tr>
<tr>
<td>Canada (western provinces)</td>
<td>3,216</td>
<td>Large gas production, CCS, exports</td>
<td>Albertan government CCS project funding</td>
</tr>
<tr>
<td>Japan</td>
<td>852</td>
<td>Reliance on energy imports and hydrogen strategy</td>
<td>Hydrogen strategy</td>
</tr>
<tr>
<td><strong>Shorter comparative analysis of select elements</strong></td>
<td></td>
<td></td>
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<tr>
<td>Other Australian jurisdictions</td>
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<td></td>
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</tr>
<tr>
<td>VIC: 2,132</td>
<td></td>
<td>Shared federal policies and network regulation, differing gas usage patterns to Victoria</td>
<td>Building efficiency comparison</td>
</tr>
<tr>
<td>QLD: 756</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>WA: 6,179</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>VIC: 508</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>QLD: 1,436</td>
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<td></td>
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<tr>
<td>WA: 3,289</td>
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</tbody>
</table>

Notes: Conversion between cubic meters and PJ assumes 1 m³ of natural gas is 0.0373 GJ (Canada Energy Regulator, 2015).
Sources: UK BEIS Energy Trends Table 4.1 (2019), Statistics Canada Table 25-10-0055-01 (2019), Australian Energy Statistics, Australian Energy Update 2020 Table Q (2018-19), Accenture analysis
There is significant uncertainty about the role of gas in the future global energy mix

At a global level, **there is no clear pathway for gas use in the coming decades**, given the wide range of potential future gas prices, relative technology costs and policies.

Modelling from the International Energy Agency highlights the wide range of potential outcomes for gas demand under different degrees of policy action.

A range of technologies have the potential to shape the role of gas in future energy pathways:

- **Increased efficiency** through improvements to technologies or processes can reduce overall gas use
- **Electrification** of thermal processes previously powered with gas can reduce gas demand
- **Carbon capture and storage (CCS)** can be paired with the gas combustion to provide low-emissions options for gas in the future
- Gas can be substituted with **biogas, biomethane** or **hydrogen** in some applications.

### IEA scenario modelling for global gas demand, 2019-2040

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Market growth (with CCS)</th>
<th>Efficiency</th>
<th>Market growth (without CCS)</th>
<th>Switching from natural gas</th>
<th>Switching to natural gas</th>
<th>Net change</th>
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</thead>
<tbody>
<tr>
<td>Stated Policies Scenario</td>
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<tr>
<td>Sustainable Development Scenario</td>
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<td></td>
<td></td>
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</tbody>
</table>

Source: IEA World Energy Outlook (2020)
Comparison jurisdictions are taking a range of no-regrets measures and investing in alternatives for the future

No comparison jurisdictions in this study have yet committed to fully decommission their gas networks.

Notes: AB: Alberta, ACT: Australian Capital Territory, BC: British Columbia
Source: Accenture analysis
Policy options involve different trade-offs between emissions reductions, complexity and costs

<table>
<thead>
<tr>
<th>Pathway for gas</th>
<th>Approach</th>
<th>Jurisdictions</th>
<th>Potential implementation in Victoria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Emissions reduction potential</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Provide rebates and incentives for energy upgrades</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Update building codes to energy neutral standard</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Replace ageing pipelines to minimise leakage</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Electrification</td>
<td>Provide rebates and incentives for electrification</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Ban new gas connections</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Remove existing buildings from gas network</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Carbon capture, utilisation</td>
<td>Provide site appraisal, long-term revenue support, grants and incentives for major strategic projects</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>and storage</td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Substitution</td>
<td>Hydrogen Support market demand and hydrogen supply concurrently, possibly with brown or blue hydrogen production in the interim</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Introduce consumer-funded blending mechanism e.g. levy on gas distribution networks</td>
<td></td>
<td>Low</td>
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<tr>
<td></td>
<td>Test a consumer-led ‘opt-in’ approach</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Provide industry funding and support</td>
<td></td>
<td>Low</td>
</tr>
</tbody>
</table>

Note: The implementation analysis presents an estimate of the costs and benefits of implementing a stylised version of the most ambitious policy among the comparison jurisdictions in Victoria.

Source: Accenture analysis
### The policy levers for reducing emissions from gas have diverse impacts across the gas value chain

<table>
<thead>
<tr>
<th>Lever for reducing emissions from gas</th>
<th>Expected impact on gas infrastructure</th>
<th>Expected impact on gas users</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exploration, production, imports, processing</strong></td>
<td><strong>Gas networks</strong></td>
<td><strong>Gas storage</strong></td>
</tr>
<tr>
<td>Gas efficiency</td>
<td>Lowers demand for natural gas, reducing upstream opportunities</td>
<td>Lowers demand for natural gas, reducing required network investment; addressing leaks may increase network investment</td>
</tr>
<tr>
<td>Electrification</td>
<td>Increases electricity demand, potentially increasing demand for gas for power generation</td>
<td>Increases electricity demand, potentially increasing demand for gas transmission for power generation</td>
</tr>
<tr>
<td>Carbon capture and storage</td>
<td>Upstream firms could participate in carbon storage; CCS could support demand for natural gas</td>
<td>Supports network connections to CCS-equipped gas users; networks may play a role in carbon dioxide transport</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>Investment opportunities for upstream segment in hydrogen export</td>
<td>Requires significant network upgrades to transport and store hydrogen, extending network life</td>
</tr>
<tr>
<td>Biomethane</td>
<td>Biomethane blending lowers demand for natural gas, reducing required investment (minor effect)</td>
<td>Opportunity for biomethane production and blending trials</td>
</tr>
</tbody>
</table>

Source: Accenture analysis
Energy efficiency is a widely adopted no-regrets measure

In most comparison jurisdictions, **energy efficiency is adopted as a no-regrets measure**: an action that has clear short-term net benefits and does not materially constrain future choices.

Gas efficiency is supported through wider energy efficiency measures and programs that specifically focus on gas users:

- For **existing buildings**, grants are often provided to improve energy efficiency.
- For **new buildings**, jurisdictions are changing building regulations to require higher energy efficiency.
- For **industrial gas users**, grants are used to support investment in efficient new equipment and process re-engineering, and carbon taxes are being applied to industrial emitters to drive efficiency.

Grants for energy efficiency are typically funded by governments.

Reducing **methane leaks** is important because of methane’s high global warming potential. In comparison jurisdictions, leaks in gas distribution networks are addressed through upgrades or replacement programs.

### Energy efficiency: increasing ambition across comparison jurisdictions

#### The United Kingdom Government will spend £1.3bn on energy efficiency in 2021-22

- Programs include the Green Homes Grant Voucher Scheme, the Home Upgrade Grant, the Social Housing Decarbonisation Fund and the Public Sector Decarbonisation Scheme.
- Over £1bn has been provided in the Public Sector Decarbonisation Scheme. The funding supports for energy efficiency and renewable and/or low-carbon heating for public sector buildings, including schools and hospitals.
- Over £66 million of funding is committed to the Transforming Foundation Industries Challenge. These projects will look at new ways to reduce waste and energy use and in a new research facility to accelerate development of promising clean technologies in key sectors: cement, glass, ceramics, paper, metals and bulk chemicals sectors.

#### Other jurisdictions:

- **British Columbia (Canada)** provides over CA$1.1bn with the Capital Renewal Funds to improve building efficiency to support the improvement of existing and aging house stock in B.C.
- **The Netherlands**: Require all new buildings meet the ‘Almost Energy Neutral Building’ requirements and limit energy consumption from 2021.

Electrification is a clear pathway to replace gas use, and countries are actively encouraging this transition

**Replacing gas with electricity is a core strategy** in many jurisdictions for reducing emissions from gas.

- For **existing buildings**, incentives are used to drive uptake of electric appliances such as heat pumps to support the transition of buildings away from the gas network.

- For **new buildings**, some jurisdictions are moving towards zero net energy building standards and banning new gas connections, with heat provided through district heating systems or by efficient electric systems.

- For **industrial gas users**, grants are used to support investment in new equipment, process re-engineering and electrification of process heat, and carbon taxes are being applied to industrial emitters to drive change.

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**Highlighted jurisdiction: The Netherlands**

- The Netherlands is actively transitioning dwellings from the gas network. By 2050, all 7.7 million dwellings should be disconnected from gas.
- Subsidies of up to €7,000 are provided to actively transition buildings and houses from the gas network.
- The Dutch government aims to transition between 30,000 and 50,000 dwellings in 2021, accelerating to 200,000 dwellings per year before 2030.
- Since 2018, new buildings have not been allowed to be connected to the gas network.

**Other jurisdictions:**

- **United Kingdom**: Electrification is one of the ten points in the UK’s new Ten Point Plan. The United Kingdom aims to install 600,000 heat pumps per year by 2028.
- **Canada (British Columbia)**: Upgrade and retrofit government buildings through the CleanBC government buildings program, and retrofit 70,000 homes and 10 million m² of commercial buildings to use clean electricity for space heating by 2030.

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CCS is seen as a feasible pathway for gas decarbonisation but it takes significant policy support and government action

Carbon capture and storage (CCS) may play an important role in reducing emissions from natural gas where geology is favourable.

- CCS can support an **ongoing role for natural gas** if capture and storage is available at a competitive price

- **Blue hydrogen production** depends on the availability of carbon storage at significant scale.

CCS projects tend to be very large and capital-intensive, comparable in size and complexity to LNG projects.

- Evidence from comparison jurisdictions indicates that large-scale CCS projects need a **long-term carbon price or emissions regulation** to attract capital commitments.

- Private companies have been generally unwilling to invest in storage site appraisal. There may be a role for government in **undertaking geological evaluations** and **making the detailed appraisal information available**.

- Governments can also play an important role in **directly funding CCS projects** and **coordinating clusters** of CCUS customers.

### CCS: major funding commitments in comparison jurisdictions

#### Highlighted jurisdiction: Alberta (Canada)
- The Alberta government committed a total of CAD$1.24bn to support two commercial-scale CCS projects. Both are in operation, capturing up to 2.8 Mt CO₂ emissions per year.
- Quest began operation in 2018 captures and stores emissions from energy-intensive oil sands production.
- The ACTL system transports emissions from fertilizer production for use and storage 240km away. It began operation in 2019.

#### Other jurisdictions
- **The Netherlands**: The European Union and the Dutch government have committed more than €100m to the Porthos CCS project. The facility will capture industrial emissions from the port of Rotterdam, with capacity to store up to 10% of the country’s total industrial emissions per year. It is expected to be operational by 2024.
- **United Kingdom**: £1bn of government funds have been committed to develop 4 CCUS projects, clustered in the country’s major industrial hubs. The government has set a target to have two clusters operational by 2025, and a further two by 2030.

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Sources: Alberta provincial government (2021), PorthosCO2 (2021), UK government (2020), Accenture analysis
Hydrogen is being considered as a low-carbon alternative for natural gas, but its future role in the energy mix is unclear.

Hydrogen is a flexible energy carrier that could replace many current applications of natural gas.

- **Green hydrogen**, made from renewables-based electrolysis, is relatively expensive today but costs are expected to decline as global uptake increases.

- **Blue hydrogen**, produced from natural gas via steam methane reforming with CCS, may be a lower-cost path to market where gas is abundant and CCS is available.

Global hydrogen production is 74 Mt today, mostly from fossil fuels. Policy efforts in leading countries are focused on reducing low-carbon hydrogen costs by **increasing the scale of production** using electrolyser capacity targets or by funding major projects, while at the same time **building customer demand** through measures such as mandates to inject hydrogen into the natural gas grid.

Many hydrogen projects have been announced, but few projects are yet online. The long-term role of hydrogen in the global energy mix is uncertain, but jurisdictions are investing in hydrogen projects to **create a potential low-carbon pathway**.

### Hydrogen: ambitious targets and strategies in comparison jurisdictions

#### Highlighted jurisdiction: Japan

- Japan has announced an ambitious Basic Hydrogen Strategy as part of its pathway to net zero.
- Hydrogen will be a key energy carrier, reducing the demand for fossil fuels for electricity generation, transport and industrial processes.
- The Strategy includes plans for a global hydrogen supply chain.
- The Japanese government is investing ~$19 billion to support its 2030 hydrogen commercialisation goal.

#### Other jurisdictions:

- **The Netherlands** is developing large-scale green hydrogen production using offshore wind power. The NortH2 project aims to produce as much as 4 gigawatts of hydrogen by 2030, scaling up to 10 gigawatts by 2040. Dutch government plans to allocate €35 million/year from 2021 to scale up projects.
- **United Kingdom**: Hydrogen is one of the ten points in the UK Ten Point Plan. The UK aims to produce 1 gigawatt of hydrogen by 2025 and 5 gigawatts by 2030, supported by a Net Zero Hydrogen Fund of £240 million.

Sources: METI (2019), NortH2 (2021), UK Government (2020), Accenture analysis
Biomethane is an option where feedstock is available at low cost close to the gas network

**Biomethane is a potential substitute for natural gas.** There are policies supporting biomethane production and injection into the grid in the United Kingdom, the Netherlands and Canada. Some jurisdictions are pursuing biomethane as a strategy to reduce emissions from agriculture.

In markets where organic feedstock is available, **biomethane can be a cost-effective option** for reducing emissions from gas. Organic feedstocks for biomethane include crop residues, animal waste, municipal solid waste, wastewater and forestry residues.

Where biomethane is to be injected into gas networks rather than used locally, **proximity to the gas network** is a significant cost factor. To be cost effective, plants must generally be located close to gas grids.

More information on the costs and availability of **biomethane feedstock** in Victoria could help determine the role of biomethane in decarbonising gas in the state.

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**Highlighted jurisdiction: United Kingdom**

- The UK is introducing a Green Gas Levy on gas distributors to fund biomethane injection into the existing gas grid.
- The government ran a consultation with key stakeholders including gas suppliers and consumers on the Levy in 2020. The levy is expected to come into effect in 2021 and support biomethane injection for 4 years.
- Substitution with biomethane into the grid is estimated to save 21.6 Mt CO$_2$ emissions over the lifetime of the scheme.

**Other jurisdictions**

- **Canada**: British Columbia is aiming to substitute 15% of natural gas in the existing grid with renewable natural gas (biomethane) by 2030. Consumers can currently pay for switching their supply to a 5-100% renewable natural gas blend through some gas distributors.
- **The Netherlands** has set a target for 2 billion cubic meters per year of biogas production by 2030, upscaling from current production of 144 cubic meters per year.

Aligning policies and regulation across government provides a strong framework to deliver net zero targets

Gas infrastructure and consumption patterns are affected by a wide range of policies and regulation across government.

Evidence from international comparisons indicates that it is important to:

- Set **interim emissions targets and sectoral pathways** to guide investment decisions across the gas value chain
- Align the **economic regulation of gas networks** with the long-term net zero goal to ensure that investment in the shared network is compatible with emissions reduction pathways
- Set up **institutions for independent climate policy advice** to ensure that there is ongoing calibration of policies and other government actions
- Align **decisions relating to upstream gas production** to ensure that long-term gas supply takes into account emissions reduction goals
- Where feasible, use **long-term price signals** to align decisions of gas producers and consumers with emissions reduction goals.

**The United Kingdom has significant policy architecture in place**

- The UK government has **legislated their target for emissions by 2050**, with interim targets and 5-yearly carbon budgets in law.
- Energy **network regulator Ofgem has considerations for net-zero built into their pricing approach**, providing a framework to support the energy market transition to low-emissions technologies.
- The **Climate Change Committee (CCC)** is an independent body that advises the government on carbon budgets and policy pathways to achieve national emissions targets.
- The **North Sea Transition Deal** is a signal to oil and gas sector that the country will be moving to a low-emissions future.
- **Carbon pricing** provides signals and incentives to the market to reduce emissions and transition to low carbon alternatives.

Sources: UK Government (2020), Accenture analysis
Changing rules and shifting gas consumption patterns takes time

Energy system change is often a slow process.
Implementing major reforms across the energy system involves consequential changes to regulations, safety rules, consumer tariffs, workforce skills and training, and supply chains.

It is important to commit to long-term plans so that the necessary consequential changes can happen in these areas.

Interventions that affect many customers or involve changing consumer behaviour should start early.
Improving gas efficiency and electrifying heat in residential, commercial and industrial applications involves changing the practices of millions of gas users.

Changes are likely to take many years to achieve widespread acceptance and should begin as soon as possible.

Gas transitions are likely to take many decades

<table>
<thead>
<tr>
<th>The Netherlands</th>
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<tbody>
<tr>
<td>• The gas infrastructure transition is expected to take more than 30 years in the Netherlands.</td>
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<tr>
<td>• The fundamental transition from the gas was started in 2013 by reducing onshore gas production and accelerated by the Climate Accord.</td>
</tr>
<tr>
<td>• The Dutch Climate Accord agreed to cut gas use to zero by 2050, and transition gas infrastructure.</td>
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<table>
<thead>
<tr>
<th>United Kingdom</th>
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<tr>
<td>• Making upgrades to gas infrastructure will take the UK 30 years</td>
</tr>
<tr>
<td>• The iron mains replacement program (IMRP) program will replace the 250,000 km-long gas pipeline network.</td>
</tr>
<tr>
<td>• The program started in 2002 and is expected to be finished by 2032.</td>
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</table>

Infrastructure and network investment decisions should be tested for compatibility with pathways to net zero

Governments are facing difficult decisions about new and existing assets on the pathway to net zero.

**Major decisions by governments and regulators about gas infrastructure and network investments should be informed by a sensitivity analysis based on a clean transition pathway and a net zero endpoint.**

This analysis would show whether gas infrastructure investment plans are compatible with likely emissions reduction pathways, highlighting any assets at risk of stranding and reducing the risk of locking pathways that are not consistent with net zero.

For example, the UK’s energy regulator requires gas network companies to align their investment plans with net zero pathways and to ‘identify where their baseline investment plans could impede the efficient achievement’ of plausible pathways to net zero, and ‘propose how their business plans can flex to address these impediments.’

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**New infrastructure investment should be robust under a clean transition pathway**

*Victoria’s historical and projected greenhouse gas emissions, and indicative trajectories*

<table>
<thead>
<tr>
<th>Year</th>
<th>Historical emissions</th>
<th>Projected emissions ranges in 2025 and 2030</th>
<th>Indicative trajectories to 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td></td>
<td>18% – 32%</td>
<td>2°C consistent trajectory</td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td>32% – 39%</td>
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<tr>
<td>2025</td>
<td></td>
<td>39% – 45%</td>
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<tr>
<td>2030</td>
<td></td>
<td>45% – 60%</td>
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<tr>
<td>2050</td>
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Victoria’s gas system

An overview
Victoria uses more gas than any state in Australia, with 55% of demand from residential and commercial customers.

### Gas consumption by state and sector, 2019

<table>
<thead>
<tr>
<th>State</th>
<th>Residential and commercial</th>
<th>Industrial</th>
<th>Gas powered generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victoria</td>
<td>226</td>
<td>55%</td>
<td>29%</td>
</tr>
<tr>
<td>Queensland</td>
<td>146</td>
<td>72%</td>
<td>4%</td>
</tr>
<tr>
<td>New South Wales</td>
<td>120</td>
<td>40%</td>
<td>46%</td>
</tr>
<tr>
<td>South Australia</td>
<td>99</td>
<td>11%</td>
<td>24%</td>
</tr>
<tr>
<td>Tasmania</td>
<td>10</td>
<td>44%</td>
<td>49%</td>
</tr>
</tbody>
</table>

**Victoria gas use: key facts**

- **Victoria** has historically high gas usage as a result of **abundant natural supply**, building heating requirements due to a **cool climate**, and high **population density** enabling economical gas pipeline development.
- There are over 2 million **residential and commercial** gas connections in Victoria.
- 80% of **residential** properties in Victoria have a gas connection.
- 11 **gas powered generation** plants produced 1,467 GWh in 2020, or 3.2% of the state’s electricity demand.

Source: AER (2020), OpenNEM (2021), Accenture analysis

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Victorian households use more gas and less electricity than other states

**Energy use by fuel and end use (2017-2018)**
GJ per household

- **Gas space heating**
  - Victoria: 55%
  - ACT: 11%
  - WA: 22%
  - SA: 23%
  - NSW: 17%
  - Queensland: 0%

- **Electricity**
  - Victoria: 19%
  - ACT: 48%
  - WA: 71%
  - SA: 71%
  - NSW: 76%
  - Queensland: 96%

- **Gas (other uses)**
  - Victoria: 26%
  - ACT: 41%
  - WA: 7%
  - SA: 6%
  - NSW: 7%
  - Queensland: 4%

**Residential gas consumption in Victoria: Key facts**

- Space heating is the main use case for gas in Victoria, accounting for 55% of all household energy use.
- In cold climates such as Victoria, many houses have central gas heaters with ducting to take warm air to multiple rooms.
- Victorian households use considerably more gas than comparison jurisdictions: 50 GJ/y compared with 34 GJ/y for the Netherlands and 40 GJ/y for the United Kingdom.
- Water heating is the second largest use case for gas in Victoria, accounting for 26% of all energy use.
- Gas is the most common way to provide domestic hot water in Victoria.
- Gas cooktops are commonplace in Victoria, but consume less than 2% of household energy use.

Source: Grattan Institute (2020)
Residential buildings are the largest end-use segment, but industrial, power generation and commercial are also material.

### Victorian gas consumption: Key facts

- Gas in buildings in Victoria is mostly used for **space heating**. For commercial buildings, there are some specific end-use applications like cooking and water heating in retail sectors, and dryers and pool heating in hotels.
- Most gas in the **manufacturing sector** is used for producing thermal energy via steam boilers. Heat can also be produced directly by burning gas at high temperatures.
- Gas is also used as **feedstock** for some manufacturing processes, including ammonia and polyethylene. In Victoria, the largest use of gas as a feedstock is a **plastics manufacturing facility** owned by Qenos in Altona.

### Gas consumption for energy by industry in Victoria, 2018-19

<table>
<thead>
<tr>
<th>Industry</th>
<th>PJ per annum (% of total gas usage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>113 (40%)</td>
</tr>
<tr>
<td>Gas powered generation</td>
<td>50 (17%)</td>
</tr>
<tr>
<td>Commercial</td>
<td>38 (13%)</td>
</tr>
<tr>
<td>Other industrial</td>
<td></td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>25 (9%)</td>
</tr>
<tr>
<td>Food and beverages</td>
<td>24 (8%)</td>
</tr>
<tr>
<td>Non-metallic mineral products</td>
<td>17 (6%)</td>
</tr>
<tr>
<td>Pulp, paper and printing</td>
<td>10 (3%)</td>
</tr>
<tr>
<td>Textiles and clothing</td>
<td>4 (1%)</td>
</tr>
<tr>
<td>Wood and wood products</td>
<td>3 (1%)</td>
</tr>
<tr>
<td><strong>Industrial total</strong>: 83.4 PJ (29%)</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** 1. Includes gas usage in Agriculture, Mining, Construction and Transport sectors. 2. Other manufacturing includes confidential fuel consumption data. The Australian Energy Statistics report use per financial year, while AEMO GSOO reports by calendar year so aggregate percentages may not match.

**Sources:** Australian Energy Statistics (2020), Northmore Gordon (2020), Grattan Institute (2020), Accenture analysis
Victoria may need to rely on gas imports from NSW to meet peak demand as production from Gippsland fields declines

Projected Victorian gas production and consumption
PJ per year

Gippsland plants | NSW supply | Other plants | Total Victorian consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>Gippsland</th>
<th>NSW</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>343</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>361</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>360</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td>341</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2023</td>
<td>347</td>
<td>60</td>
<td>60</td>
<td>367</td>
</tr>
<tr>
<td>2024</td>
<td>321</td>
<td>60</td>
<td>60</td>
<td>347</td>
</tr>
<tr>
<td>2025</td>
<td>265</td>
<td>60</td>
<td>60</td>
<td>381</td>
</tr>
</tbody>
</table>

Victorian gas production: Key facts

- Victoria has historically been a **net exporter of gas** to other Australian states.

- AEMO forecasts shortfalls in supply for the Eastern Australian gas market by 2024, as **Victorian production declines** and some fields in the Gippsland Basin cease production. Gas fields in the Otway Basin are also forecast to deplete at the same time.

- **LNG import terminals** have been proposed in Victoria in anticipation of potential gas shortfalls. However, plans for a floating facility proposed by AGL at Crib Point have been **rejected by the state government in 2021 due to environmental concerns.**

- Fracking and other unconventional gas exploration are permanently banned in Victoria. In 2021, this **ban was enshrined into the state’s constitution.**

Note: Actual total gas production and consumption is shown for 2019 and 2020
Sources: AEMO, (GSOO 2020, VGPR 2021), AEMO Gas Bulletin Board data, Accenture analysis

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Victoria has an extensive gas network, supplying over 2 million customers and exporting gas to neighbouring states.

- Over 2 million customers are connected to Victoria’s gas distribution networks.
- 1,900km of transmission pipelines.
- 30,000km of distribution pipelines.
- Construction of the Victorian transmission system began in the 1950s. The latest major additions to the network were between 2014 and 2017.

Sources: AER (2020), Accenture analysis
Victoria’s gas sector is privately owned by a mix of Australian and international companies and investors

<table>
<thead>
<tr>
<th>Description</th>
<th>Ownership</th>
<th>Revenue (example)</th>
<th>Structure of competition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing</td>
<td>• There are six gas processing plants in Victoria, processing gas from the Bass Strait and Otway basins</td>
<td>• Privately owned</td>
<td>• Six processing plants serving gas extraction projects</td>
</tr>
<tr>
<td></td>
<td>• The Longford Plant in South Gippsland is the largest</td>
<td>• Domestic and foreign owners</td>
<td>• Diverse ownership</td>
</tr>
<tr>
<td></td>
<td>• Other plants at Orbost, Iona, Lang Lang, Minerva and Otway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission and storage</td>
<td>• The Victorian Transmission System (VTS) is a 2,000 km network across the state</td>
<td>• VTS is privately owned by APA Group, an Australian company listed on the ASX; largest shareholders are Australian</td>
<td>• Transmission is a statewide monopoly subject to economic regulation</td>
</tr>
<tr>
<td></td>
<td>• There are several gas storage facilities across the state</td>
<td>• Largest storage site at Iona is owned by Lochard Energy</td>
<td>• Interstate pipelines are unregulated</td>
</tr>
<tr>
<td></td>
<td>• Interstate pipelines export to South Australia and New South Wales</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td>• Three gas distributors, each responsible for a separate region</td>
<td>• Privately owned, large foreign ownership share</td>
<td>• Three regional monopolies subject to economic regulation</td>
</tr>
<tr>
<td></td>
<td>• The distributors are Australian Gas Networks, Multinet and AusNet Services</td>
<td>• Australian Gas Networks are owned by CKI Group</td>
<td></td>
</tr>
<tr>
<td>Retailers</td>
<td>• Victoria has 15 different gas retailers and 19 brands</td>
<td>• AusNet Services is listed, with State Grid 32%, Singapore Power 20%, others 49%</td>
<td>• Competitive market, subject to licensing, monitoring and benchmarking by regulators (the Australian Energy Regulator and the Essential Services Commission)</td>
</tr>
</tbody>
</table>

• Privately owned
• Domestic and foreign owners

Sources: Australian Energy Regulator (2020), company reports, Accenture analysis
The economic regulation of Victoria’s gas infrastructure is not yet aligned with the State’s net zero target

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Processing</th>
<th>Transmission and storage</th>
<th>Distribution</th>
<th>Retailers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• There is no economic regulation of the gas processing market.</td>
<td>• The gas transmission network is a statewide monopoly subject to economic regulation.</td>
<td>• The three distribution networks are geographic monopolies subject to economic regulation.</td>
<td>• Full retail contestability was introduced for electricity and gas in 2002.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The Australian Energy Regulator (AER) regulates revenue and investment for the transmission network under the National Gas Law and the National Gas Rules.</td>
<td>• The AER regulates revenue and investment for the distribution networks under the National Gas Law and the National Gas Rules.</td>
<td>• In January 2009, retail price regulation was removed for both markets.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• There is an information and arbitration framework for non-regulated interstate pipelines.</td>
<td></td>
<td>• There are no regulated offers or tariffs: retailers set their own prices.</td>
</tr>
<tr>
<td>Net zero target alignment</td>
<td>• Gas processing plants report their emissions under the National Greenhouse and Energy Reporting Act.</td>
<td>• There is no direct consideration of the State’s net zero target in the economic regulatory framework for the gas transmission network.</td>
<td>• There is no direct consideration of the State’s net zero target in the economic regulatory framework for the distribution networks.</td>
<td>• Retailers are subject to licensing, monitoring and benchmarking by regulators (the Essential Services Commission and the Australian Energy Regulator).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• The regulatory framework for retailers does not directly take into account the State’s net zero target</td>
</tr>
</tbody>
</table>

Sources: Climate Change Victoria, AER 2020, Accenture analysis
Victoria committed to net zero by 2050 in 2017, but is yet to set interim targets or pathways

Mt/y

State total emissions
Natural gas
Other
State emissions from natural gas
Transport
Electricity generation
Fugitives
Direct combustion

Greenhouse gas emissions in Victoria


Current emissions

• Victoria’s total net emissions in 2018 were 102.2 Mt CO$_2$, making up almost 20% of Australia’s total emissions.
• Emissions from natural gas contributed to 17% of all greenhouse gas emissions in Victoria, majority of emissions is from other fossil fuels.
• Most gas emissions are from direct combustion, followed by emissions from fugitive, electricity generation and transport.

Pathway to net zero

• The Victorian Climate Change Act 2017 established a target of net zero emission by 2050.
• The Climate Change Act requires the Victorian Government to set five yearly interim greenhouse gas emissions reduction targets, starting in 2021.
• ‘Net zero emissions’ refers to achieving an overall balance between greenhouse gas emissions produced and greenhouse gas emissions taken out of the atmosphere.
• The Climate Change Act provides for the use of offsets to achieve net zero emissions in 2050 and to meet interim targets.

Timing

• Six interim targets periods will be set for 5-year target periods between 2021 and 2050.
• In 2019, an independent expert panel made recommendations for interim emissions reduction targets for Victoria for 2025 and 2030.
• Interim targets for 2025 and 2030 are expected to be finalised in 2021.
• The expert panel noted that offsets can provide additional flexibility to meet interim targets, but recommended prioritising the transition of the Victorian economy.
Victoria has implemented some measures to reduce emissions from natural gas

### Policy actions and progress for decarbonising the Victorian gas sector

<table>
<thead>
<tr>
<th>Buildings</th>
<th>Industry</th>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increase <strong>energy efficiency</strong> with the Victorian Energy Upgrades (VEU) program by upgrading inefficient appliances (e.g. hot water systems, and heaters).</td>
<td>• Award <strong>Gas Efficiency Grants</strong> to promote gas efficiency projects.</td>
<td></td>
</tr>
<tr>
<td>• Substitute gas stoves and hot water pumps with <strong>electric alternatives</strong> to remove the requirement of gas.</td>
<td>• Increase energy efficiency with electrification with the <strong>EREP program</strong> targeted at large users of gas.</td>
<td></td>
</tr>
<tr>
<td>• Support the development of <strong>CCS for industry and electricity generation</strong>.</td>
<td></td>
<td>• Pilots <strong>CO2CRC Otway Project</strong> has stored over 65,000 tonnes of natural carbon dioxide rich gas in depleted gas reservoirs.</td>
</tr>
<tr>
<td>• Committed to develop a <strong>renewable hydrogen industry</strong>, and is conducting multiple pilots for commercial use.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Conduct feasibilities studies of <strong>gas blending</strong> (10% hydrogen blending with natural gas).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Gas efficiency and reducing use**

**Electrification**

**Decarbonise gas with carbon capture**

**Substitute gas with hydrogen or biomethane**

---

**Government funds committed:**

- Small
- Medium
- Large

---

Note: 1. Small investment is government investment up to <A$0.5bn, medium is A$0.55bn – A$1bn and large is A$1bn or more. Expenditure category estimated.
Sources: DELWP Services, Accenture analysis

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United Kingdom
Case study
Gas usage in the UK is dominated by residential consumption and electricity generation

### Gas consumption in the UK, 20191

<table>
<thead>
<tr>
<th>Category</th>
<th>PJ per annum (% of total gas usage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>1,107 (40%)</td>
</tr>
<tr>
<td>-commercial</td>
<td>1,064 (39%)</td>
</tr>
<tr>
<td>Other industries3</td>
<td>171 (6%)</td>
</tr>
<tr>
<td>Food and beverages</td>
<td>168 (6%)</td>
</tr>
<tr>
<td>Chemicals</td>
<td>72 (3%)</td>
</tr>
<tr>
<td>Mineral products</td>
<td>71 (3%)</td>
</tr>
<tr>
<td>Paper and printing</td>
<td>50 (2%)</td>
</tr>
<tr>
<td>Iron and steel</td>
<td>16 (1%)</td>
</tr>
<tr>
<td>Textiles and leather</td>
<td>14 (1%)</td>
</tr>
<tr>
<td>Industrial total: 402 PJ</td>
<td>(15%)</td>
</tr>
</tbody>
</table>

Notes:
1) Gas consumed in the energy industry not used for power generation/transformation are excluded from these numbers.
2) Includes heat generation.
3) Includes Agriculture, Construction, Vehicles and non-ferrous metal industries. Numbers may not add to 100% due to rounding.

Sources:
- Energy Technologies Institute (2016).
- Accenture analysis.

### UK gas use: key facts

- **85% of residential properties** in the UK have a gas connection.
- Gas makes up **65% of final household energy consumption**, compared to 22% of energy from electricity.
- Around **75% of household gas use is for space heating**. A further 20% is used for water heating, and 5% for cooking.
- Gas powered generation UK provided **41% of total electricity generation** in 2019.
- In 2019, gas was the **largest provider of energy for industry** in the UK, providing 39% of total energy. Electricity provided 35%.

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After moving away from coal as a major energy source in the 1990s, gas is currently the largest source of electricity in the UK.

**The phase out of coal: key drivers**

- The UK moved away from coal in the 1990s as a result of the ‘dash-for-gas’. Favourable market conditions led to increased investment in gas over coal and nuclear.
- In the early 2000s, EU air quality legislation requirements forced coal-fired plants to adhere to emissions limits, or close operations completely by 2015. Nine plants chose to close by 2015 because the costs of upgrades to meet emissions standards were too high.
- From 2005 onwards, cost pressures from the EU Emissions Trading Scheme and policy signals from consistent investment and support for low-carbon generation have led to a continued decline in reliance on coal.
- The UK recently set a new record for the number of ‘coal free days’ – 67 days of power up to June 2020 were provided without relying on coal-fired generation.
- Coal-fired power will soon be completely phased out of the UK economy, with the government recently announcing plans to bring forward the 2025 phase-out of coal to 1 October 2024.

---

**Input for electricity generation by source, UK 1990-2019**

% of total fuel input (million tonnes of oil equivalent)

*Note: 1. Includes energy from wind, solar, waste, tide, hydro and bioenergy, as well as other fuels. Sources: UK Department of Business, Energy and Industrial Strategy (BEIS) Electricity Generation Statistics (DUKES 5.1.1), Accenture analysis*
The UK has very extensive gas infrastructure, with over 280,000km of pipelines, connecting more than 23 million homes.

UK National Transmission System and distribution networks

- Gas network
  - Gas terminals
  - Local gas networks
  - Gas pipelines

Network operators
- SGN
- Wales and West Utilities
- Northern Gas Networks
- Cadent Gas
- Firmus, SSE Airtricity and SGN

UK gas networks: key facts

- Over 23 million homes connected to gas for space heating, water heating and cooking.
- 6,600km of transmission pipelines.
- 275,000km of distribution pipelines.
- 3 LNG import terminals, and 4 international pipelines.
- Gas network infrastructure is worth around £24bn (A$43bn).
- The majority of the UK’s National Transmission system was constructed and rapidly expanded in the 1960s after natural gas was discovered in the North Sea.
- Major upgrades of the network have been underway since 2002 through the Iron Mains Risk Replacement Programme, set to run until 2032.
- Initially focused on safety concerns of ageing pipelines, the program has also reduced methane leakage and provided options to switch iron pipes with hydrogen- and biomethane-ready polyurethane piping.
- The program is replacing all iron mains at a rate of around 3,500km of pipelines per year.


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Gas production in the UK has declined since 2000, and the country now relies on imports to meet demand.

**Gas supply in the UK**

**Petajoules (PJ)**

- **Production**
- **Net imports**
- **Total demand**

Note: 1. Includes stock changes, changes, transfers and statistical difference between total production and total supply. 2. Difference between imports and exports, shown for years where UK is a net importer of gas, including LNG.

Source: Chart adapted from 'Digest of UK Energy Statistics 2020: Natural Gas' using BEIS Energy Trends Table 4.1, Accenture analysis.

**UK gas production: Key facts**

- Domestic gas production peaked in 2000, but has since **declined as gas fields in the North Sea are depleted**, and offshore processing facilities reach the end of their operating life.

- Gas imports have increased to meet demand as domestic production decreased. Most of this infrastructure was recently built in anticipation of dwindling local supply, with a UK-Netherlands pipeline opened in 2005, and **two LNG import terminals completed in 2009**.

- UK currently imports gas from Norway, the Netherlands and Belgium via pipelines, with Norway making up 57% of all UK gas imports in 2019.

- **Total LNG imports tripled between 2018-2019**, and LNG imports now make up 39% of total UK gas imports in 2019.

- The UK is **signalling plans to exit offshore gas production**, looking to confirm to a **North Sea Transition Deal** with the oil and gas industry in early 2021 to support the country’s shift away from fossil fuels.

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Carbon budgets and bold interim targets have clarified timelines for the UK’s path to net zero, with policy details expected soon

**UK carbon emission budgets**

Million tonnes carbon dioxide equivalent (MtCO₂e)

- Past carbon budgets
- Active carbon budgets
- Recommended Sixth Carbon Budget
- Headroom for IAS emissions
- Historical emissions
- Climate Change Committee’s ‘Balanced Net Zero Pathway’ scenario

**Pathway to net zero**

- In 2019, the UK government **legislated their commitment to national net-zero greenhouse gas emissions by 2050**.
- The **Climate Change Committee (CCC) provides the government with recommendations for the country’s carbon budget**, in five-yearly intervals. Recommendations for the UK’s 6th carbon budget for 2033-2037 have been laid out by the CCC, and the government is expected to release the official budget in 2021.
- The Government’s **10 Point Plan for a Green Industrial Revolution** was released in November 2020. It identifies the broad areas of expected policy action that will define the country’s pathway to net zero.
- **Detailed road maps** for specific sectors aligned with the 10 Point Plan are expected ahead of UK hosting the COP26 Climate Change conference in November 2021, including a Net Zero Strategy, Hydrogen Strategy, Industrial Decarbonisation Strategy and a Heat and Buildings Strategy.
- In 2020, the UK updated their interim target to a **68% reduction in 1990 levels of greenhouse gas emissions by 2030**. Their previous commitment was a 53% reduction by that year.

---

Note: 1. Emissions from International Aviation and Shipping

Sources: Climate Change Committee (2020), UK Government 10 Point Plan for a Green Industrial Revolution (2020), Accenture analysis

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Regulation of the UK’s gas networks is aligned to emissions targets, providing a framework to fund the path to net-zero

Ofgem is the UK’s energy network regulator
- Responsible for price regulation of gas transmission network monopoly and distribution network regional monopolies
- Pricing approach RIIO: Revenue = Incentives + Innovation + Outputs
- Latest RIIO has net-zero built into the pricing approach aims: “RIIO-2 will prepare the regulated network companies to deliver Net Zero at lowest cost to consumers, while maintaining world-class levels of system reliability”.

Economic regulation
- Gas network innovation competition: Up to £20m per year of funding available for gas network operators to demonstrate options for low-carbon gas networks.
- RIIO funding packages: Total of £40bn allocated to supporting energy networks to meet Net-Zero, including network upgrades and maintenance.

Energy network programs
- Renewable heat incentive: Funding available since 2014 to support low-carbon options for domestic and non-domestic building heating.
- H21 project
  - £9m of funding for joint project between gas distribution companies, testing feasibility of delivering 100% hydrogen to buildings through local distribution networks. Hydrogen is currently produced using steam methane reforming facilities, with plans for future production using an electrolyser powered by renewable sources of grid electricity.
- FutureGrid
  - £9m of funding for UK’s national transmission network operator National Grid to repurpose decommissioned gas transmission assets for hydrogen trials.

Sources: Ofgem (2020), H21 (2021), National Grid (2021), Energy Networks Association (2021), Accenture analysis
The United Kingdom is using a range of levers to reduce emissions from gas.

### Policy pathways for decarbonising the UK gas sector

<table>
<thead>
<tr>
<th>Gas efficiency and reducing use</th>
<th>Buildings</th>
<th>Industry</th>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Boost gas efficiency through building heating and energy efficiency grants</td>
<td></td>
<td>• Incentivise efficiency and low-carbon options for industrial processes through funding schemes and innovation competitions</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electrification</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Fund transition of local heat distribution networks to low-carbon sources</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decarbonise gas with carbon capture</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Establish two industrial CCS clusters by 2025, and additional funding for two more clusters by 2030</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Fund innovation for reducing costs of CCS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Substitute gas with hydrogen or biomethane</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Invest in options for a low-carbon gas networks, via the Gas Network Innovation Competition and network demonstrations of small-scale trials of hydrogen-powered homes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Invest in innovation for accelerating production of low-carbon hydrogen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Inject biomethane into the existing gas grid via Green Gas Support Scheme²</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: 1. Small investiture is government investment up to <£0.5bn, medium is £0.5bn - £1bn and large is £1bn or more. Expenditure category estimated. Sources: Climate Change Committee (2020), UK Government 10 Point Plan for a Green Industrial Revolution (2020), UK Government Energy White Paper (2020), UK Government Industrial Decarbonisation Strategy (2021). Accenture Analysis
The UK is investing in no-regrets energy efficiency actions and creating options for hydrogen and CCS

<table>
<thead>
<tr>
<th>Policy approach</th>
<th>Definition</th>
<th>Policy goal for gas sector</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-regrets</td>
<td>Policies and actions that have expected <strong>short-term net benefits</strong> for emissions reductions and costs</td>
<td>Boost gas use efficiency and reduce gas use</td>
<td>• Multiple funding pools to transition to lower-carbon and more efficient heating</td>
</tr>
<tr>
<td></td>
<td>Actions that <strong>involve an investment risk</strong> to open up transition pathways</td>
<td>Electrification</td>
<td>• Funding to support transitions to electric alternatives to gas in buildings and industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inject biomethane in the existing gas grid</td>
<td>• Fund biomethane injection through ‘Green Gas Levy’ on gas suppliers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use existing gas networks for hydrogen</td>
<td>• Multiple innovation funding schemes for small-scale hydrogen trials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Develop low carbon hydrogen production</td>
<td>• Fund low-carbon hydrogen production projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Support offshore gas industry transition to low-carbon future</td>
<td>• North Sea Transition Deal agreement with offshore gas sector</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Build industrial CCS clusters</td>
<td>• Pair UK’s largest industrial clusters with CCS projects, with potential to re-purpose offshore gas assets</td>
</tr>
</tbody>
</table>

Policy plans focus on phasing out unabated gas-powered generation and financing low-carbon industries

**Policy recommendations for decarbonising the UK gas sector**

<table>
<thead>
<tr>
<th>Gas efficiency and reducing use</th>
<th>Buildings</th>
<th>Industry</th>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Enforce ‘zero-carbon ready’ houses through updated Future Homes standards</td>
<td>• Use taxpayer funded mechanism to support deep decarbonisation in sectors with risks of carbon leakage</td>
<td>• Phase out unabated gas generation by 2035</td>
</tr>
<tr>
<td>Electrification</td>
<td>• Consult on updates to the Gas Act to phase out gas connections in new houses</td>
<td>• Reform industrial energy and electricity pricing to favour low-carbon options</td>
<td>• Prepare all new gas powered generation plants for hydrogen by 2025</td>
</tr>
<tr>
<td>Decarbonise gas with carbon capture</td>
<td>• Consult on standards for ‘hydrogen ready-appliances’ for residential use</td>
<td>• Develop clear business models and revenue mechanisms to encourage private investment in hydrogen and CCUS projects</td>
<td></td>
</tr>
</tbody>
</table>
The Netherlands

Case study
The Netherlands has the highest dependency on gas in Europe due to historical large supply from the Groningen field

- Annual gas consumption in the Netherlands is over 2,000 cubic meters per capita, almost three times higher than the European average.
- Gas consumption in the Netherlands is similar to Victoria, both jurisdictions have a high dependency on gas.
- Large gas consumption in the Netherlands is driven by the historical high domestic production, a comprehensive distribution grid, the dominant role of gas in heating and low gas prices.
- Consumption is reducing to support the transition to a low-carbon economy and protect the public safety from earthquakes caused by gas production.

**Groningen gas field drove Netherlands’ dependency**
- The discovery of the giant Groningen natural gas field in 1959 had a profound impact on the Dutch energy system.
- The abundant supply and national gas transport grid enabled the use of gas in households and industry and supported the transition from coal.
- However, gas production resulted in a series of severe earthquakes. Consequently, gas production rapidly decreased and will be stopped by 2022.

**Gas consumption in selected countries**
Cubic metres, per capita (2019)

<table>
<thead>
<tr>
<th>Country</th>
<th>Gas Consumption (Cubic Metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>2,100</td>
</tr>
<tr>
<td>Victoria</td>
<td>1,600</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1,200</td>
</tr>
<tr>
<td>Ireland</td>
<td>800</td>
</tr>
<tr>
<td>Spain</td>
<td>600</td>
</tr>
<tr>
<td>Europe</td>
<td>500</td>
</tr>
<tr>
<td>France</td>
<td>400</td>
</tr>
<tr>
<td>Ukraine</td>
<td>300</td>
</tr>
<tr>
<td>Poland</td>
<td>200</td>
</tr>
<tr>
<td>Denmark</td>
<td>100</td>
</tr>
<tr>
<td>Sweden</td>
<td>50</td>
</tr>
</tbody>
</table>

**Gas consumption in the Netherlands**
- Annual gas consumption in the Netherlands is over 2,000 cubic meters per capita, almost three times higher than the European average.
- Gas consumption in the Netherlands is similar to Victoria, both jurisdictions have a high dependency on gas.
- Large gas consumption in the Netherlands is driven by the historical high domestic production, a comprehensive distribution grid, the dominant role of gas in heating and low gas prices.
- Consumption is reducing to support the transition to a low-carbon economy and protect the public safety from earthquakes caused by gas production.

Sources: BP data (2019), University of Oxford (2019), Accenture analysis
Gas is a key fuel in the Netherlands; the majority of electricity is generated using gas

The largest segment for gas use is to generate electricity. Around 55% of electricity comes from gas-powered generators.

The Netherlands has an energy-intensive industrial sector. Most gas is used in chemical and industry. Industrial activity is localised in five regions with industrial clusters.

In the residential sector, ~90% of buildings are heated by gas.

Over 7 million houses are connected to the gas grid, which is now declining.

Notes: 1. Other industries include waste, agriculture, water industry and services. Numbers might not add up to 100% due to rounding.

Sources: IEA (2020), CBS (2020), Accenture analysis
Gas is more than half of the Netherlands’ electricity supply today and will significantly reduce by 2030

**Electricity generation in the Netherlands**
Share of electricity generation (2020)

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural gas</th>
<th>Coal</th>
<th>Other</th>
<th>Renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>57%</td>
<td>18%</td>
<td>5%</td>
<td>18%</td>
</tr>
<tr>
<td>2030</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>72%</td>
</tr>
</tbody>
</table>

- The majority of electricity in the Netherlands is generated by fossil fuels; 57% by gas and 18% by coal.
- Renewables have a relatively low share of electricity generation, at about 18% in 2020. This is well below the global average of 28%.

**Electricity generation in the Netherlands**

- The 2019 Climate Agreement has set 2030 targets for the electricity generation from renewables on a path to a carbon-free electricity system by 2050.
- The Agreement would see at least 70% renewable power generation by 2030 and coal-fired power generation would be entirely stopped.
- The majority of electricity is expected to be generated by solar, and onshore and offshore wind.
- A series of tenders will be announced to develop offshore wind farms, following the Dutch Offshore Wind Energy Roadmap 2030.

**Offshore wind and onshore renewables will displace fossil fuels for electricity generation by 2030**

- The 2019 Climate Agreement has set 2030 targets for the electricity generation from renewables on a path to a carbon-free electricity system by 2050.
- The Agreement would see at least 70% renewable power generation by 2030 and coal-fired power generation would be entirely stopped.
- The majority of electricity is expected to be generated by solar, and onshore and offshore wind.
- A series of tenders will be announced to develop offshore wind farms, following the Dutch Offshore Wind Energy Roadmap 2030.

The Netherlands has transitioned from net exporter to net importer of gas

Gas production and demand in the Netherlands
Billion Nm³

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
<th>Domestic demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>2005</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>2010</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>2015</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>2020</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>2025</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>2030</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Demand for gas exceeds domestic supply**

- The Groningen natural gas field is one of the largest onshore gas fields in the world.
- The discovery of the giant Groningen natural gas field in 1959 had big implications for the Dutch energy system. The abundant and cheap gas supply enabled gas use in households and industry.
- Extensive gas extraction resulted in a series of earthquakes in Groningen.
- Groningen production has declined since 2013, and the Netherlands has been a net gas importer since 2017. Production from Groningen will be fully halted by 2022.

**The Netherlands has transformed from a net exported to a net importer of gas**

- The Netherlands was a net exporter, has transitioned to net importer due to lowered production.
- Gas imports are expected to increase over time. Most of the gas is imported from Norway, Russia and the United Kingdom.
- A network of pipelines connects the Netherlands with Germany, Belgium and the UK to import gas.

The Netherlands has a significant gas network for residential, commercial and industrial customers

Gas infrastructure in the Netherlands

• The gas distribution and transmission networks have a combined length of over 136,000 km, almost 4 times longer than Victoria.
• There are more than 7 million households connected to the gas network, which is over 90% of all households.
• The number of gas connections is reducing as a result of decarbonisation of the gas infrastructure.

Transmission network

• The gas transmission network is operated by GTS (Gasunie Transport Service), which is owned by Gasunie, a private-public partnership between the state of the Netherlands, Shell and ExxonMobil.
• The network is divided into the transmission network and the regional transport network.
• Transmission network of over 12,000 km, compared to 1,900 km in Victoria. The network is connected to neighbouring countries for the import and export of gas. Besides that, there is also export via the BBL pipeline to the UK.
• Parallel networks exist for gas for residential use (‘L-gas’) and industrial use (‘H-gas’). These networks are connected via blending stations.

Distribution network

• The distribution network provides L-gas to small users of gas, households and SMEs.
• The network is split in 7 regional networks and is operated by private network administrators.

The Netherlands’ climate goals are more ambitious than Europe-level goals

<table>
<thead>
<tr>
<th>Global climate goals</th>
<th>European goals</th>
<th>Dutch goals</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paris Agreement in 2015</td>
<td>• Limit global warming to less than 2°C.</td>
<td>• Reduction of energy usage of 32.5%.</td>
<td>• Net zero by 2050 (in negotiation).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Aim for global warming to less than 1.5°C.</td>
<td>• Reduction greenhouse gas emissions of at least 40% (compared to 1990).</td>
<td>• 80-95% reduction of greenhouse gas emissions (compared to 1990).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Works on a 5-year cycle of increasingly ambitious climate action carried out by countries.</td>
<td>• At least 32% electricity generated with renewables.</td>
<td>• 95% reduction of greenhouse gas emissions (compared to 1990).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 49% reduction of greenhouse gas emissions (compared to 1990).</td>
<td>• 100% electricity generated with renewables.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• A push for a 55% reduction of greenhouse gas emissions is proposed by the Netherlands.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: Paris Agreement (2015), National Climate Agreement, the Netherlands (2019), Accenture analysis
The Netherlands is adopting a full set of measures to decarbonise gas

<table>
<thead>
<tr>
<th>Policy actions and progress for decarbonising the Dutch gas sector</th>
<th>Government funds committed:</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas efficiency and reducing use</strong></td>
<td><strong>Buildings</strong></td>
<td>• Require all new buildings meet the <strong>Almost Energy Neutral Building requirements</strong> and limit energy consumption from 2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Industry</strong></td>
<td>• Impose a <strong>carbon tax</strong> “on every ton emitted exceeding a fixed reduction path” in 2021 to promote efficiency in industries</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Generation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Electrification</strong></td>
<td><strong>Buildings</strong></td>
<td>• Transition buildings and houses from the gas network</td>
<td>• Provide heat to buildings with electric pumps or <strong>district heating networks</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Industry</strong></td>
<td>• Transition to <strong>electrifying low temperature</strong> heating processes in industry from 2025</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Generation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Substitute gas with hydrogen or biomethane</strong></td>
<td><strong>Buildings</strong></td>
<td>• Scale up green gas projects for <strong>biomethane</strong> to replace natural gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Industry</strong></td>
<td>• Examine substitution of natural gas with <strong>hydrogen</strong> in industry</td>
<td>• Develop large-scale green hydrogen production using offshore wind power</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Generation</strong></td>
<td>• Prepare new gas-powered generation plants for <strong>hydrogen and/or CCS by 2030</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Decarbonise gas with carbon capture</strong></td>
<td><strong>Buildings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Industry</strong></td>
<td>• Subsidise <strong>CCUS projects</strong> to capture and store CO₂ from industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Generation</strong></td>
<td>• Subside CCUS projects</td>
<td>• <strong>Residual emissions</strong> from electricity generation could be stored by CCS</td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1. Small investiture is government investment up to <€0.5bn, medium is €0.5bn - €1bn and large is €1bn or more. Expenditure category estimated.

Dutch ‘no-regrets’ policies focus on reducing gas usage

<table>
<thead>
<tr>
<th>Policy approach</th>
<th>Policy goal for gas sector</th>
<th>Strategy</th>
</tr>
</thead>
</table>
| **No-regrets**  | Reducing gas use in buildings | • Implementation of Almost Energy Neutral Building requirements for all new buildings from 2021  
• Transitioning buildings from the gas network (including phasing out 200,000 existing homes per year, targeting 1.5 million homes and 15% of commercial and public buildings natural gas free by 2030) and providing heat to buildings in alternative ways |
|                 | Reducing gas use in industry | • Introducing carbon tax has been introduced to ensure a reduction in CO₂ in industry in line with the industry target in the Climate Agreement |
|                 | Decommissioning of the Groningen gas field | • Decommissioning of the Groningen gas field in 2022 will accelerate the reduction of gas use in the Netherlands |
| **Creating options** | Funding CCUS for industrial use | • Decarbonising gas use for processes where replacement of gas is not possible, by capturing CO₂ emissions from major industries with the CCUs projects in the Port of Rotterdam and Amsterdam |
|                 | Exploring the use of hydrogen and biofuels in industry | • Planning to accelerate production of low-carbon hydrogen and biomethane through the and Dutch Hydrogen Strategy and Green Gas Roadmap  
• Planning and conducting initial studies for replacing natural gas with hydrogen in industry.  
• Developing Europe’s largest green hydrogen project: NortH2 |

The Netherlands will decarbonise gas with a strategy of energy efficiency, electrification, substitution and CCS

<table>
<thead>
<tr>
<th>Approaches to decarbonise gas in the Climate Agreement from the Dutch Government</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Buildings</strong></td>
</tr>
<tr>
<td>Gas efficiency and reducing use</td>
</tr>
<tr>
<td>Electrification</td>
</tr>
<tr>
<td>Decarbonise gas with carbon capture</td>
</tr>
<tr>
<td>Substitute gas with hydrogen or biomethane</td>
</tr>
</tbody>
</table>

European subsidies and Dutch grants support Porthos, an industrial scale CCUS project in the Port of Rotterdam

**Partners**
- Porthos is a joint venture between the Port of Rotterdam Authority, Gasunie and EBN.
- Gasunie is the gas network owner and EBN is the state-owned upstream hydrocarbons company with expertise in offshore infrastructure.
- Joint development agreements have been signed with four industry partners to capture and store CO₂ from industrial processes.

**Goal and progress**
- Porthos will store 2.5 million tonnes of CO₂ from industry annually for 15 years in empty gas fields beneath the North Sea, up to 10% of industrial CO₂ emissions in the Netherlands.
- The project’s feasibility study was completed in April 2018. Construction is planned for 2022-2023 and the system will be fully operational from 2024 onwards.

**Cost-effectiveness**
- Cost effectiveness of CSS and other CO₂ emission reducing methods was assessed by the Netherlands Environmental Assessment Agency.
- Their analysis assessed that the cost-effectiveness of CSS is similar to solar panels and wind farms, making this a feasible option for CO₂ emission reduction.

**Subsidies and funding**
- Porthos received grants from the Dutch government (€1,2 million) and European Commission (€6,5 million).
- The European Union has provided a subsidy of €102 million to realise the infrastructure.
- Industry targets for €2 billion funding from the sustainable energy transition subsidy scheme (SDE++) from the Dutch government.

**Sources:** Porthos CO₂ (2020), Accenture analysis
CCS can be a cost-effective approach to reduce large amounts of CO₂ emissions, but policy incentives are important for its success.

Cost effectiveness and potential for CO₂ reduction measures in 2030 (in the Netherlands)
EUR per reduced ton CO₂

<table>
<thead>
<tr>
<th>Measure</th>
<th>Annual reduction potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry efficiency savings</td>
<td>0</td>
</tr>
<tr>
<td>Increased efficiency greenhouses</td>
<td>5</td>
</tr>
<tr>
<td>Solar panels</td>
<td>10</td>
</tr>
<tr>
<td>CCS</td>
<td>100</td>
</tr>
<tr>
<td>Substitute coal by gas</td>
<td>200</td>
</tr>
<tr>
<td>Wind farms</td>
<td>300</td>
</tr>
<tr>
<td>Biomass</td>
<td>400</td>
</tr>
<tr>
<td>Houses (isolation)</td>
<td>500</td>
</tr>
<tr>
<td>Houses (zero gas use)</td>
<td>600</td>
</tr>
<tr>
<td>Houses (heat pumps)</td>
<td>700</td>
</tr>
<tr>
<td>Green gas</td>
<td>800</td>
</tr>
</tbody>
</table>

CCS has a high CO₂ reduction potential and is relatively cost-effective

- Cost-effectiveness of approaches to reduce CO₂ emissions in the Netherlands by 2030 was assessed by the Netherlands Environmental Assessment Agency.
- The analysis assessed the costs per reduced ton of CO₂ and their annual reduction potential.
- The report revealed that capturing CO₂ with CSS is a relatively cost-effective measure with a high reduction potential.
- Costs per reduced emissions are similar to electricity generation via renewables (solar and wind farms) or substituting coal with gas.

Policy design is a success factor for CSS

- A recent study assessed 12 project attributes that the literature identified as possible determinants for CSS project outcomes.
- The results of this study suggest that the credibility of revenues and incentives to be among the most important attributes, along with capital cost and technological readiness.
- Improving the prospects for investment in CCS will depend on addressing these challenges.
Canada: Alberta & British Columbia

Case studies
British Columbia is expected to surpass Alberta to become Canada’s largest gas producer by 2035

**Canadian gas production by province**

*Billion cubic meters per day*

<table>
<thead>
<tr>
<th>Year</th>
<th>British Columbia</th>
<th>Alberta</th>
<th>Saskatchewan</th>
<th>Rest of Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>18.5</td>
<td>12.3</td>
<td>3.2</td>
<td>0.1</td>
</tr>
<tr>
<td>2025</td>
<td>19.2</td>
<td>12.6</td>
<td>3.3</td>
<td>0.1</td>
</tr>
<tr>
<td>2030</td>
<td>20.1</td>
<td>13.0</td>
<td>3.4</td>
<td>0.1</td>
</tr>
<tr>
<td>2035</td>
<td>21.0</td>
<td>13.4</td>
<td>3.5</td>
<td>0.1</td>
</tr>
<tr>
<td>2040</td>
<td>21.9</td>
<td>13.8</td>
<td>3.6</td>
<td>0.1</td>
</tr>
<tr>
<td>2045</td>
<td>22.8</td>
<td>14.2</td>
<td>3.7</td>
<td>0.1</td>
</tr>
<tr>
<td>2050</td>
<td>23.7</td>
<td>14.6</td>
<td>3.8</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**Natural gas production in Canada**

**Alberta**
- Alberta has historically been Canada’s largest gas producer, accounting for 63% of total Canadian production in 2020.
- Production is forecasted to remain high, with both provincial and federal governments laying out visions to use gas a way to phase out coal-fired power plants.
- Gas production in Alberta is predicted to increase to match oil sands production in the province over the coming decade.

**British Columbia**
- Under scenario modelling by Canada’s Energy Regulator, British Columbia is expected to surpass Alberta’s production levels to become Canada’s largest natural gas producer by 2035.
- As countries look to move away from coal as a source of energy, British Columbia is positioning itself to become a major global exporter of gas.
- LNG Canada, a terminal in the north of the province, will be Canada’s first LNG export terminal and is expected to be completed by 2025. The project is a joint venture between 5 international companies, with around CA$40bn dollars of total investment. Two Japanese gas utilities companies has signed long-term LNG purchasing contracts with Mitsubishi, which owns around 15% of the project.

Notes: 1. Projections are from the ‘Evolving Scenario’, which assumes that action to reduce GHG emissions continues at a rate similar to recent Canadian and global trends.

Sources: Canada Energy Regulator, Canada’s Energy Future Data Appendices (2020)
Despite similar production trends, Alberta uses six times more gas than British Columbia due to a large industrial sector.

**Canadian gas consumption, 2019**
Gigalitres (% of province total use)

<table>
<thead>
<tr>
<th>Province</th>
<th>Gas powered generation</th>
<th>Residential and commercial</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>12%</td>
<td>60%</td>
<td>28%</td>
</tr>
<tr>
<td>British Columbia</td>
<td>71%</td>
<td>48%</td>
<td>24%</td>
</tr>
<tr>
<td>Ontario</td>
<td>17%</td>
<td>60%</td>
<td>28%</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>12%</td>
<td>60%</td>
<td>28%</td>
</tr>
<tr>
<td>Quebec</td>
<td>17%</td>
<td>60%</td>
<td>28%</td>
</tr>
<tr>
<td>Manitoba</td>
<td>12%</td>
<td>60%</td>
<td>28%</td>
</tr>
<tr>
<td>Alberta</td>
<td>71%</td>
<td>48%</td>
<td>24%</td>
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<td>28%</td>
</tr>
<tr>
<td>Manitoba</td>
<td>12%</td>
<td>60%</td>
<td>28%</td>
</tr>
</tbody>
</table>

**Western province gas usage: key facts**

- **Alberta**
  - Accounted for 55% of total Canadian gas demand in 2018.
  - Gas provided 61% of total industrial energy use in 2018.
  - Gas accounts for 89% household space heating and 94% of water heating.

- **British Columbia**
  - Accounted for 6% of total Canadian gas demand in 2018.
  - Gas provided 24% of total industrial energy use in 2018.
  - Gas accounts for 54% of household space heating and 80% of water heating.

Notes: Industrial includes agriculture and transport industries, and total gas used as a feedstock. Values are total gas used for energy and electricity. Sources: Statistics Canada, Table 25-10-0030-01 (2021), Natural Resources Canada Comprehensive Energy Use Database (2018), Accenture analysis.
Alberta’s oil and gas sector makes up 45% of the province’s total gas use, due to energy-intensive extraction processes.

Gas consumption in Alberta by sector, 2019
Gigalitres per annum used for energy (% of total)

- Mining and oil and gas extraction: 21,235 (45%)
- Gas powered generation (utilities): 5,672 (12%)
- Gas powered generation (industry): 5,472 (12%)
- Residential: 4,512 (10%)
- Commercial: 3,913 (8%)
- Transport: 2,213 (5%)
- Chemicals: 2,062 (4%)
- Other industries: 1,381 (3%)
- Refined petroleum products manufacturing: 449 (1%)
- Paper and printing: 431 (1%)

Note: 1. Other industries includes metal, cement, refined petroleum products and other manufacturing, construction and agriculture.

Sources: Statistics Canada, Table 25-10-0030-01 (2021), Canada Energy Regulator (2021), Accenture analysis

Alberta industrial gas use: key facts

- Alberta is one of the world’s largest oil-producing regions. Since 2000, the oil and gas industry contributed on average around 20% of the province’s GDP.

- Around 75% of Alberta’s crude oil is produced from oil sands – an energy-intensive process that requires large amounts of steam to heat bitumen deposits.

- Gas is central to Alberta’s oil production, providing most of the required energy for production and processing.

- Oil sands operations in Alberta account for around 25% of total Canadian gas demand.
Gas currently makes up 48% of Alberta’s electricity generation and is expected to replace coal-fired generation by 2030.

### Electricity generation by source, Alberta 2005-2030

<table>
<thead>
<tr>
<th>Year</th>
<th>Coal</th>
<th>Gas</th>
<th>Total renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>55%</td>
<td>25%</td>
<td>30%</td>
</tr>
<tr>
<td>2010</td>
<td>50%</td>
<td>30%</td>
<td>20%</td>
</tr>
<tr>
<td>2015</td>
<td>45%</td>
<td>35%</td>
<td>20%</td>
</tr>
<tr>
<td>2020</td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>2025</td>
<td>35%</td>
<td>45%</td>
<td>20%</td>
</tr>
<tr>
<td>2030</td>
<td>30%</td>
<td>50%</td>
<td>20%</td>
</tr>
</tbody>
</table>

### Alberta’s changing electricity profile

- Alberta is an outlier in Canadian electricity generation profile. Most provinces rely on hydroelectric power for the majority of their electricity generation. As a whole, Canada generates 9% of its electricity from natural gas.
- In 2015, Alberta’s government announced plans to close the province’s remaining 14 coal-fired power plants by 2030.
- In the interim, coal-fired facilities are shifting to co-firing natural gas alongside coal.
- Alberta’s government is pursuing plans to remove impact assessment requirements for new natural gas generation, highlighting their long-term plans to consolidate the role of gas in the electricity generation mix.

Notes: 1. Projections are from the ‘Evolving Scenario’, which assumes that action to reduce GHG emissions continues at a rate similar to recent Canadian and global trends. 2. Total renewables includes wind, hydro, tidal, solar, biomass and geothermal.

Sources: Canada Energy Regulator, Canada’s Energy Future Data Appendices (2020)

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Alberta has the most extensive gas infrastructure in Canada, with over almost 30,000km of pipelines.

**Western province gas infrastructure: key facts**

- Alberta and British Columbia have Canada’s largest gas pipeline infrastructure.
- The NGTL system and the Alliance pipeline are both in Alberta, with a combined length of more than 30,000km.
- The Westcoast Energy Pipeline System is located in British Columbia, and is over 5,000km long.
- 58% of Canada’s underground natural gas storage is located in Alberta.
- Major infrastructure upgrades are expected in both Alberta and British Columbia in 2021. Network owner TC Energy has committed a total of CA$10bn of new upgrades to the NGTL network.

**Canadian natural gas infrastructure**

Sources: Canada Energy Regulator, National Energy Board (2018), TC Energy (2021), Accenture analysis
Alberta is investing in options for hydrogen and making a large investment in CCS alongside natural gas.

Policy pathways for decarbonising the UK gas sector

<table>
<thead>
<tr>
<th>Buildings</th>
<th>Industry</th>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas efficiency and reducing use</td>
<td>• Investing CA$80m in Industrial Energy Efficiency and CCUS Grant Program for industrial emitters regulated through the Technology Innovation and Emissions Reduction Regulation</td>
<td></td>
</tr>
<tr>
<td>Electrification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decarbonise gas with carbon capture</td>
<td>• Invested CA$1.24bn in two commercial-scale CCS projects to reduce emissions from oil sands and fertilizer sectors.</td>
<td></td>
</tr>
<tr>
<td>Substitute gas with hydrogen or biomethane</td>
<td>• Offer carbon credits for regulated facilities that reduce emissions below their reduction targets through Alberta’s Carbon Offset Program, including credits for biogas production, CCUS and energy efficiency</td>
<td></td>
</tr>
<tr>
<td>• Develop a provincial hydrogen strategy, in line with national Canadian hydrogen strategy, with a vision to export hydrogen by 2040</td>
<td>• Invest CA$63m to fund bioenergy projects, including projects to produce electricity from biogas combustion</td>
<td></td>
</tr>
</tbody>
</table>

Note: 1. Small investment is government investment up to <CAD$500m, medium is CAD$500m - CAD$1bn and large is CAD$1bn or more.

Source: Alberta Government, Alberta’s Natural Gas Vision and Strategy (2020)
Government funding kick-started two commercial CCS projects in Alberta, providing capacity to capture 2.8 Mt CO$_2$ per year.

**Alberta’s CCS projects: Key facts**

- **Quest** began operating in 2015 and is owned and operated by Shell Canada.
- The Quest facility captures around one-third of the total CO$_2$ emissions from an oil sands production facility near Edmonton, Alberta.
- Quest was designed to capture around 1.1 Mt CO$_2$ emissions per year. Over 5 Mt CO$_2$ emissions have been captured to date.

- The **Alberta Carbon Trunk Line (ACTL)** system transports CO$_2$ emissions from two fertiliser production facilities to usage and storage facilities in Central Alberta, 240km away.
- The system has an expected capacity of around 1.7 Mt CO$_2$ per year. Since commencing operation in 2020, around 1 Mt CO$_2$ has been captured.
- The system has pipeline capacity to transport up to 14.6 Mt CO$_2$ per year, providing options for future CCS projects in the region.

---

**CCS project committed funding from government to date**

$millions, AUD equivalent

- **Quest**: $775 (State or provincial government funding), $125 (Federal government funding), $900 (Total).
- **ACTL system**: $515 (State or provincial government funding), $66 (Federal government funding), $580 (Total).
- **CarbonNet**: $55 (State or provincial government funding), $95 (Federal government funding), $150 (Total).

Emissions from Alberta’s oil and gas sector present major challenges for Canada’s national net-zero ambitions.

- In 2020, the Canadian government announced ambitions to achieve net-zero by 2050. The Canadian Net-Zero Emissions Accountability Act sets out plans to legislate the target and formalises 5-yearly reporting requirements, but does not yet include any legally binding obligations.
- Canada introduced a federal carbon tax in 2019, to be put in place as a ‘back-stop’ for provinces that choose not to introduce their own carbon pricing mechanisms. The current price is CA$40 per tonne and will rise to CA$170 per tonne by 2030. Some Canadian jurisdictions have also committed to net-zero by 2050.
- Alberta currently accounts for one third of Canada’s total greenhouse gas emissions and does not have any emissions targets in place.
- Oil sands production in Alberta currently accounts for around 26% of the province’s greenhouse gas emissions. Plans for a cap on oil sands emissions have recently been announced by Alberta’s government but are not yet in place.
- In 2019, Alberta’s government repealed a provincial carbon tax, and issued a court challenge against the national carbon tax. The national tax was upheld by the Supreme Court.

Sources: Canada Energy Regulator (2020), Alberta Innovates (2021), Accenture analysis.
In British Columbia, residential and commercial buildings account for the largest share of gas usage

Gas consumption in British Columbia by sector, 2019
Gigalitres per annum used for energy (% of total)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Gigalitres</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>2,031</td>
<td>26%</td>
</tr>
<tr>
<td>Commercial</td>
<td>1,345</td>
<td>17%</td>
</tr>
<tr>
<td>Mining and oil and gas extraction</td>
<td>1,093</td>
<td>14%</td>
</tr>
<tr>
<td>Other industries</td>
<td>1,077</td>
<td>14%</td>
</tr>
<tr>
<td>Paper and printing</td>
<td>716</td>
<td>9%</td>
</tr>
<tr>
<td>Transport</td>
<td>692</td>
<td>9%</td>
</tr>
<tr>
<td>Gas powered generation (utilities)</td>
<td>456</td>
<td>6%</td>
</tr>
<tr>
<td>Gas powered generation (industry)</td>
<td>410</td>
<td>5%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>22</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

Notes: 1. Other industries includes metal, cement and other manufacturing, construction and agriculture.
Sources: Statistics Canada, Table 25-10-0030-01 (2021), Natural Resources Canada Comprehensive Energy Use Database (2018), Accenture Analysis

British Columbia gas use: key facts

- Natural gas accounts for around **48% of total household energy use** in British Columbia. Electricity accounts for 43%.
- In commercial buildings, gas is used for around **43% of total energy use**. Electricity accounts for 54%.
- British Columbia’s upstream oil and gas sector accounts for the largest industrial consumption of gas.
British Columbia is a large gas producer, but exports most of its production to the United States and the rest of Canada

**Gas production in British Columbia, 2005 - 2019**

<table>
<thead>
<tr>
<th>Year</th>
<th>Exports</th>
<th>BC usage</th>
<th>Total BC production</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2009</td>
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<td></td>
<td></td>
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<tr>
<td>2011</td>
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<td>2013</td>
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<tr>
<td>2015</td>
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<td></td>
</tr>
<tr>
<td>2017</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**British Columbia natural gas production: key facts**

- British Columbia currently produces **one-third of Canada’s natural gas** and is well positioned to begin shipping significant volumes gas to meet growing energy demand in Asia.
- Around **80% of natural gas produced in the province is exported** to the United States and Canadian provinces.
- Gas is **exported to the United States** via the Westcoast Energy Pipeline System.
- Some gas is **exported to Alberta** and to other provinces through the NGTL or Alliance pipelines.

Note: Exports are displayed as net exports (total exports – total imports)

Sources: Statistics Canada, Table: 25-10-0030-01 (2021), Canada Energy Regulator (2021), Accenture analysis
Natural gas makes up only 2% of electricity generation in British Columbia

**Electricity generation by source, 2019**

<table>
<thead>
<tr>
<th>Source</th>
<th>% (PJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>90%</td>
</tr>
<tr>
<td>Other renewables</td>
<td>8%</td>
</tr>
<tr>
<td>Gas</td>
<td>2%</td>
</tr>
<tr>
<td>Oil and petroleum products (&lt;1%)</td>
<td></td>
</tr>
</tbody>
</table>

There are only 5 gas-fired power stations in operation in the province, supplying a total of 2% electricity generation needs. Two of these plants are co-generation plants, supplying both heat and power for industrial and agricultural processes.

90% of electricity in British Columbia is produced from hydroelectric sources, including tidal and wave due to availability of natural resources. Small amounts of oil are used to power remote off-grid communities.

British Columbia is a net exporter of energy, exporting natural gas and electricity, and importing some refined petroleum products.

Note: Exports are displayed as net exports (total exports – total imports).
Sources: Statistics Canada, Table: 25-10-0030-01 (2021), Canada Energy Regulator (2021), Accenture analysis
While producing gas for export, the CleanBC plan provides policy support for gas efficiency in buildings and industry.

### British Columbia’s CleanBC policy recommendations and actions for gas usage

<table>
<thead>
<tr>
<th>Buildings</th>
<th>Industry</th>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas efficiency and reducing use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Fund building efficiency upgrades, heat pumps and electric water heaters via BetterHomesBC rebate program, and some local government schemes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Upgrade and retrofit government buildings through CleanBC government buildings program</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Electrification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Decarbonise gas with carbon capture</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Substitute gas with hydrogen or biomethane</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Offer carbon credits for using renewable natural gas blends, paid for by consumers through their gas distributor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Introduce minimum requirement of 15% renewable natural gas in the existing gas grid by 2030</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Enforce regulations to reduce methane leakage from oil and gas sector by 45% by 2025</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Incentivise industrial emission reductions with a carbon tax rate, set to increase to $50 per tonne in 2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Develop regulatory frameworks for CCS projects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Develop regulatory frameworks for CCS projects</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sources:** British Columbia Government, CleanBC plan (2019), Accenture analysis
Japan
Case study
Japan is dependent on fossil fuel imports for its energy needs, with imported LNG making up 23% of total energy supply.

Overview of Japan’s energy mix

- Japan is **highly dependent on imported fossil fuels** for its energy mix, as it lacks domestic reserves of fossil fuels. Therefore, substantial amounts of crude oil, natural gas (as LNG) and coal are imported.
- Energy provided by imported fossil fuels provide for 88% of all energy supply, one of the highest importers among OECD countries.
- The remainder 12% of energy production is from domestic sources, such as nuclear power and renewables.
- **Gas plays a significant role in energy supply for Japan.** Gas is the largest source for electricity generation, accounting for 34% of all energy generation.

Nuclear power generation has reduced since March 2011

- **Nuclear power generation made a large contribution** to electricity production until 2011, contributing up to 20% of all energy supply.
- This contribution declined significantly in 2011, when a tsunami hit the coast of Tohoku and the Fukushima plant went into meltdown.
- Public confidence in nuclear electricity at record low levels following the accident, and **90% of all operational nuclear power reactors were suspended**.
- Lower nuclear output led to a decrease in energy self-sufficiency and an increase in electricity costs and carbon emissions.
Japan has set an ambitious new 2030 emissions reductions target

Annual greenhouse gas emissions
Thousand tonnes, 1990-2018

Japan’s greenhouse gas emissions have remained high since 1990
- Japan’s high dependency on fossil fuels has resulted in high greenhouse gas emissions.
- Electricity generation represents almost 50% of all greenhouse gas emissions. Emissions increased following the Fukushima accident and subsequent nuclear shutdown.
- Greenhouse gas emissions started to reduce from 2015. This was driven by the expansion of renewable power generation, energy efficiency improvements and the restart of some nuclear power plants.

Japan has nearly doubled its 2030 emissions reduction goal
- At the US-sponsored Climate Summit in April 2021, Japan increased its 2030 emissions reduction target from 26% to 46%. Prime Minister Suga indicated that the country would strive to exceed that pledge and reduce emissions by 50% by that year.
- Japan is reviewing its Strategic Energy Policy and is likely to aim for lower use of carbon-emitting fossil fuels in the electricity mix to help achieve the emissions reduction goal.

Sources: OECD Stats (2020), Accenture analysis
Natural gas is set to play a smaller role in Japan’s electricity mix

Japan’s superseded 26% target would have seen gas decline as a share of electricity production
Share of electricity mix¹ (%)

The role of natural gas in Japan’s energy mix today
- Gas accounts for 35% of Japan’s electricity generation, playing an important role in Japan’s energy system. Natural gas has helped to meet the shortfall from declining nuclear generation.
- **Almost 70% of natural gas consumption is for electricity production.** Other end uses for gas are industry (14%), residential (8%) and services/other² (8%).
- Japan is the world’s largest LNG importer. The majority of LNG is imported from Australia, Qatar and Malaysia.

To meet the new more ambitious -46% 2030 target, gas is likely to play a smaller role in Japan’s energy mix
- It is likely that the role of gas in Japan’s energy mix will change to meet the government’s new emissions reduction goal.
- The International Energy Agency recommended that Japan clearly define the role of natural gas in achieving its greenhouse emissions reduction goals to provide clarity to gas companies for long-term LNG procurement strategies and infrastructure investments.
- Renewables and zero-carbon fuels will play a major role in meeting the country’s 2030 goals.
- Japan plans to use hydrogen to replace gas for flexible power generation, setting targets in December 2020 for hydrogen and ammonia-based generation.

### Japan’s superseded 26% target would have seen gas decline as a share of electricity production

<table>
<thead>
<tr>
<th>Year</th>
<th>Coal</th>
<th>Oil</th>
<th>Gas</th>
<th>Nuclear</th>
<th>Renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>8</td>
<td>35</td>
<td>21</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>2030</td>
<td>33</td>
<td>3</td>
<td>24</td>
<td>21</td>
<td>24</td>
</tr>
</tbody>
</table>

Note: 1. May not add up to 100 due to rounding 2. Services/other includes commercial and public services, agriculture, forestry, and fishing.
Sources: IEA Japan (2021), Bernstein Research, Accenture analysis

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Hydrogen will contribute to Japan’s diverse energy mix and help it reach net zero by 2050

<table>
<thead>
<tr>
<th>Options</th>
<th>Clean energy</th>
<th>Justification</th>
</tr>
</thead>
</table>
| Renewables | ✓            | • Japan has set a 46% emissions reduction target for 2030. Japan will increase electricity generation with renewables, via hydro, solar, bioenergy and wind.  
• Japan aims to be a world leader in offshore wind electricity generation, with plans to install up to 45 gigawatts of capacity by 2040.  
• Japan’s high population density and geographic characteristics make expansion of solar capacity difficult. |
| Hydrocarbons | ✗           | • Japan lacks domestic reserves of hydrocarbons and is reliant on imports for domestic energy supply. Japan is reliant on overseas fuels for 88% of its primary energy supply, one of the highest among OECD countries.  
• Japan’s hydrocarbon use contributes to high levels of CO₂ emissions. |
| Nuclear     | ✓            | • Nuclear had a share of almost 25% of electricity generation before the Great East Japan Earthquake in March 2011 and the accident at the Fukushima plant.  
• Public confidence in nuclear electricity at record low levels following the accident and 90% of all operational nuclear power reactors was suspended. |
| Hydrogen     | ~            | • Hydrogen is expected to be an important way to diversify Japan’s energy security and replace gas as an energy source.  
• Japan was the first country in the world to develop a “Basic Hydrogen Strategy” to build a low-cost, high-volume hydrogen supply chain.  
• Japan’s initial imports may be ‘brown’ hydrogen produced from coal. |

Sources: IEA Japan (2021), IAEA (2021), Accenture analysis
Japan plans to import hydrogen to diversify its energy mix and reduce emissions

**Japan’s Basic Hydrogen Strategy**

| **Japan faces energy supply challenges** | • Japan is highly dependent on fossil fuels. Almost 90% of its primary energy supply is from fossil fuels imported from overseas.  
• Japan’s self-sufficiency ratio for energy is the second lowest among the 34 OECD countries.  
• Japan has committed to net zero emissions by 2050. |
| **Hydrogen could play a major role as future energy carrier** | • Japan is seeking to energy supply needs to be diversified to reduce risks in procurement and supply.  
• Japan’s CO₂ emissions need to be reduced in electricity generation, transport, heating and industrial processes.  
• **Hydrogen has been identified as important energy carrier** in Japan’s future energy system. |
| **Japan has set targets for imports of green and blue hydrogen** | • Japan plans to develop a commercial-scale supply chain to procure **300,000 tons of hydrogen annually** by 2030, equivalent to 36 PJ, roughly equivalent in output to a nuclear reactor.  
• Its strategy refers to importing **green and blue hydrogen**.  
• Japan will look to reduce the cost of hydrogen over time to make it more competitive with other energy sources taking into account climate costs. |
| **Use cases** | **Electricity generation, mobility, industry**  
• Japan is looking to commercialise **hydrogen for electricity generation** and will seek to bring costs into line with LNG-powered generation.  
• Japan aims to increase the number of **hydrogen fuel cell vehicles** to 200,000 by 2025 and 800,000 by 2030, to increase the number of **hydrogen filling stations** to 320 by 2025, and to develop and commercialise **hydrogen fuel cell trucks**.  
• Japan will also explore the potential to use hydrogen to reduce emissions in **industrial processes** and for heat where electrification is difficult. |

Sources: METI (2019), Accenture analysis
Japan aims to build a commercial hydrogen fuel supply chain with plans to import 36 PJ of hydrogen by 2030

### Japan’s hydrogen demand potential 2025-2030

<table>
<thead>
<tr>
<th>Year</th>
<th>High hydrogen scenario</th>
<th>Low hydrogen scenario</th>
<th>Medium hydrogen scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2026</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2027</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2028</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2029</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Japan is a world leader in the uptake of hydrogen as an energy source and is expected to dramatically develop hydrogen use.
- Japan’s 2017 hydrogen strategy aims for 36 PJ (300,000 tonnes) of hydrogen imports annually by 2030.

### Australia’s potential in the hydrogen market

- Australia has a long history of exporting coal and natural gas to Japan.
- Australia’s free trade agreements with Japan could provide a competitive advantage over other potential suppliers of hydrogen without established trading relationships.
- The Hydrogen Energy Supply Chain (HESC), a consortium of Australian and Japanese companies, is a A$500 million pilot project in the Latrobe Valley in Victoria. This project aims to be the first commercially viable hydrogen export project in Australia.
- Victoria has a significant competitive advantage due to its abundant, world-class coal resources and high potential for CCS.
- The infrastructure built by the HESC project to transport, liquify, store and ship hydrogen is the same infrastructure renewable hydrogen projects will need.

Other Australian jurisdictions
Victoria has a higher share of residential and commercial gas consumption than other Australian jurisdictions

<table>
<thead>
<tr>
<th>Gas consumption by state and sector, 2019*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJ per year (% of total)</td>
</tr>
<tr>
<td>Residential and commercial</td>
</tr>
<tr>
<td>Industrial</td>
</tr>
<tr>
<td>Gas powered generation</td>
</tr>
</tbody>
</table>

Western Australia has high gas use overall but a relatively low proportion of residential and commercial consumption

Victoria’s high residential and commercial gas use is driven by demand in winter

- Victoria has higher gas use than other jurisdictions in eastern Australia.
- Victoria’s high residential and commercial gas use is driven by large demand for gas for space heating in winter months. Its monthly gas usage in winter months is about three times higher than usage in summer. Peak demand on cold days can be up to four times higher than average summer demand.
- As well as being a major gas exporter, Western Australia has the highest domestic gas use in Australia, driven by large local gas reserves and a large industrial sector. WA’s gas use is dominated by gas for power generation and industrial use (e.g. mining, industry and the mineral processing sector). Only a small proportion is for residential, commercial, and small industrial use.

Only the Australian Capital Territory has an explicit plan to phase out gas

- No Australian state has a comprehensive strategy to reduce emissions from natural gas.
- The Australian Capital Territory plans to phase out the use of natural gas as part of its plan for net zero emissions by 2045. The ACT has already removed the mandatory requirement for gas connections in new houses and has increased energy standards for new dwellings.

Note: *Gas consumption for WA is for 2017-2018; other states are from 2019. Gas consumption excludes exports as LNG.
Western Australia, Queensland and the Northern Territory are significant gas exporters

Australia’s liquefied natural gas infrastructure

Australia has ten LNG production facilities across three jurisdictions

- Australia is the world’s largest exporter of liquefied gas (LNG).
- Australia exports around 80 million tonnes of LNG per year, valued A$36.1bn in 2020. The largest export markets are Japan, China and South Korea.
- In total, there are ten LNG production facilities. Five LNG projects are based in Western Australia, three LNG facilities are located on Curtis Island in Queensland and the two LNG facilities are based in the Northern Territory.

Western Australia has 10% of global LNG capacity

- Western Australia leads Australian LNG production, supplying 56% of national exports, with Queensland contributing 29% and the Northern Territory 15%.
- Production capacity in Western Australia compromises 10% of global capacity.
- Producing gas for export involves emissions during exploration, extraction, production, processing and pipeline transmission, and from the conversion of gas to LNG at liquefaction plants.

Sources: Climate Analytics (2018), EIA (2020), IBIS World (2020), Accenture analysis
No Australian jurisdiction has a strategy for gas emissions in place yet

<table>
<thead>
<tr>
<th>Goals and strategies</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climate goals</strong></td>
<td>▪ All Australian states and territories have emissions reduction targets and have committed to net zero by no later than 2050.</td>
</tr>
</tbody>
</table>
| **General decarbonisation strategy** | ▪ Most jurisdictions are transitioning to renewable energy. South Australia, Tasmania and the Australian Capital Territory have committed to 100% renewables before 2030.  
▪ The Australian Capital Territory plans to phase out natural gas by 2045. Other jurisdiction do not have targets or plans specifically for gas.  
▪ There are few policies in place to reduce emissions in other sectors such as transport, agriculture or industrial processes. |
| **Strategies for decarbonising gas** | ▪ Several jurisdictions have released strategies or roadmaps for hydrogen industry development or the uptake of hydrogen technologies, including the Western Australian Renewable Hydrogen Strategy (2019), South Australia’s Hydrogen Action Plan (2019), the Queensland Hydrogen Industry Strategy 2019-2024 (2019) and the Victorian Hydrogen Investment Program. New South Wales is developing a hydrogen strategy as part of its Net Zero 2050 Plan.  
▪ Four hydrogen projects are currently operating; most hydrogen projects to date are under development. Queensland and Western Australia are leading with the largest number of hydrogen projects in operation and under development.  
▪ The Gorgon LNG project in Western Australia is required to capture and store CO₂ as a condition of its environmental approval.  
▪ The CarbonNet project in Victoria aims to develop a commercially viable CCS hub in Gippsland for the state to manage future carbon emissions from industrial sources. |

Sources: Climate Council (2019), ARENA (2021), DESI (2021), Accenture analysis
Most jurisdictions have some energy efficiency policies in place, but few that directly target gas use outside the ACT

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Key energy efficiency policies</th>
</tr>
</thead>
</table>
| New South Wales             | ▪ The NSW Energy Savings Scheme, which provides financial incentives to install energy efficient equipment and appliances in NSW households and businesses, has been in place since 2009.  
▪ The NSW Government is increasing the energy saving target from 8.5% to 13% by 2030, which will require electricity retailers to invest in more energy efficiency measures.  
▪ The NSW Energy Savings Scheme, which provides financial incentives to install energy efficient equipment and appliances in NSW households and businesses, has been in place since 2009.  
▪ The NSW Government is increasing the energy saving target from 8.5% to 13% by 2030, which will require electricity retailers to invest in more energy efficiency measures. |
| Australian Capital Territory| ▪ The ACT Government has removed the mandatory requirement for gas connections to new suburbs.  
▪ Energy efficiency standards are improving, with the average star rating for new houses there rising from 6.5 in 2016 to 6.9 in 2018.  
▪ The Energy Efficiency Improvement Scheme established in 2013 will be expanded to incentivise a transition from natural gas to efficient electric heating and hot water systems.  
▪ The ACT Government has removed the mandatory requirement for gas connections to new suburbs.  
▪ Energy efficiency standards are improving, with the average star rating for new houses there rising from 6.5 in 2016 to 6.9 in 2018.  
▪ The Energy Efficiency Improvement Scheme established in 2013 will be expanded to incentivise a transition from natural gas to efficient electric heating and hot water systems. |
| South Australia             | ▪ The Retailer Energy Efficiency Scheme, which requires that energy retailers assist households and businesses to reduce their energy use and costs and lower greenhouse gas emissions, has been in place since 1 January 2015.  
▪ The National Construction Code (NCC) mandates minimum energy efficiency standards for new buildings to promote energy efficient homes.  
▪ New buildings are required to have a minimum efficiency rating of 6 of higher to adhere to energy efficiency standards. These standards are ranked 10th among the world’s top 25 energy consuming countries.  
▪ The Retailer Energy Efficiency Scheme, which requires that energy retailers assist households and businesses to reduce their energy use and costs and lower greenhouse gas emissions, has been in place since 1 January 2015.  
▪ The National Construction Code (NCC) mandates minimum energy efficiency standards for new buildings to promote energy efficient homes.  
▪ New buildings are required to have a minimum efficiency rating of 6 of higher to adhere to energy efficiency standards. These standards are ranked 10th among the world’s top 25 energy consuming countries. |
| Queensland                  | ▪ The Business Energy Savers Program provides information and energy audits for business customers.  
▪ The Affordable Energy Plan provided rebates to residential customers for energy efficiency in 2018-2019.  
▪ The National Construction Code (NCC) mandates minimum energy efficiency standards for new buildings to promote energy efficient homes.  
▪ New buildings are required to have a minimum efficiency rating of 6 of higher to adhere to energy efficiency standards. These standards are ranked 10th among the world’s top 25 energy consuming countries.  
▪ The Business Energy Savers Program provides information and energy audits for business customers.  
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▪ New buildings are required to have a minimum efficiency rating of 6 of higher to adhere to energy efficiency standards. These standards are ranked 10th among the world’s top 25 energy consuming countries. |
| Tasmania                    | ▪ The Power$mart Homes and Power$mart Business programs form the basis of Tasmania’s state-wide energy efficiency program.  
▪ The Power$mart Homes program provides free energy efficiency upgrades to low-income households to lower electricity use and reduce greenhouse gas emissions and the Power$mart Business programs provides businesses with funding to carry out energy efficiency audits.  
▪ The Power$mart Homes and Power$mart Business programs form the basis of Tasmania’s state-wide energy efficiency program.  
▪ The Power$mart Homes program provides free energy efficiency upgrades to low-income households to lower electricity use and reduce greenhouse gas emissions and the Power$mart Business programs provides businesses with funding to carry out energy efficiency audits. |
| Nationwide                  | ▪ The National Construction Code (NCC) mandates minimum energy efficiency standards for new buildings to promote energy efficient homes.  
▪ The Nationwide House Energy Rating Scheme (NatHERS) is a star rating system (out of 10) that rates the energy efficiency of a home based on its design. The NatHERS tool is one option for complying with the energy efficiency elements of the NCC.  
▪ New buildings are required to have a minimum efficiency rating of 6 of higher to adhere to energy efficiency standards. These standards are ranked 10th among the world’s top 25 energy consuming countries.  
▪ The National Construction Code (NCC) mandates minimum energy efficiency standards for new buildings to promote energy efficient homes.  
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▪ New buildings are required to have a minimum efficiency rating of 6 of higher to adhere to energy efficiency standards. These standards are ranked 10th among the world’s top 25 energy consuming countries. |

Sources: DESI (2021), ACEEE (2018), Norton Rose Fulbright (2020), Government websites, Accenture analysis

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Western Australia and Queensland have the most hydrogen projects, but Victoria’s HESC project is the largest single project

The clean hydrogen industry is gaining momentum in Australia

- Since 2018, most Australian jurisdictions have released hydrogen strategies or action plans.
- Several funding programs have prioritised hydrogen-related investment opportunities, leading to a growing number of hydrogen projects.
- States and territories have developed strategies to support hydrogen projects. Western Australia and Queensland have the highest number of projects funded and under development.

Over A$700m of funding has been announced for hydrogen projects

- States and territories have announced ~A$200m of funding for hydrogen projects, alongside A$500m of Australian Government funding.
- The largest number of supported projects are in Western Australia and Queensland.
- The largest single state government funding commitment to date is the Victorian Government’s pledge of $50m to the Hydrogen Energy Supply Chain - Pilot Project, which has also received a commitment of A$50m from the Australian Government.
- The HESC project will produce hydrogen for export to Japan, has received the largest amount of support. The project developers announced that operations had begun in March 2021.

Sources: CSIRO HyResource (2020), Accenture analysis
Appendix
We shortlisted eight jurisdictions for deep-dive analysis

We started with select OECD countries with significant gas infrastructure, based on consultation with experts and a desktop review.

We identified three selection criteria to refine the shortlist:

1. The role of natural gas is broadly comparable to Victoria, and the jurisdiction is facing comparable challenges.
2. The jurisdiction is adopting relevant policies and actions: e.g. net zero, CCS, biomethane, hydrogen.
3. Analysis of the jurisdiction is feasible in the timeframe of the project, with ready access to information and experts.

Shortlisted jurisdictions

- United Kingdom
- Ireland
- Netherlands
- Belgium
- Germany
- Japan
- Unites States (state)
- Canada (province)
We applied selection criteria to the shortlisted jurisdictions

Using desktop analysis and consulting with experts at the University of Queensland Centre for Natural Gas, the International Energy Agency and the UK Energy Systems Catapult, we applied the selection criteria to the shortlisted jurisdictions, and three emerged:

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Role of gas</th>
<th>Policy settings</th>
<th>Feasibility</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td><img src="https://via.placeholder.com/15" alt="UK" /></td>
<td><img src="https://via.placeholder.com/15" alt="UK" /></td>
<td><img src="https://via.placeholder.com/15" alt="UK" /></td>
<td>National Grid’s Gas Markets Plan lays out a 10-year plan for transforming the gas market on the path to net zero by 2050</td>
</tr>
<tr>
<td>Ireland</td>
<td><img src="https://via.placeholder.com/15" alt="Ireland" /></td>
<td><img src="https://via.placeholder.com/15" alt="Ireland" /></td>
<td><img src="https://via.placeholder.com/15" alt="Ireland" /></td>
<td>Gas Networks Ireland is planning for a net zero gas network by 2050 using biomethane, CCS and hydrogen</td>
</tr>
<tr>
<td>Netherlands</td>
<td><img src="https://via.placeholder.com/15" alt="Netherlands" /></td>
<td><img src="https://via.placeholder.com/15" alt="Netherlands" /></td>
<td><img src="https://via.placeholder.com/15" alt="Netherlands" /></td>
<td>Planned phase-out of gas, replaced by CCS, biofuels, EVs, renewables, other sources of heat</td>
</tr>
<tr>
<td>Belgium</td>
<td><img src="https://via.placeholder.com/15" alt="Belgium" /></td>
<td><img src="https://via.placeholder.com/15" alt="Belgium" /></td>
<td><img src="https://via.placeholder.com/15" alt="Belgium" /></td>
<td>Planning for net zero via hydrogen, biomethane, synthetic methane and biofuels</td>
</tr>
<tr>
<td>Germany</td>
<td><img src="https://via.placeholder.com/15" alt="Germany" /></td>
<td><img src="https://via.placeholder.com/15" alt="Germany" /></td>
<td><img src="https://via.placeholder.com/15" alt="Germany" /></td>
<td>National hydrogen strategy provides for using existing gas infrastructure for hydrogen; Germany is the largest biogas producer in Europe</td>
</tr>
<tr>
<td>Japan</td>
<td><img src="https://via.placeholder.com/15" alt="Japan" /></td>
<td><img src="https://via.placeholder.com/15" alt="Japan" /></td>
<td><img src="https://via.placeholder.com/15" alt="Japan" /></td>
<td>Significant investment in the hydrogen economy in Japan and globally</td>
</tr>
<tr>
<td>Unites States (or US state)</td>
<td><img src="https://via.placeholder.com/15" alt="US" /></td>
<td><img src="https://via.placeholder.com/15" alt="US" /></td>
<td><img src="https://via.placeholder.com/15" alt="US" /></td>
<td>Some state-level measures to support gas decarbonization (e.g. California Energy Commission report)</td>
</tr>
<tr>
<td>Canada (Alberta)</td>
<td><img src="https://via.placeholder.com/15" alt="Canada" /></td>
<td><img src="https://via.placeholder.com/15" alt="Canada" /></td>
<td><img src="https://via.placeholder.com/15" alt="Canada" /></td>
<td>Significant gas infrastructure; Alberta’s Natural Gas Vision and Strategy looking to position as clean gas producer</td>
</tr>
</tbody>
</table>
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