Understanding the Energy Industry

SDG&E

enerdynamics
The Energy Education Experts

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Introduction

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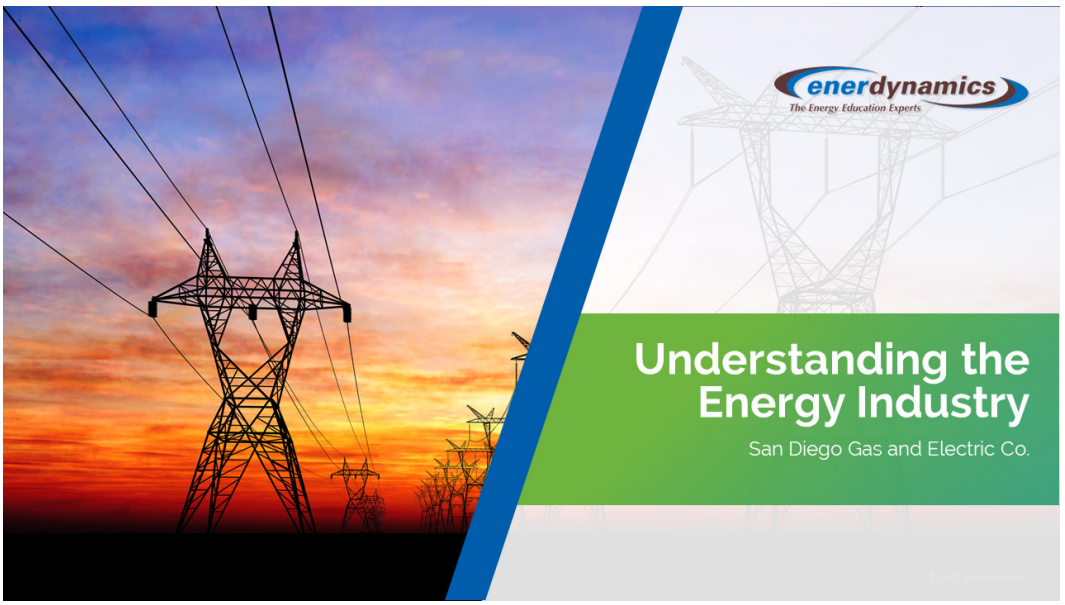

Key concepts

- Natural gas can be stored, which gives system operators considerable flexibility in matching supply and demand.
- Electricity has historically been uneconomic to store except in limited situations. This means system operators must constantly match generation to demand.
- Natural gas is measured by volume and by energy content.
- Electricity is measured by capacity (or demand) and energy (or usage).

Glossary of terms introduced in this module

- **British thermal unit (Btu):** The quantity of heat required to raise the temperature of one pound of water by one degree Fahrenheit.
- **Capacity:** The maximum electric power output of a generating unit (measured in MW) or the maximum amount of power that lines or equipment can safely carry. Electric generation that is available in a specific region or market to ensure reliability. The maximum amount of natural gas that can be produced, transported, stored, distributed, or utilized in a given period of time..
- **Conductor:** A material that allows electrons to move easily from one atom to another, thereby facilitating electric flow. Typically used to describe a wire that conducts electricity in any part of the electrical grid.
- **Cubic foot:** The amount of gas required to fill a volume of one cubic foot under stated conditions of temperature, pressure, and water vapor.
- **Demand:** The total amount of gas or electricity used at any given moment in time, or averaged over a period of time.
- **Hydrocarbon:** Chemical compound containing carbon and hydrogen.
- **Load:** An amount of end-use demand.
- **Methane:** The simplest of hydrocarbons and the main component of natural gas.
- **Quadrillion:** 1,000,000,000,000,000 or 10 to the 15th.
- **Supply:** Electricity available on the grid or natural gas available to any given pipeline system.
- **Therm:** A unit of heating value, one therm is equivalent to 100,000 Btu.
- **Watt:** A unit of power capacity or demand.
- **Watt-hour:** A measure of electrical energy or usage equivalent to the consumption of one watt for one hour.
- **Wellhead:** The point where gas is pumped from the reservoir and enters the gathering system.

Welcome

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Notes

Agenda

Slide 3

Today we will cover...

- Overview of Natural Gas and Electricity
- Customers
- The Natural Gas Physical System and Operations
- The Electric Physical System and Operations
- Regulation and Deregulation
- Making Money and Managing Risk
- The Future

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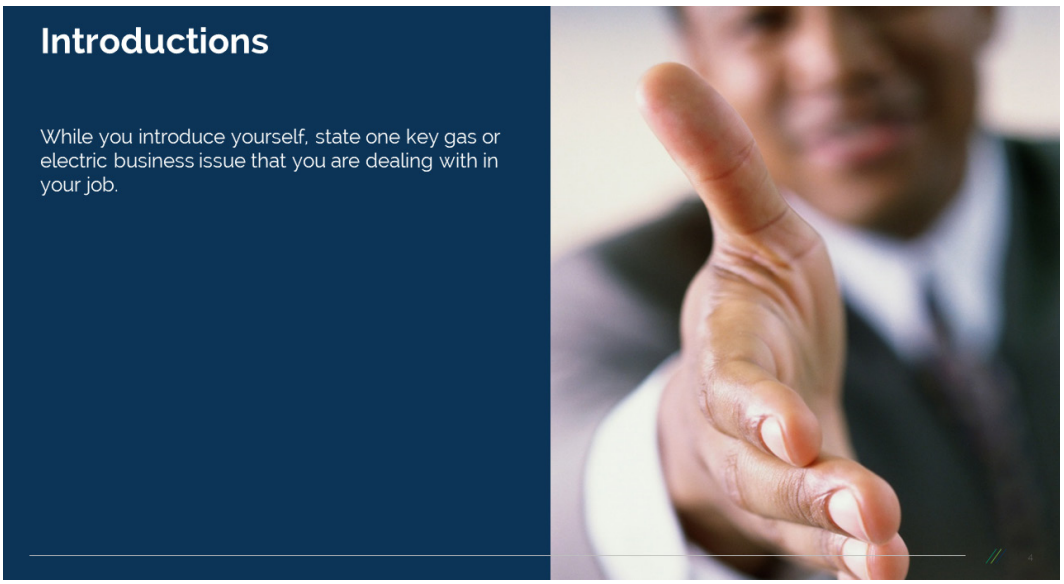

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In this book you will find:

- Content of entire presentation
- Key concepts and glossary at the beginning of each section
- Additional information that we may not cover in class today
- Delivery system infographics and lists of energy units and common acronyms (at the end of the guide)

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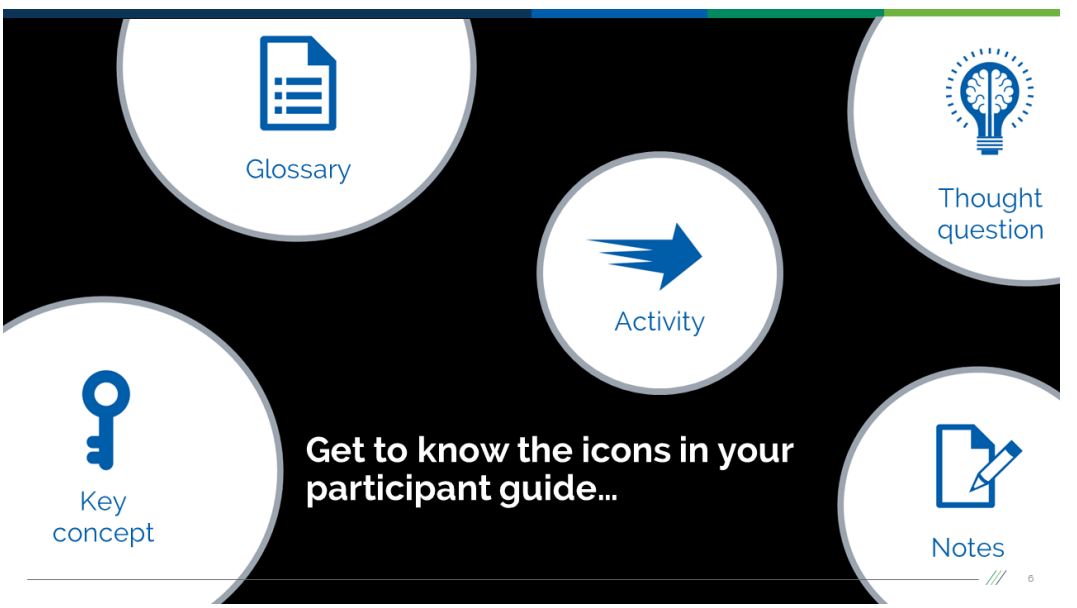

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For questions after this class:

Feel free to contact me with questions!

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Stay connected with Enerdynamics after class…

- Visit our blog, Energy Currents, at www.enerdynamics.com/Energy-Currents_Blog
- Subscribe to Energy Insider, our quarterly eNewsletter – just include your email address in the course evaluation or subscribe on our website at: www.enerdynamics.com

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U.S. Primary energy consumption

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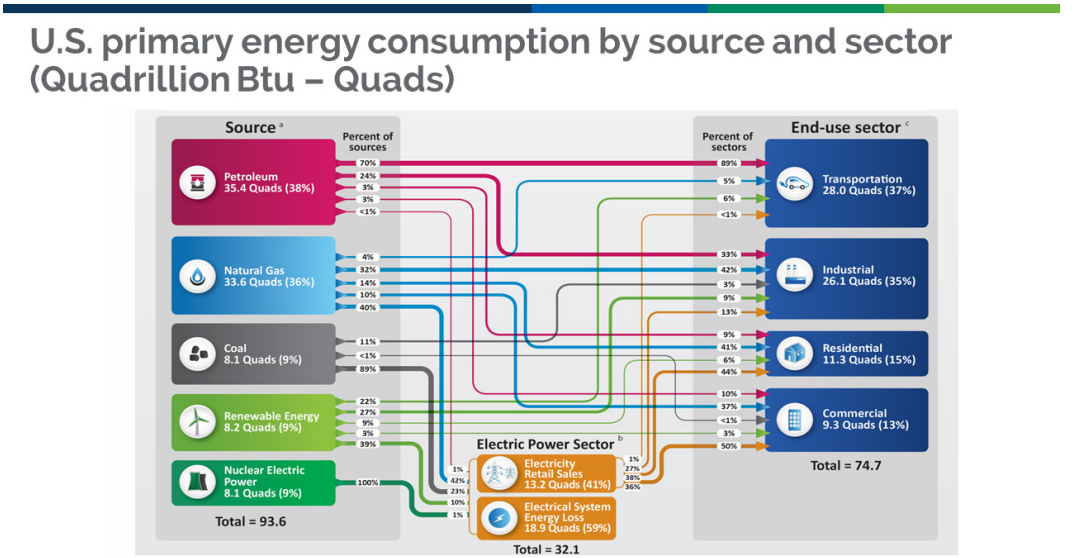

Source: Energy Information Administration, 2023

This chart shows the sources of energy consumed in the United States and how they are used. The left side of the chart shows the various sources of energy and how much of total energy consumed each source represents. If you look at trends in recent years, you will see some reduction in the use of coal and an increase in the use of renewables.

Electric power is shown in the center. If you follow the lines from the various energy sources to the electric power sector, you can see how much of each source is used to generate electricity. On the right side of the chart are the sectors that use these energy sources and electricity. As an example, 4% of the natural gas consumed in the U.S. is used for transportation (CNG in cars and vehicle fleets), 32% of the natural gas consumed in the U.S. is used by the industrial class (boilers and process heat), 14% of the natural gas consumed in the U.S. is used by residential customers, and 10% of the natural gas consumed in the U.S. is used by commercial customers (space and water heating for both of these end-use sectors). The remaining 40% of the natural gas consumed in the U.S. is used to generate electric power.

The numbers on the right side of the infographic show the percentage of total energy consumption each energy source accounts for. For instance, for the transportation sector, 89% of the energy used comes from petroleum with lesser amounts from natural gas and renewables. Currently less than 1% of the energy used in transportation comes from electricity, though this is likely to change in the future.

In this graphic, a quadrillion is 1,000,000,000,000,000 (10 to the 15th).

What is natural gas and how does it work?

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What is natural gas?

- A combustible gaseous mixture of **hydrocarbons**, primarily consisting of **methane**

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Key physical characteristics of natural gas

- Can be stored in pipes or underground
- Gas is compressible
- Flow can be directed
- Supply and demand can be balanced across hours or even days
- Disturbances travel slowly
- Severe outages are very rare

Key concept

A key difference between natural gas and electricity is that natural gas can be easily stored. Operators can store gas in the actual pipes that deliver it by putting more gas into the system on a given day than is consumed by customers. Underground storage fields and various types of above ground storage (including liquefied natural gas) can also be used to store gas. The result is that system operators do not need to balance supply and demand on a moment by moment basis. They do, however, need to maintain minimum operating pressures and also need to be very careful to never exceed maximum pressures.

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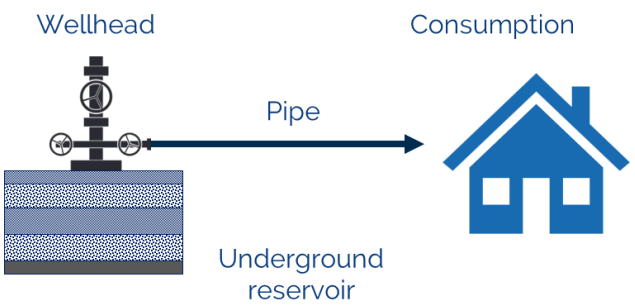
How natural gas works



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The natural gas system is often referred to as a "pump and dump" system that works similar to a garden hose. Pressure is higher at the spigot and lessens as water travels through the hose to the point at which it is consumed. The natural gas delivery system works in a very similar manner.

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Natural gas in our society

- Natural gas provides 36% of gross energy consumed in the U.S.
- Natural gas is an important fuel for electric generation
- Over 83 million customers use natural gas
- End users spent about $189 billion on natural gas in 2023
- Natural gas is sometimes seen as a "bridge fuel" to a sustainable future but also sometimes seen as a fossil fuel that needs to be reduced

What is electricity and how does it work?

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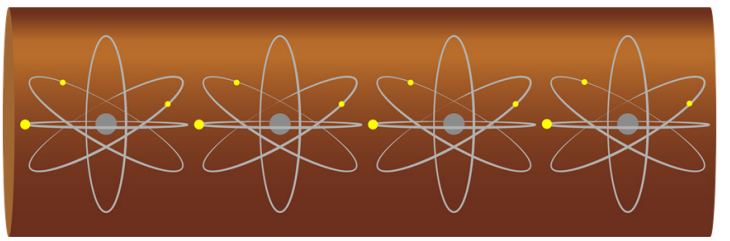
What is electricity?

- It's easier to describe what it does than what it is
- The **flow/movement** of electrons through a **material/conductor**



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How electricity works

- Source, path, and load
- Path must be "complete" (continuous loop)
- Control and protective devices add user-friendliness and safety

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To create a complete circuit you must have a _____, _____, and _____.

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Key physical characteristics of electricity

- Cannot be stored in wires
- Path of flow is difficult to control
- Supply and demand must always be in balance
- Disturbances travel quickly
- Outages do occur, but overall reliability is high

Key concept

Storing electricity (or the potential to create electricity) has historically been difficult and expensive. The result is that system operators must balance generation and demand very closely on a moment by moment basis. However, there are various types of economic electric storage that are now or will soon be available that are dramatically changing this paradigm.

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Electricity – vital to our society but not free!

- Energy consumed to provide electricity is 38% of U.S.total energy
- Everything stops when the power goes out
- Over 159 million customers use electricity in the U.S.
- U.S. customers spent over $488 billion on electricity in 2022
- The use of electricity is environmentally benign, but generation of electricity is one of the largest causes of air pollution and greenhouse gases

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Gas and electricity are competitors and partners

- 40% of gas consumed is in competition with electricity for end-use markets
- 40% of gas consumed is used to generate electricity

Gas units and volume/energy

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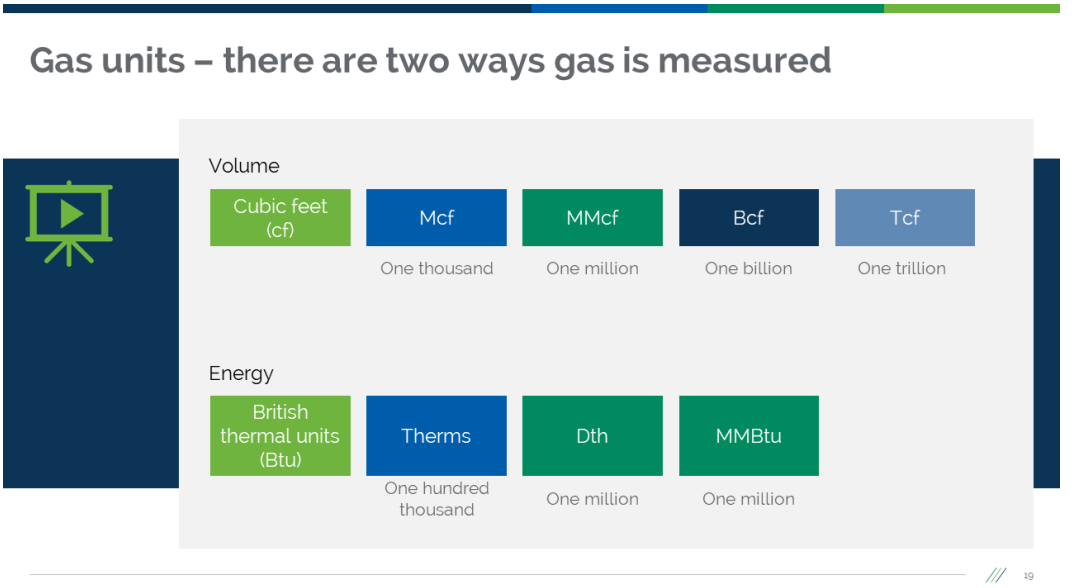

Key concept

Natural gas is measured by volume and by energy content. A cubic foot is the standard measurement of volume and it is the amount of gas that, under standard temperature and pressure, fits into a space that is one foot by one foot by one foot. Customers, however, are more concerned about the energy content of the gas they receive because this is what heats their water and cooks their food. The standard unit for measuring energy in natural gas is a British thermal unit or Btu, which is the amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit at sea level pressure.

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Typical gas consumption

- Gas fireplace: 0.2 therm/hour
- Large gas furnace: 1 therm/hour
- Gas water heater: 25 therms/month
- 250 MW power plant: 2,250 MMBtu/hour

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How much does natural gas service (supply and transport) cost for a residential customer in San Diego?

- ◯ a) About $0.50/therm
- ◯ b) About $1.75/therm
- ◯ c) About $2.00/therm
- ◯ d) About $2.50/MMBtu

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A gas marketer that has a 10-customer portfolio, each using 100 therms per month, would need to buy 100 Dth per month to supply these customers:

- ◯ a) True
- ◯ b) False
- ◯ c) Not certain, need more information

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If the gas marketer transports 10,000 Dth per day at a rate of $0.50/Dth, her transport cost could also be stated as $0.05/MMBtu:

- ◯ a) True
- ◯ b) False
- ◯ c) Not certain, need more information

Electric units and usage/capacity

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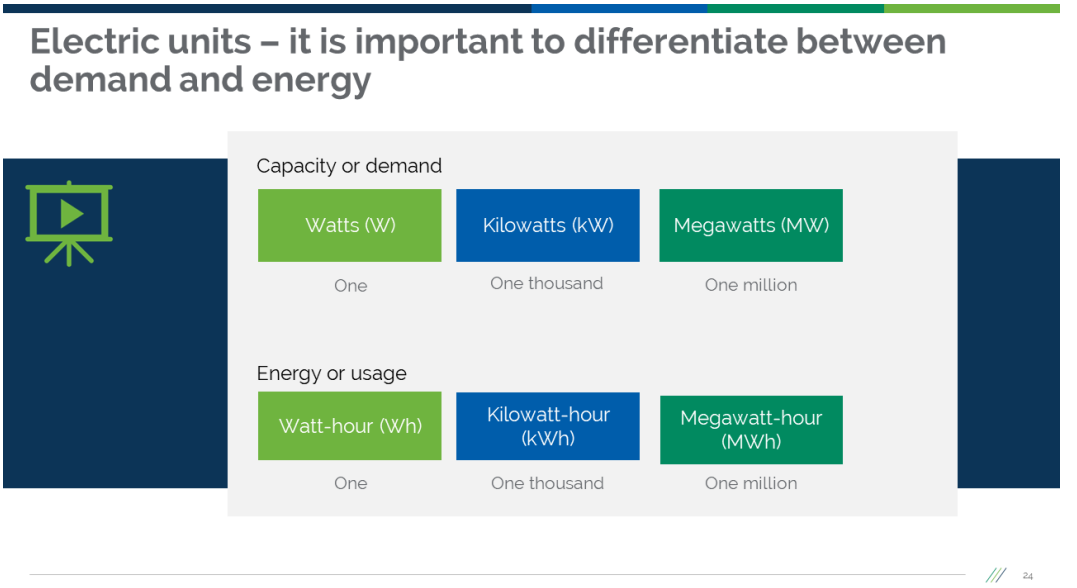

Key concept

Electricity is measured by capacity (demand) and energy (usage). Demand reflects the instantaneous amount of work required to perform a function such as creating light. Similarly capacity reflects the instantaneous ability to provide energy required to do work. Capacity and demand are measured in units of watts, kilowatts, and megawatts. Energy or usage reflects demand or capacity multiplied by the amount of time that demand or capacity is in use. Energy and usage are measured in units of watt-hours, kilowatt-hours, and megawatt-hours.

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Typical electric usage/capacity

- Light bulb:
  - LED, 7.5 to 17 W
  - Compact fluorescent, 11 to 42 W
  - Incandescent, 60 to 100 W
- Single-family home:
  - 3-5 kW peak demand
  - 910 kWh/month
- Industrial facility:
  - >500 kW peak demand
- Utility power plant::
  - 100 MW – 1,000 MW

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How much does electricity service (supply and transport) cost for a residential customer in San Diego?

- a) About $0.10/kWh
- b) About $0.25/kWh
- c) About $0.50/kWh
- d) About $10.00/MWh

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If a building has one thousand 14-watt light bulbs and 80% are turned on at the same time, what is the lighting demand for the building:

- a) 11.2 MWh
- b) 11.2 kWh
- c) 11.2 kW
- d) Not certain, I need more information

Demand is measured in units of W, kW, MW

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If 80% of those one thousand 14-watt light bulbs (from previous question) are turned on for two hours, how much energy will they use?

- a) 22.4 kWh
- b) 22.4 MWh
- c) 11.2 kWh
- d) 11.2 kW
- e) Not certain, I need ore information

Energy is measured in units of Wh, kWh, MWh

Customers

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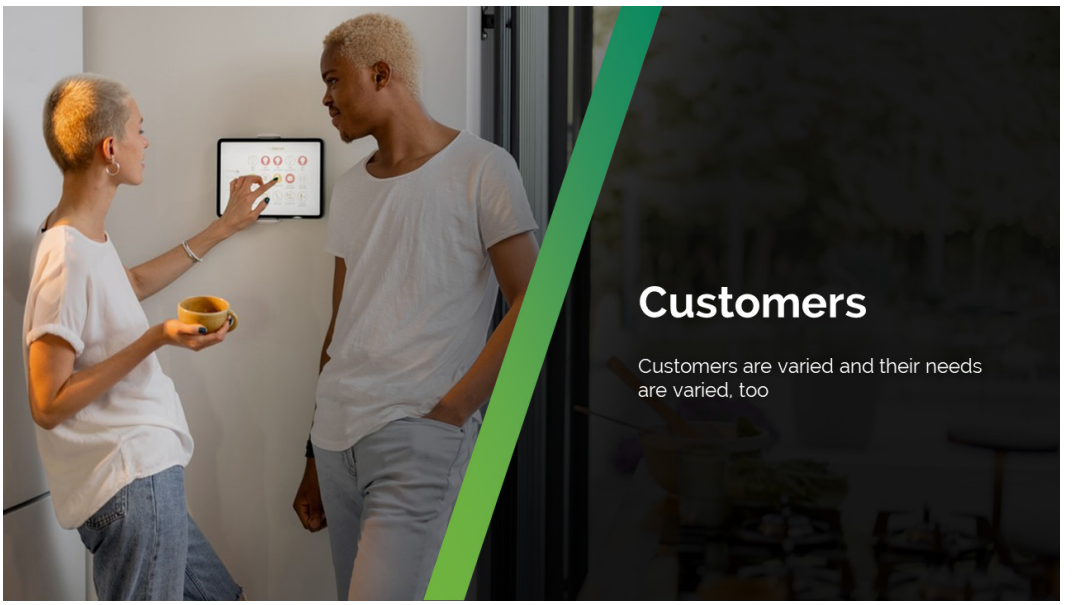

Key concepts

- The importance of understanding how various customer types use natural gas.
- The importance of understanding when various customer types use natural gas.
- The importance of understanding how various customer types use electricity.
- The importance of understanding when various customer types use electricity.
- Daily peaks in electric usage are also extremely important.
- The difference between bundled and unbundled service.

Glossary of terms introduced in this module

- **Bundled service:** Gas or electric supply (commodity) and distribution service packaged together in a single transaction. Usually provided by the gas or electric utility, which on behalf of its customers buys supply and then delivers it to them.
- **Commercial customer:** An end user that uses natural gas or power to create a service.
- **Commodity:** A standardized product or service (such as natural gas or electric supply) that is easily traded among market participants.
- **Core customers:** Residential and small commercial customers who generally lack alternatives to utility service.
- **Customer class:** A group of end users with similar characteristics, used to segment customers for the purpose of setting rates.
- **Demand side management:** The act of reducing energy use or moving energy use from peak to off-peak periods to reduce overall energy costs.
- **Industrial customer:** An end user that uses natural gas or power for manufacturing or production of a product.
- **Marketer:** An entity that buys gas or electricity, arranges for its transportation and then resells it to end users or other gas purchasers.
- **Non-core customers:** Relatively large customers who have alternate fuel capability such as large commercial, industrial, cogeneration, and electric generation customers.
- **Peak demand:** The maximum demand for natural gas or electricity in a given period of time.
- **Residential customer:** An end user that uses natural gas or power in a home.
- **Retail marketer:** A firm that sells products and services directly to end users.
- **Unbundled service:** Gas or electric supply (commodity) service that is separated from distribution service and sold by an entity other than the utility. With unbundled service, the utility still delivers the commodity.

Who are customers?

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The utility industry historically referred to customers as "ratepayers," with the implication being that they had no other choice than to purchase gas and electric service from the utility. Over the years this has changed dramatically. Utility customers now have a myriad of choices they never had before, and thus it is extremely important to understand how they use gas and electricity and what services are attractive to them.

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Who are customers?

Gas	Electric
Residential	Residential
Commercial	Commercial
Industrial	Industrial
Electric generation	Agriculture
Cogeneration	Electric vehicles
Natural gas vehicles	Wholesale
Wholesale	

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Bundled service is when both _____ and _____ are tied together into one service.

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Unbundled service is when _____and _____ are separate services provided by two separate entities. While supply can be offered by marketers, aggregators, or the utility, distribution remains a monopoly function provided by the utility only.

Gas customers and their usage

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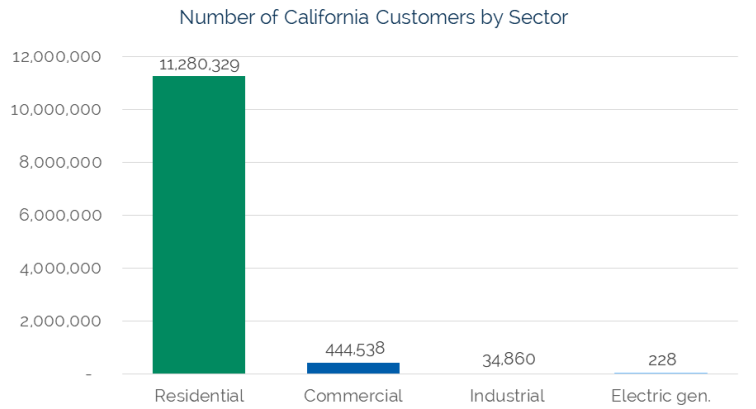
Residential gas customers far outnumber commercial and industrial . . .



Source: 2022 data from Energy Information Administration and California Energy Commission

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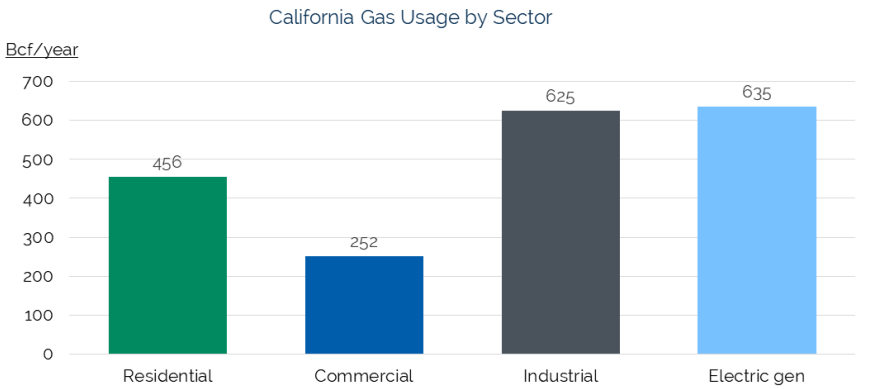
But gas usage is divided almost equally among residential/commercial, industrial, and electric generation



Source: 2023 data from Energy Information Administration

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While the number of residential customers far exceeds the number of industrial or power customers, the usage of the residential class on a per customer basis is far less than either other sector. Because they use a lot less natural gas than either industrial or power customers, residential customers are more costly to serve on a per unit basis.

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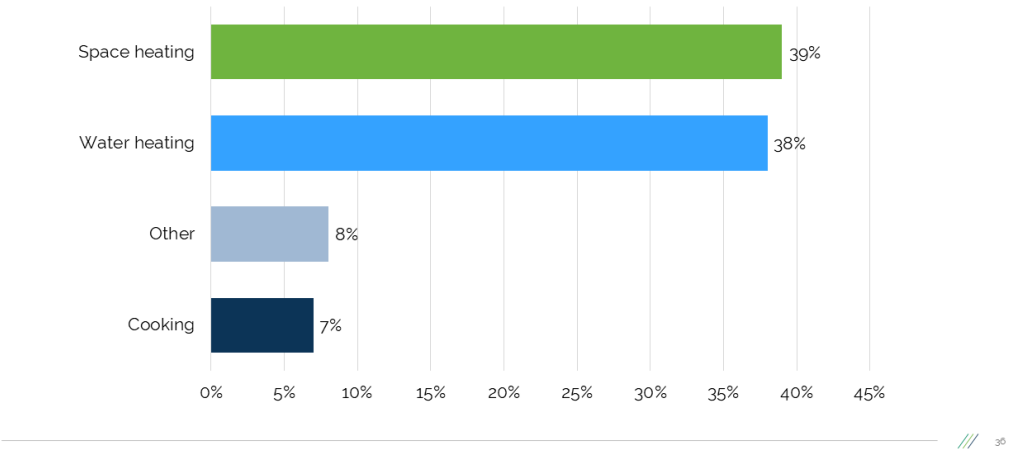
California residential gas use



Key concept

It is important for system planners and operators to understand how various customer groups use natural gas in both the short term and the long term. For instance, because 39% of residential gas use and 36% of commercial gas use in California is for space heating, system operators will prepare for increased demand if the weather is predicted to be colder than normal in the next week. And in the longer term, if climate models predict warmer than normal winters in the future, system planners can assume that average usage for residential and commercial customers is likely to decline.

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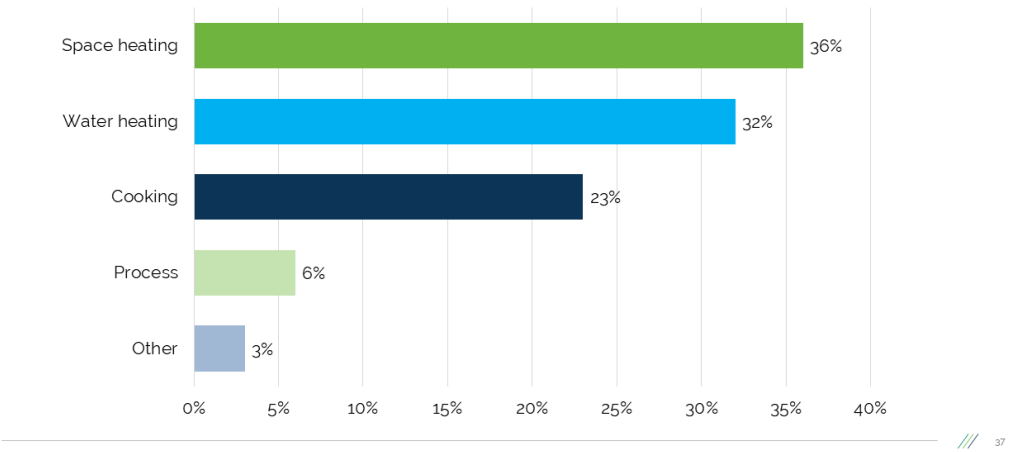
California commercial gas use



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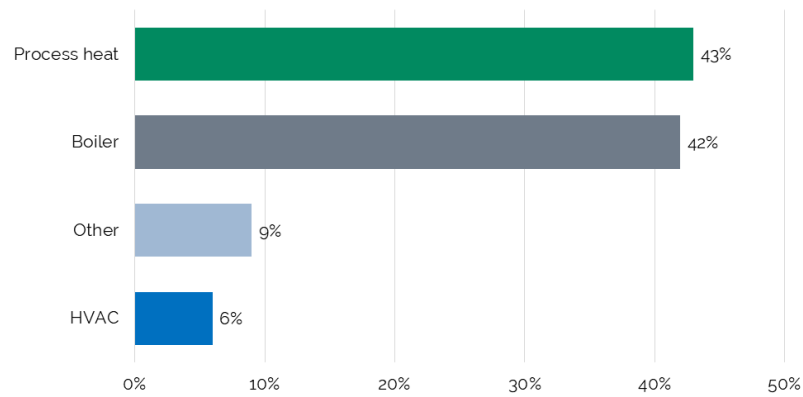
California industrial gas use



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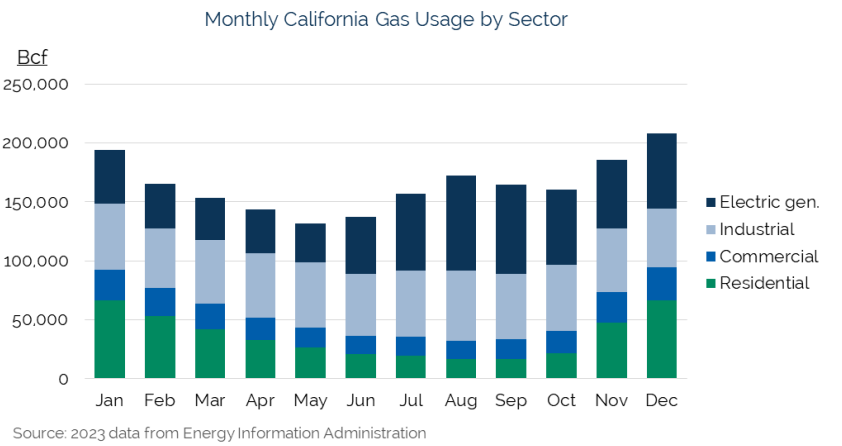
California gas usage peaks in the winter, but late summer peak is also large



Source: 2023 data from Energy Information Administration

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Key concept

It is important to understand when various customer types use natural gas. And when multiple customers' usage is combined, their aggregate use tells us how the system needs to be designed, operated, and maintained. However, since natural gas can be stored in storage facilities and the pipes themselves, operators have more flexibility in meeting peak loads than on the electric side.

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Which do you think would cause the largest increase in annual California gas demand?

- a) A cold winter
- b) A hot summer
- c) Lots of rain
- d) A severe drought
- e) Increased battery storage capacity

Key factors that drive gas demand

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Key factors that drive gas demand

What are the factors that drive gas demand in both the short term and the long term for the customer group your table has been assigned?

Residential	Commerical	Industrial	Electric gen.

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Customer needs are varied but often center around price and supply reliability

What does the customer need?

- Safe and reliable gas supply on demand throughout the year

What does the customer want?

-
-
-
-

Electric customers and their usage

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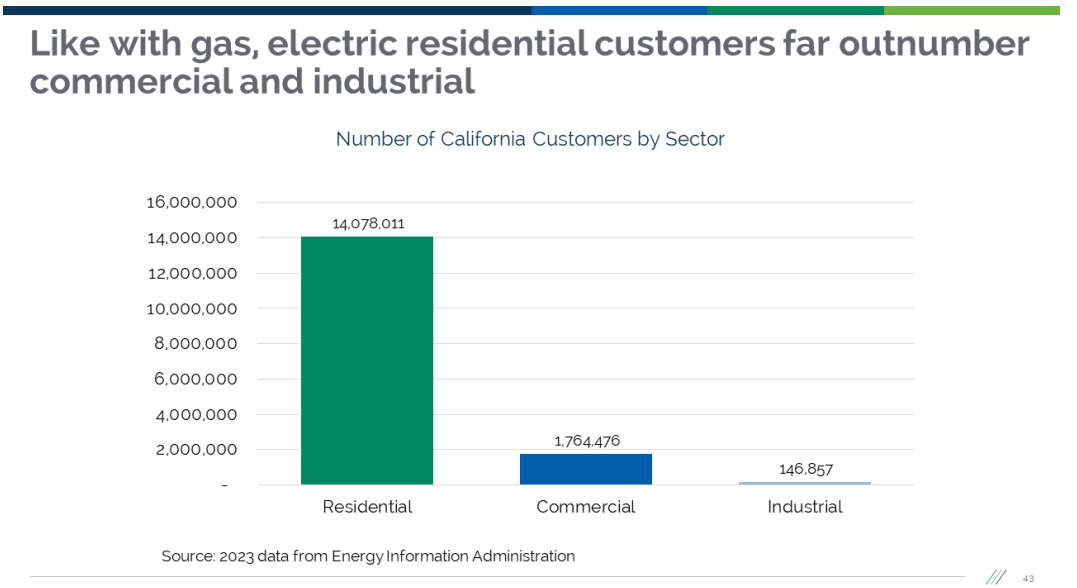

As with natural gas, there are far more residential customers than either commercial or industrial customers. And also like natural gas, residential customers use far less electricity on a per-customer basis than industrial customers, making them more costly to serve. While usage for transportation (electric vehicles) is small now, this could grow significantly in the coming years.

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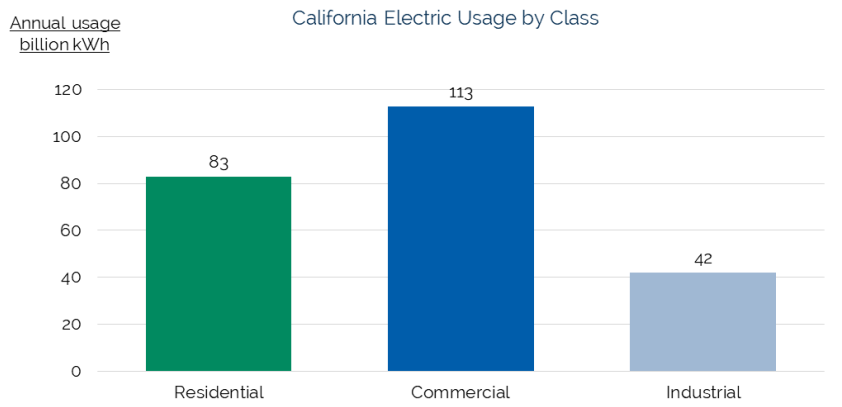
But usage by commercial customers is largest



Source: 2023 data from Energy Information Administration

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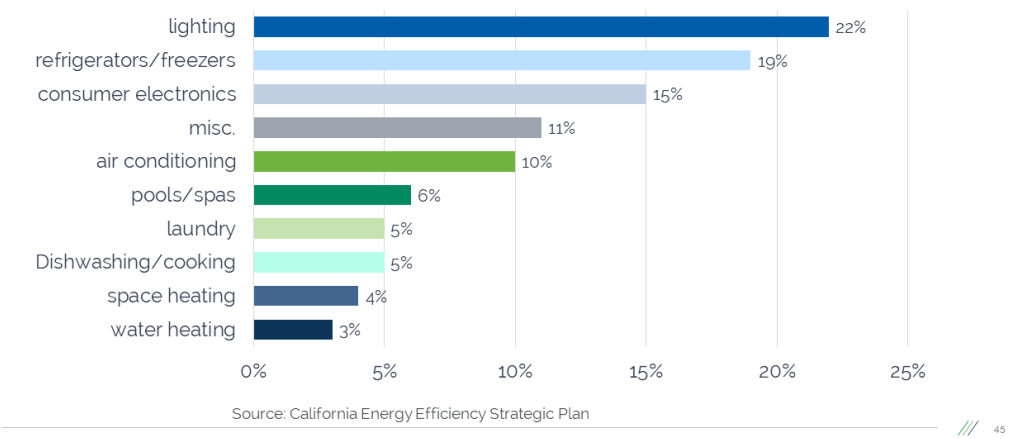
California residential electric use



Source: California Energy Efficiency Strategic Plan

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Key concept

As with natural gas, it is also important for system planners and operators to understand how various customer groups use electricity in both the short term and the long term. For instance, because 10% of residential electricity use and 15% of commercial electricity use in California is for air conditioning, system operators will schedule the system for increased demand if the weather is predicted to be warmer than normal in the next week. And in the longer term, if climate models predict warmer than normal summers, system planners can assume that average usage for both customer classes will likely increase. However, such long-term increases need to be balanced with the effects of increased energy efficiency.

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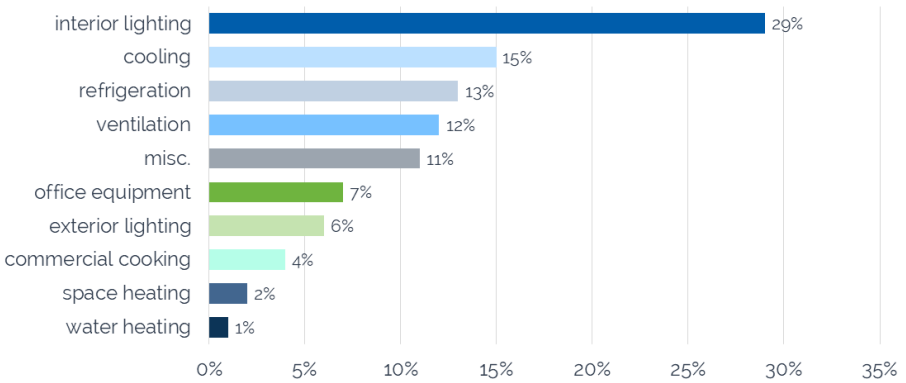
California commercial electric use



Source: California Energy Efficiency Strategic Plan

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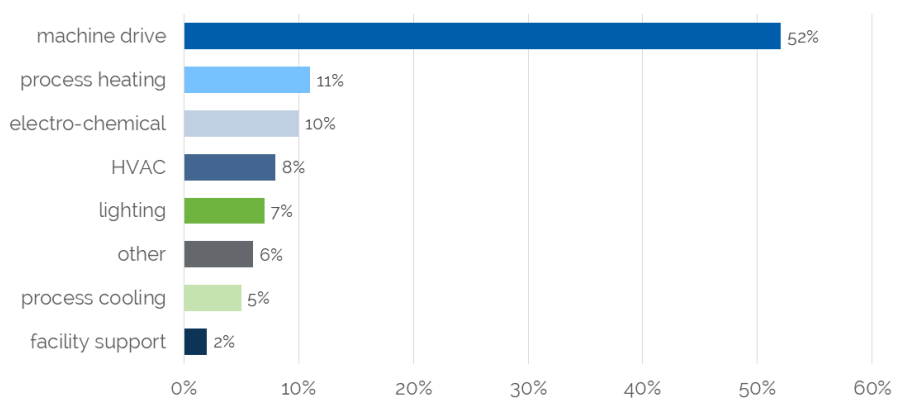
Industrial electric use is dominated by motors



Source: California Energy Efficiency Strategic Plan

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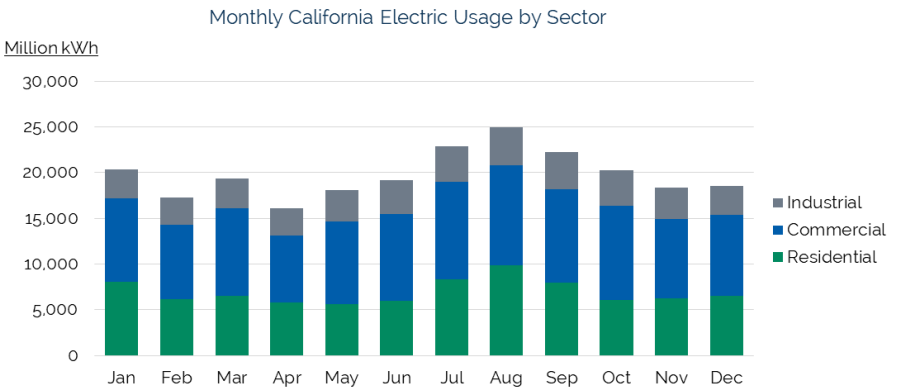
Electric loads also vary across the year, with peaks in summer and winter



Source: 2023 data from Energy Information Administration

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Key concept

It is also important to understand when various customer types use electricity. And when combined, their aggregate use tells us how the system needs to be designed, operated, and maintained. However, since bulk electric storage has historically not been cost-effective, the system has always been designed to meet the system peak. This means the system must be designed for peak usage plus a reserve margin which is required in the event any part of the system is down for maintenance or any other reason.

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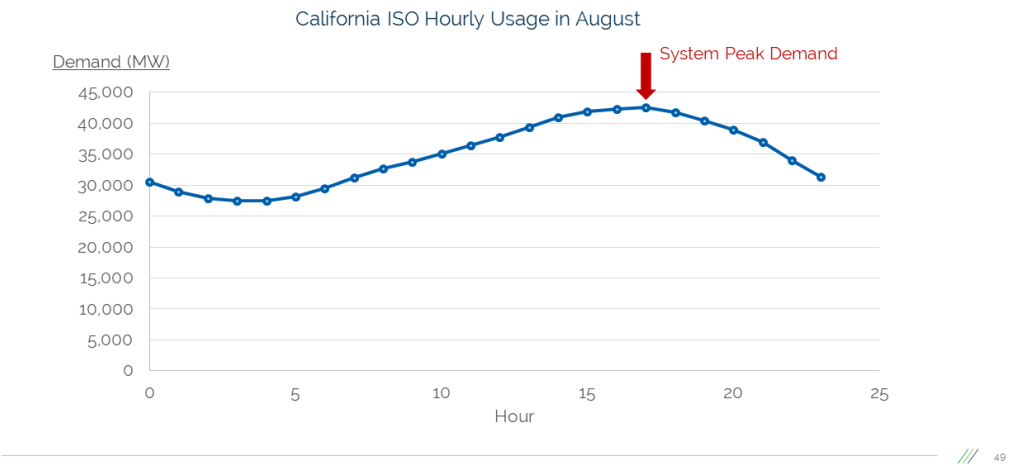
Electric loads vary across the day with peaks that are often significantly higher than base usage



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Key concept

The electric system must be designed to meet system peak even if that is only for a short period of time.

Key concept

While many are unaware, the gas and electric service provided by a utility is actually two services: the commodity itself and the delivery of the commodity. In many areas of the country, and especially for smaller customers, the utility still provides both commodity and delivery in a "bundled" service. However, there are areas of the country where certain customers (and in some states all customers) purchase commodity service from a marketer or aggregator. The rules for eligibility vary by state and are also different for gas and electric services. While many residential and smaller commercial customers may not be interested in purchasing "unbundled" service, larger customers often are since providers other than the utility have greater flexibility in pricing and other options. In these instances, the distribution function (delivery) remains a monopoly service.

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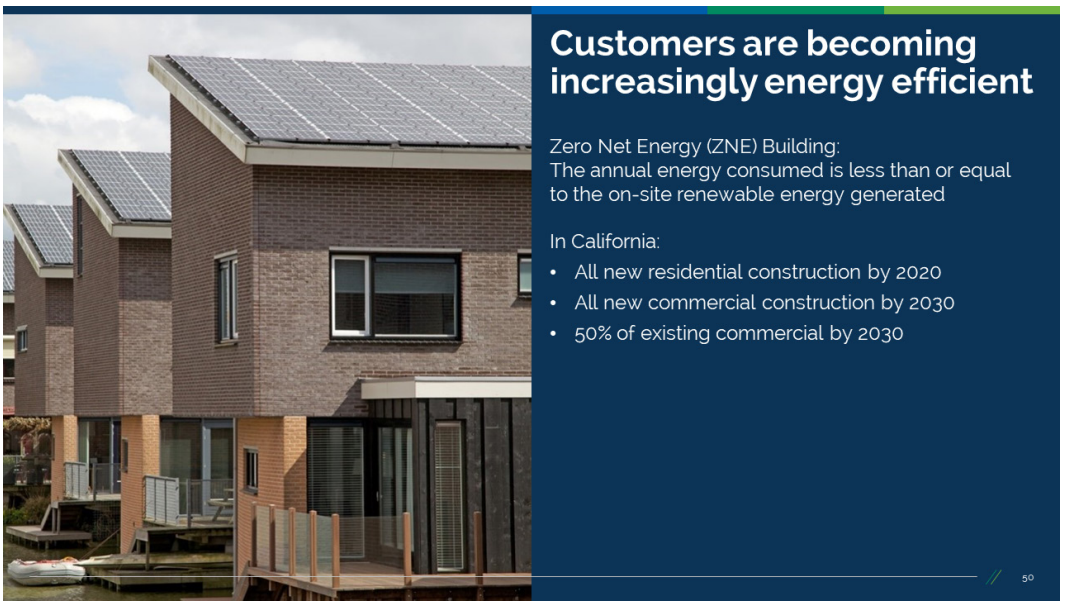

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What is most important to you as an electric customer?

- a) Reliability
- b) Quick outage response
- c) Low prices
- d) Help with energy efficiency
- e) Support for new services such as solar or home automation

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Key factors that drive electric demand

What are the factors that drive electric demand in both the short term and the long term for the customer group your table has been assigned?

Residential	Commerical	Industrial

Slide 53

Customer needs are varied but often center around price and supply reliability

What does the customer need?

- Safe and reliable electric service on demand throughout the year

What does the customer want?

-
-
-
-

The Natural Gas Physical System and Operations

Slide 54

Key concepts

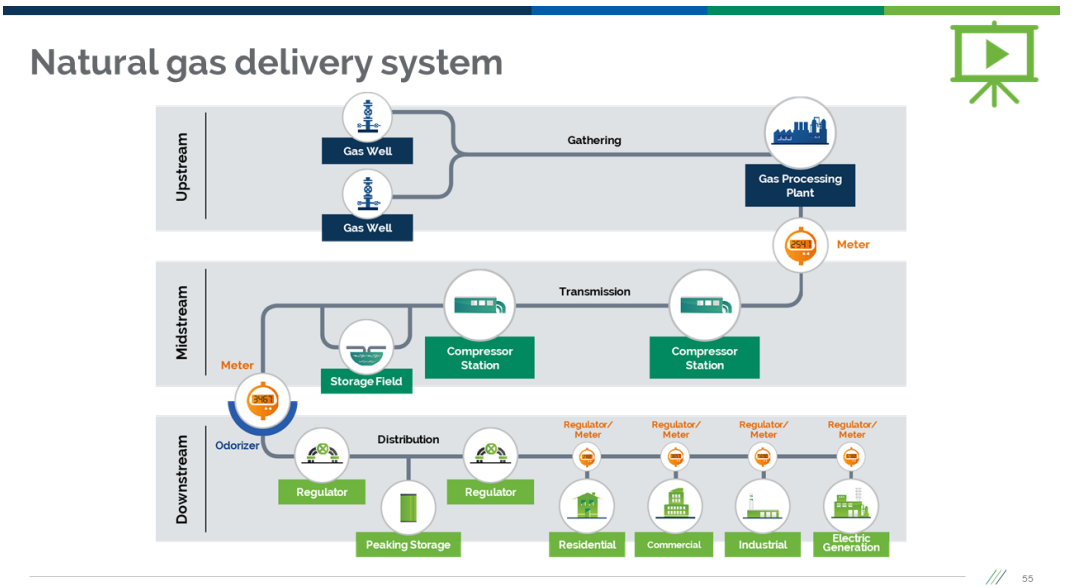
- How shale gas has revolutionized U.S. natural gas supply.
- How value is added to natural gas through the value chain.

Glossary of terms introduced in this module

- **Baseload:** Natural gas and electric usage that is constant throughout a specified time period. Also used to refer to the generating units that run all 24 hours of the day to serve a system's baseload demand.
- **Coalbed methane:** Any gas produced from a coal seam.
- **Distribution system:** The delivery of electricity over medium and low-voltage lines to consumers of the electricity. Or, a gas pipeline normally operating at pressures of 60 pounds per square inch or less that brings gas from the higher-pressure transmission line to the customer.
- **Energy efficiency:** Using less gas or electricity to perform the same amount of work or to get the same end value.
- **Gathering system:** A system of small pipelines that collects gas from individual lease facilities for delivery to a mainline system.
- **Liquefied natural gas (LNG):** Natural gas that has been chilled to the point that it liquefies. LNG is used as a means to store and transport natural gas.
- **Processing plant:** A facility designed to clean raw natural gas by separating impurities and various non-methane hydrocarbons and fluids to produce what is known as pipeline quality dry natural gas.
- **Shale gas:** Natural gas produced from shale formations.
- **Storage:** A means of maintaining gas in reserve for future demand, either through injection into a storage field or by holding it within the pipeline (known as line packing).
- **Supply basin:** A geographical area where numerous reservoirs are located.
- **Transmission:** The process of transporting large volumes of natural gas at high pressure over long distances. Also the process of transporting bulk power at high voltages over long distances.
- **Well:** The hole drilled into the earth's surface to produce natural gas.

The physical system and operations

Slide 55

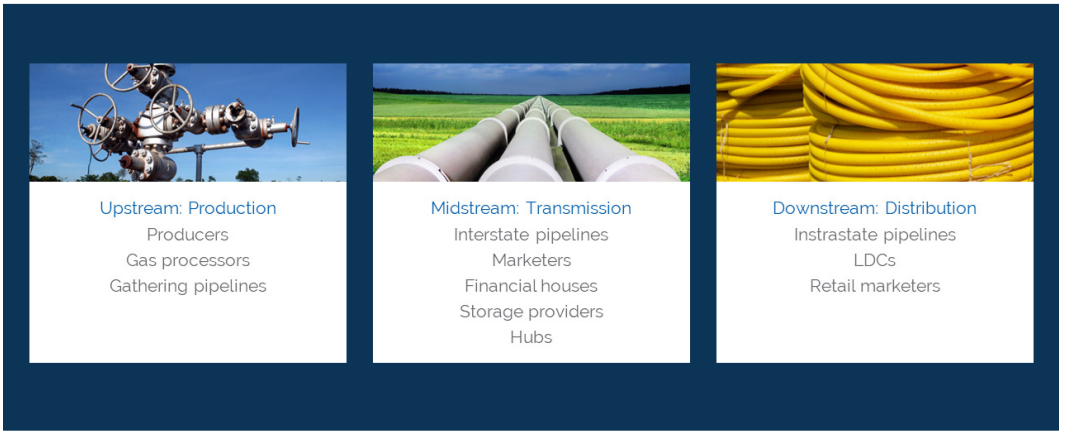


Here are the steps involved with bringing gas from where it is discovered to where it is consumed:

- Underground natural gas reservoirs are discovered through exploration.
- Natural gas is produced from wells that remove the gas from reservoirs.
- The raw gas is gathered by a system of small pipes and delivered to a lease facility where it is separated from production liquids.
- Gas is then moved in a gathering system from multiple leases or fields to a processing facility that removes valuable natural gas liquids (NGLs) and impurities.
- The gas enters a mainline pipeline system for transportation to a local distribution system.
- Either the pipeline, the distribution system or a storage facility stores the gas until it is needed.
- And finally, the local distribution system transports the gas to end-use locations where it is consumed.

Slide 56

Participants in the gas delivery chain

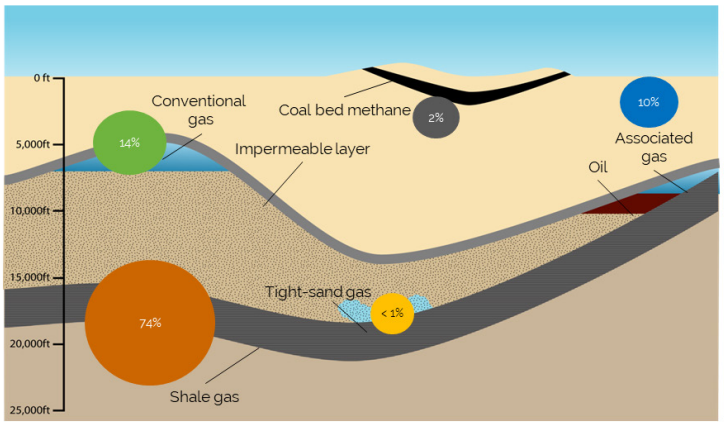


Unlike the electric industry, the natural gas industry historically has not been vertically integrated. Though affiliated companies might own different pieces of the delivery chain under the same corporate parent, LDCs own the distribution system and some transmission within the state. Some LDCs also own storage. This leaves plenty of opportunities for additional market participants throughout the delivery chain (including storage and transmission which may compete with the LDC).

Gas supply and where it's found

Slide 57

Domestic gas comes from different types of supply



2022 data from Energy Information Administration

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Conventional natural gas reservoirs are geologic traps in which an impermeable rock traps gas that has collected in pores in permeable rock. Over time the gas migrates up to the impermeable cap through cracks in the rock because the gas is less dense than other materials in the rock. When water is present in the formation, the lighter gas will displace the water to the bottom of the permeable layer. Conventional natural gas is typically found in sandstone beds and carbonate rock. Reservoirs may contain just natural gas, in which case the gas is called non-associated, or may contain both gas and oil, in which case the gas is called associated. Wells are drilled into these reservoirs and natural gas flows upward from the high-pressure condition in the buried reservoir to the lower pressure condition at the wellhead (the top of the well at the surface). Natural gas also accumulates in other types of formations resulting in what is called unconventional gas. Gas in these formations includes:

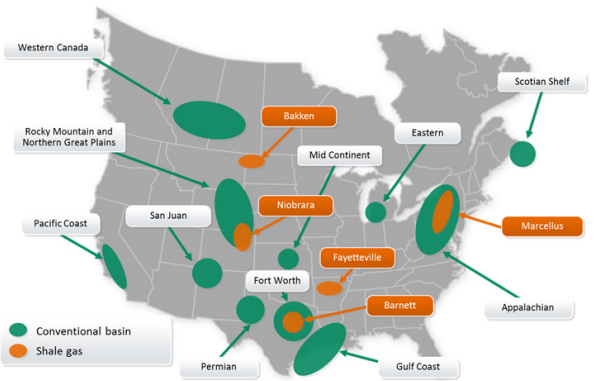
- Tight sands gas — formed in sandstone or carbonate (called tight gas sands) with low permeability which prevents the gas from flowing naturally.
- Coalbed methane (CBM) — formed in coal deposits and absorbed (meaning attached to solid particles instead of occupying pores in the rock).
- Shale gas — formed in fine-grained shale rock (called gas shales) with low permeability and absorbed by clay particles or held within minute pores and microfractures.
- Methane hydrates — trapped in water with crystalline ice-like substances.

Both conventional and unconventional sources (except for methane hydrates) have become important resources in recent years.

Slide 58

Nearly ¾ of the natural gas produced in the U.S. comes from hydraulic fracturing gas produced in the U.S. comes from hydraulic fracturing

Major gas supply basins



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Based on what you have heard, what do you think of fracking?

- a) It is a potential environmental disaster and should be banned
- b) It will cause environmental decline, but is worth it for cheaper gas supply
- c) It has environmental issues that can be managed with proper regulation
- d) It is safe

Key concept

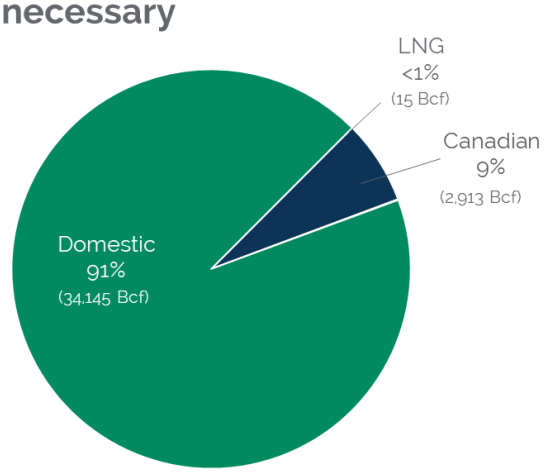
The development of shale gas accessed through fracking has totally transformed the U.S. natural gas supply picture. In 2000 shale gas provided only 1% of U.S. natural gas production; by 2010 it was over 20%, and by 2021 shale gas provided nearly ¾ of U.S. production.

The future of natural gas in California is somewhat in question. While many areas in the U.S. see natural gas as a bridge fuel (displacing coal) as we move towards a future of greater renewables, this is not a consensus in California. Some believe that California should move aggressively towards greater renewables, and reduce (or even eliminate) dependence on natural gas as a fuel to generate electricity. The election of Gavin Newsom as governor may change how California views natural gas as he has stated his preference for a transition away from fossil fuels.

"LNG is an acronym for _____ _____ _____."

Slide 60

U.S. natural gas supply is a net exporter of natural gas, but some imports are necessary



2023 data from Energy Information Administration

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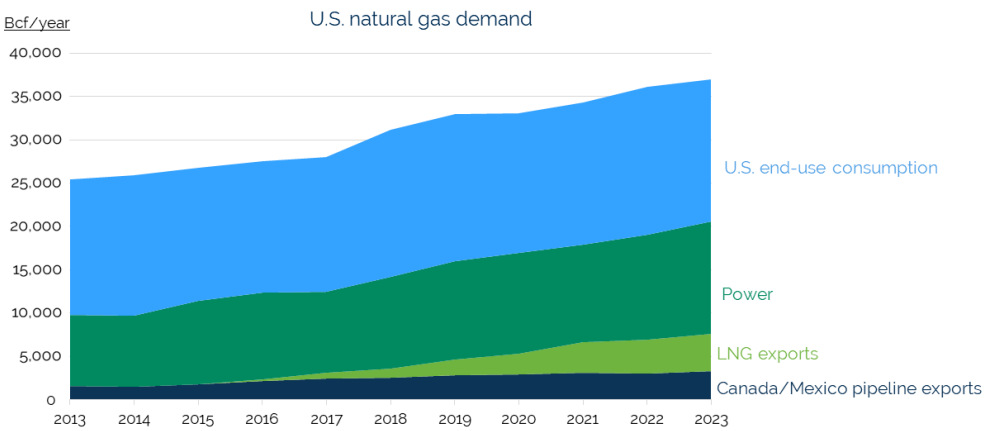
U.S. exports have increased from 6% to 21% of overall demand in the last 10 years



Source: Energy Information Administration

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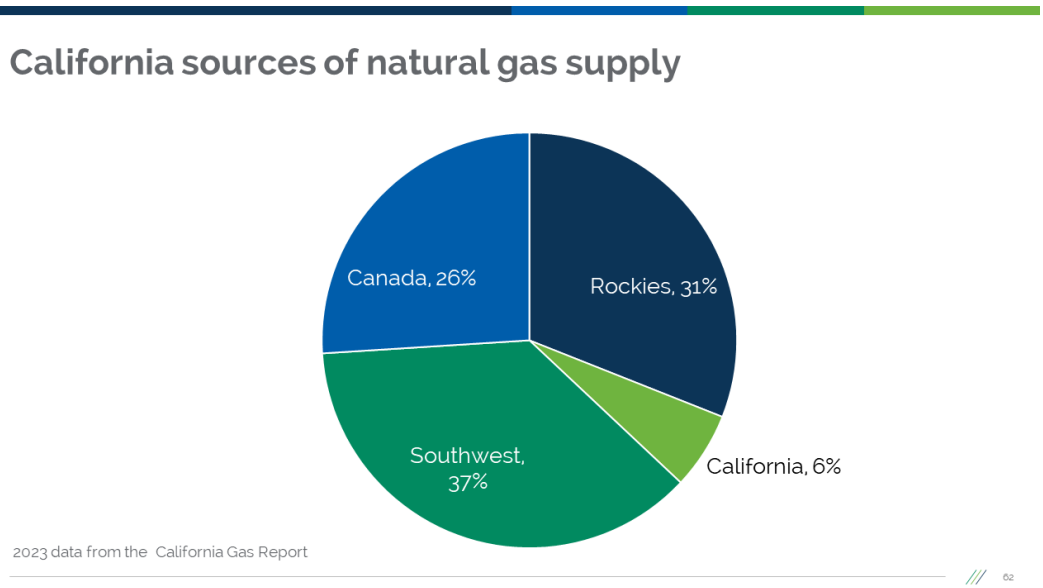

California is fortunate to have natural gas infrastructure that allows us to receive gas from a number of supply basins. This means the state does not need to rely on any one supply source, and that there is competition from these various supply regions to serve the California market.

Notes

Renewable natural gas

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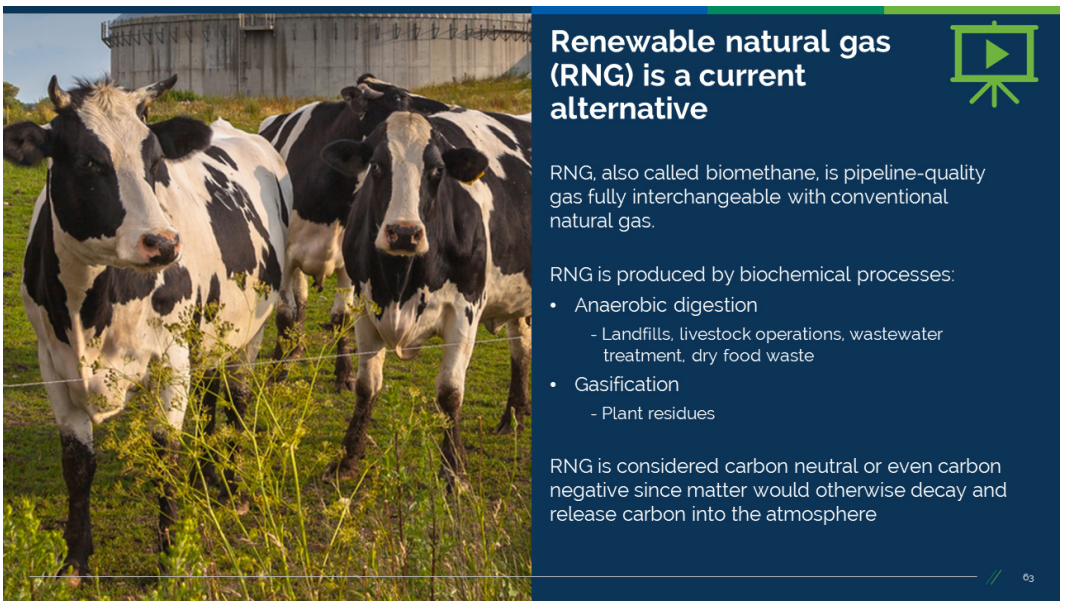


Renewable energy is an increasingly important part of California's clean energy future. You've probably heard of renewable energy sources like solar and wind, but you may not have heard of renewable natural gas (RNG). Learn more about this renewable fuel and how it can help reduce greenhouse gases and address climate change.

A new study shows that replacing less than 20 percent of the traditional gas supply with RNG captured from sources like dairies, wastewater treatment plants and landfills can achieve greenhouse gas (GHG) emissions reductions equivalent to converting 100 percent of buildings to electric only energy by 2030. And using a mix of in and out of state RNG is 3 times more cost-effective in reducing GHGs than an electrification pathway.

What is Renewable Natural Gas?

Natural gas, which consists largely of methane, has traditionally been sourced from decomposing organic matter found underground (ie. fossils). However, there are other sources of decomposing organic matter that can generate natural gas. One example is a landfill, which produces gas from its decomposing organic waste. This gas, also known as biogas, can be captured and cleaned of non-methane elements to make Renewable Natural Gas (RNG). The resulting RNG is the same as and can be used interchangeably with traditional natural gas; the only difference is that this natural gas came from a landfill instead of a fossil.

Renewable Natural Gas can be produced from a variety of existing waste streams and renewable biomass sources, such as:

- Animal waste from dairies
- Food waste from landfills
- Organic waste from wastewater treatment plants
- Organic waste from landfill-diversion facilities

Benefits of Renewable Natural Gas

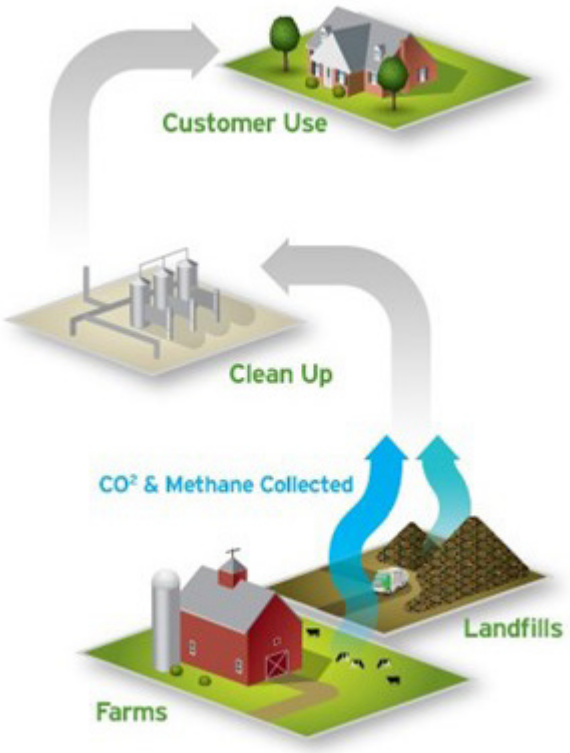
You can use RNG to power equipment or vehicles that use natural gas, or to generate your own electricity on site. This can be a great way to save money and energy. Other benefits include:

- Capture emissions of unused "waste" methane
- Reduce the need for conventional fuel
- Cut production and waste disposal costs

RNG can be an important renewable energy tool because it is available anytime consumers need it. Wind and solar are intermittent energy sources – meaning the energy isn't available when the sun isn't shining, and the wind isn't blowing. Waste material can be converted into deliverable, renewable energy 24 hours per day, seven days a week and can be deployed when and where it is needed through the pipeline network.

How is Renewable Natural Gas Produced from Biogas?

Biogas is the raw gas produced from decomposing organic waste. It typically consists of mainly methane and carbon dioxide, along with traces of other elements. In order to become RNG, biogas needs to be cleaned and conditioned, which means removing or reducing non-methane elements such as carbon dioxide. This process generates a Renewable Natural Gas that's completely interchangeable with traditional pipeline-quality natural gas and ensures safe and reliable operation of the pipeline network and customer equipment. RNG is extremely versatile and can be delivered anywhere along the nation's extensive pipeline infrastructure.



Courtesy of the American Gas Association

The abundance of these materials allows for production of substantial quantities of biogas. A study by UC Davis estimates that more than 20 percent of California's current residential natural gas use can be provided by RNG derived from our state's existing organic waste alone. Looking outside California, the United States could produce up to 10 trillion cubic feet of RNG annually by 2030 — that's more than five times California's projected natural gas consumption.

Source: SoCalGas website

Hydrogen

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With limits to RNG availability, is hydrogen the big thing?

"Our California-based utility businesses are helping build California's 21st century energy system through deliberate investments in hydrogen, renewable natural gas, fuel cells, and carbon capture and storage. This hydrogen blending program is a key milestone in our efforts to decarbonize our energy system, while delivering affordable and reliable energy to 22 million California customers."

Kevin Sagara, Group President for Sempra Energy and Chairman of SoCalGas and San Diego Gas & Electric

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Notes

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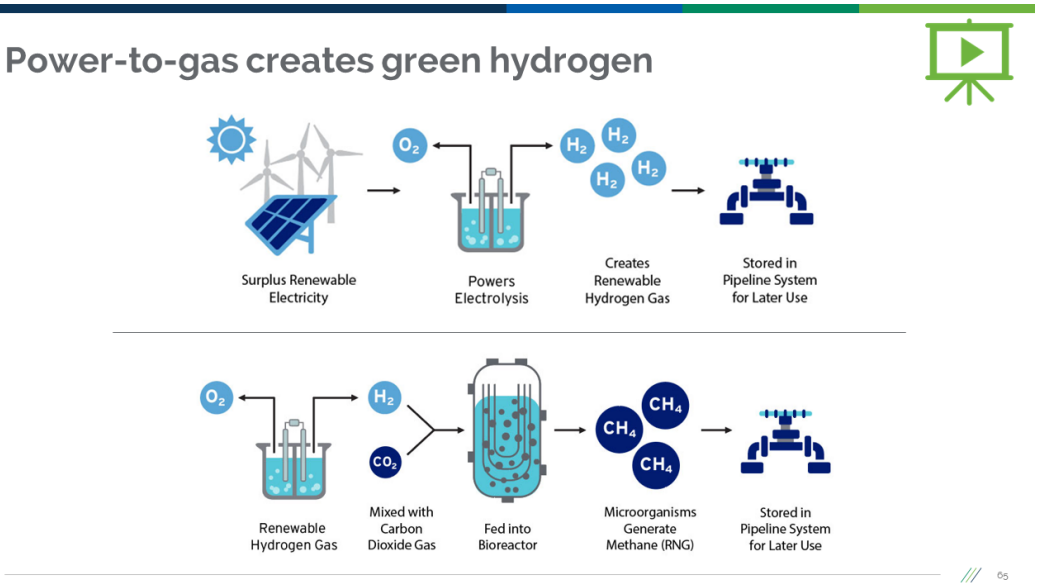

Hydrogen's Role in Clean Energy to Take the Spotlight in SoCalGas' "H2 Hydrogen Home"

First project of its kind in the U.S. aims to show how this carbon-free gas made from renewable electricity can fuel clean energy systems in a carbon-neutral future

LOS ANGELES, Dec. 15, 2020 — As part of its efforts to support California's climate change goals and its mission to become the cleanest, safest and most innovative energy company in America, Southern California Gas Co. (SoCalGas) today announced it will build a state-of-the-art demonstration project to show the role hydrogen could play in attaining California's goal of achieving carbon neutrality. Named the H2 Hydrogen Home, the project is the first of its kind in the U.S. and will include a home, solar panels, a home battery, an electrolyzer to convert solar energy into clean hydrogen, and a fuel cell to convert that hydrogen back to electricity. The hydrogen will also be blended with natural gas for use in the home's appliances. The H2 Hydrogen Home is expected to be complete by late 2021.

"California will continue to lead by bringing green hydrogen into its energy mix, just as it led by integrating renewable electricity and batteries for electric storage," said Maryam Brown, SoCalGas president. "The H2 Hydrogen Home will help guide decision-making that will ultimately create the 21st century energy system needed to provide clean, affordable and resilient energy for Californians."

"As we move to a clean energy future, hydrogen is a zero-emission fuel that could play a significant role in California," said California Assembly member Jacqui Irwin. "This demonstration home will be a great way to see hydrogen in action. Looking forward I am excited about the development of hydrogen technology as a way to create jobs for Californians in a green economy."

"This home is a great way to show in a tangible way how green hydrogen can store renewable power for an unlimited length of time and how it can be reconverted to electricity whenever it's needed," said Janice Lin, Founder and President of the Green Hydrogen Coalition.

The H2 Hydrogen Home is designed with solar panels, which will power the project's home on sunny days and also provide excess electricity that will be stored for night use and cloudy days. Some of that extra electricity will charge a home battery for short-term energy storage. The rest of the solar power will be converted to clean hydrogen using an electrolyzer and stored until needed. That stored hydrogen will also be converted back to electricity with an on-site fuel cell. And finally, the hydrogen will be blended with natural gas and used in the home's heat pump HVAC unit, water heater, clothes dryer, and gas stove.

Hydrogen provides an ideal solution for long-term storage of renewable energy on the larger grid as well, according to energy experts. While power from solar and wind can be stored for several hours in grid-scale batteries, there are times when longer-term storage is needed. Converting renewable electricity to hydrogen allows it to be stored for weeks, months or years. The hydrogen can then be converted back to clean electricity and dispatched to the power grid when it is needed to supplement solar and wind generation or battery storage, using either turbine generators, or fuel cells. Such a system is also far more cost-effective than one that uses batteries only, according to a recent study by Caltech.

Source: SoCalGas press release

Liquefied natural gas

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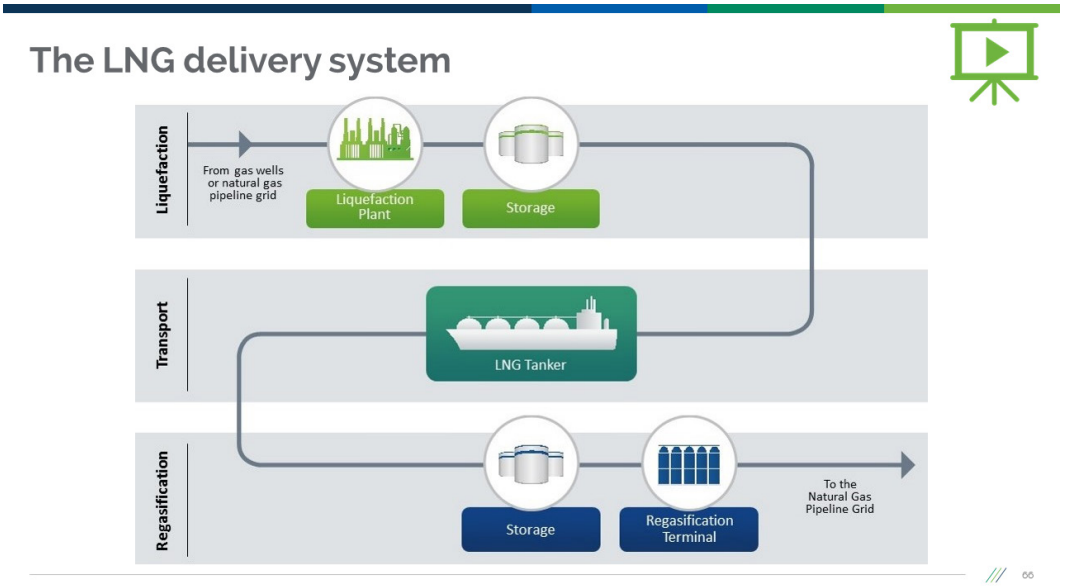
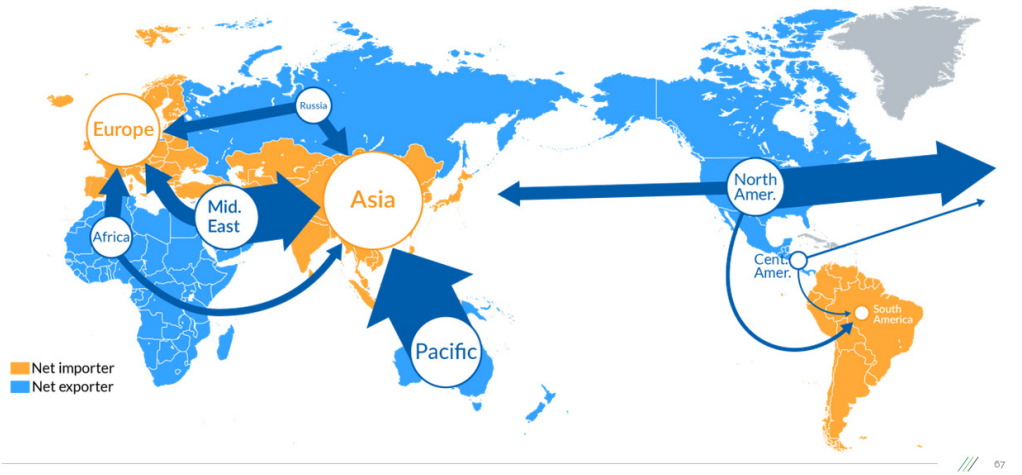


An alternative to delivery by pipeline is to convert natural gas to LNG and then transport it by tanker ship or truck. Natural gas can be converted to liquid by cooling it below approximately minus 260 degrees Fahrenheit. After the conversion, the volume is reduced by a factor of 610, making it practical to transport by tanker. Because large volumes of LNG can be moved across long distances where pipelines are not feasible, LNG transported by ships makes it possible for gas markets to access natural gas reserves that are located throughout the world. As recently as 2010 almost 2% of U.S. gas supply was imported as LNG. Today the U.S. meets less than 1% of its gas supply needs through LNG and in 2021 set a record high for exports of LNG, averaging 9.7 Bcf per day. This is a 50% increase from 2020! However, recent reports now suggest that some of the natural gas price increases we've seen in 2022 are a result of global demand for exported U.S. LNG.

Slide 67

Internationally, there is vibrant cross-border trade both via pipeline and via liquefied natural gas (LNG) tankers



Notes

Gas transmission

Slide 68

Transmission system

- Moves gas from supply basin to local distribution company (LDC) system
- Lines are made of steel, are large diameter (24-48 inches), and buried underground
- Operated at high pressures (200 – 1,000+ psi)
- Capacity of specific pipe depends on pipe size, rated line pressure, and available compression
- SDG&E's natural gas facilities include 234 miles of transmission pipeline and one compressor station

Slide 69

Important points about the transmission system

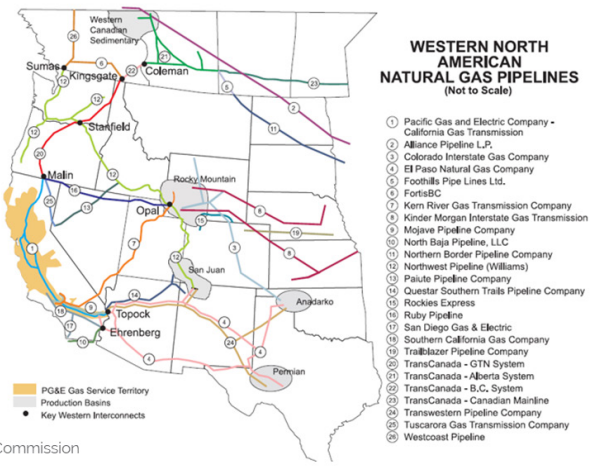
- We have a robust system in the U.S./Canada, but pipe is constrained going into New England
- New pipelines cost between $3 - $13 million per mile
- Pipeline expansions occur when customers commit to long-term contracts
- Barriers to construction include public opposition, permitting difficulties, and regulatory uncertainty

Notes

California pipelines and storage

Slide 70

Western U.S./Canada transmission pipelines



Source: California Energy Commission

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Storage facilities

- Gas is stored by being pumped into a "vessel" at high pressure
- There are multiple types of storage
  - Depleted reservoir
  - Salt storage
  - Aquifer
  - LNG (large storage atterminals plus small local storage)
  - Pipes
- SoCalGas owns four natural gas storage facilities

SoCalGas owns four natural gas storage facilities. These facilities have a combined working gas capacity of 137 Bcf and have over 200 injection, withdrawal, and observation wells that provide natural gas storage services for core, noncore, and non-end-use customers. SoCalGas' and SDG&E's core customers are allocated a portion of SoCalGas' storage capacity. SoCalGas offers the remaining storage capacity for sale to others, including SDG&E for its non-core customer requirements. Natural gas withdrawn from storage is important for ensuring service reliability during peak demand periods, including heating needs in the winter, as well as peak electric generation needs in the summer.

The Aliso Canyon natural gas storage facility represents 63 percent of SoCalGas' natural gas storage capacity. SoCalGas discovered a natural gas leak at one of its wells at the Aliso Canyon natural gas storage facility in October 2015 and permanently sealed the well in February 2016. SoCalGas was subsequently authorized to make limited withdrawals and injections of natural gas at the Aliso Canyon natural gas storage facility and, as of November 2021, has been directed by the CPUC to maintain up to 41 Bcf of working gas to help achieve reliability for the region at reasonable rates as determined by the CPUC.

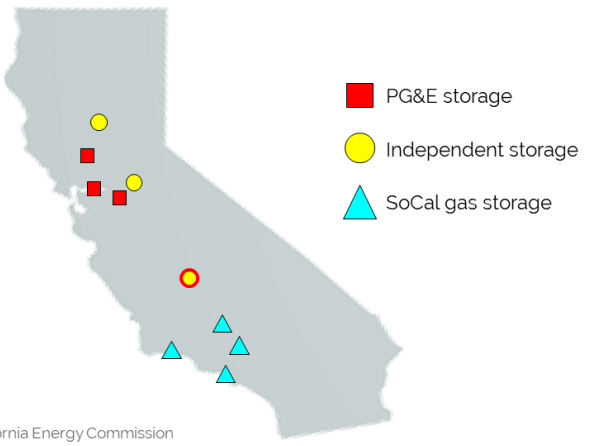
Slide 72

Important points about storage

- Each facility is rated for injection, capacity, and withdrawal capacity
- Salt storage allows for quick withdrawal, but is more expensive to develop
- Storage availability depends on local characteristics and some regions don't have underground storage capabilities
- New construction is limited by available sites

Slide 73

California storage



Source: California Energy Commission

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How underground storage works:

Natural gas in a pipeline is further pressurized so that it can be injected into the underground storage facility. If a reservoir is being used, the gas will occupy the same geologic formations it occupied prior to being produced. As the gas is injected, the pressure inside the reservoir (or other suitable formation) increases. When it's time to withdraw the gas, the field operator opens valves to allow the gas to flow to the surface. The accumulated pressure acts in much the same way as a new discovery, pushing the gas toward the lower pressure on the surface.

A certain quantity of "cushion" gas is required for the gas to be withdrawn from the storage facility. This gas is not withdrawn during the process but stays in the reservoir to provide enough pressure for the withdrawal gas to flow. "Working" gas, in contrast to cushion gas, is the gas that is injected and withdrawn – or cycled – during the storage cycle.

California requires gas storage to meet its customers' summer and winter peak demand. Without storage, California would need to build much more pipeline capacity and/or curtail customers during peak times.

Gas distribution

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Distribution system

- Moves gas from interconnect with transmission (citygate) to customer
- Lines are made of steel or plastic with diameters much smaller than transmission pipe
- System includes supply mains, feeder mains, distribution mains, and service lines with progressively lower pressures
- Typical pressures range from a few psi to 200 psi
- Capacity of specific pipe depends on pipe size, rated line pressure, and upstream pressure from the transmission system (distribution systems do not typically have compression)
- SDG&E's natural gas facilities include 8,966 miles of distribution pipelines and 6,562 miles of service pipelines

Slide 75

Important points about the distribution system

- Distribution systems are designed to maintain reliability to residential customers in extreme cold
- Distribution systems are often designed assuming that industrial and power plant customers can be curtailed if needed to maintain service to residential customers
- Costs vary widely depending on type of line
- Pipes are expanded as needed to serve customers
- A large amount of aging infrastructure exists, which can create safety and reliability issues

Notes

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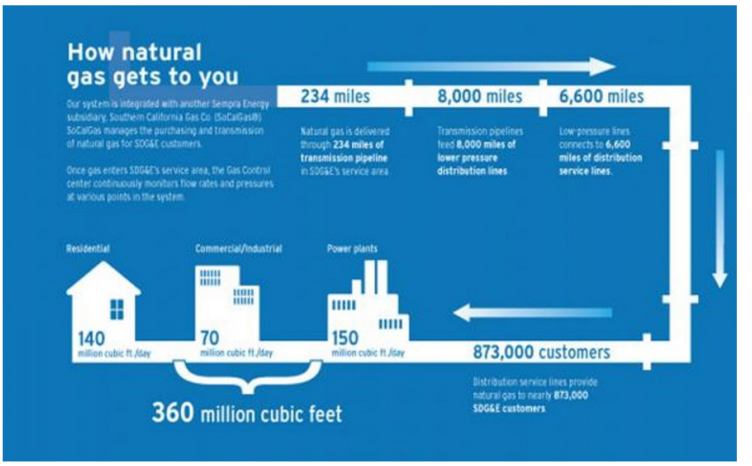
Facts about the SDG&E system



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How natural gas gets to you:

- Our system is integrated with another Sempra Energy subsidiary, Southern California Gas Co. (SoCalGas). SoCalGas manages the purchasing and transmission of natural gas for SDG&E customers.
- Once gas enters SDG&E's service area, the Gas Control center continuously monitors flow rates and pressures at various points on the system.
- Natural gas is delivered through 234 miles of transmission pipeline in SDG&E's service area.
- Transmission pipelines feed 8,000 miles of lower pressure distribution lines.
- Low pressure lines connect to 6,600 miles of distribution service lines.
- Distribution service lines provide natural gas to nearly 873,00 SDG&E customers.
- SDG&E customers consume an average of 360 million cubic feet per day (Mcf/d).

Safe Operation of San Diego's Natural Gas System

The pipes that deliver natural gas to most of our homes and businesses are underground, so we don't always think twice when we're cooking a meal or warming our home how the natural gas system works. But, just like most of the electric system we see above ground, the below-ground infrastructure of the natural gas system is equally important.

SDG&E and Southern California Gas Company (SoCalGas) work together to operate the integrated natural gas system that encompasses most of Southern California. SDG&E's service area encompasses all of San Diego County, consists of more than 230 miles of large high-pressure transmission pipeline which make up the "backbone" of the natural gas system and nearly 15,000 miles of lower pressure distribution and individual service lines that bring the natural gas to our homes and businesses.'

On an average day, San Diego residents and businesses use more than 360 million cubic feet of natural gas to fuel area restaurants, hotels, schools, manufacturing facilities and the military. Natural gas also fuels most of the regions power plants that generate electricity. At SDG&E, we believe that safety is of utmost priority, which is why we have skilled crews who are focused day after day on ensuring the safety of the natural gas system.

These crews perform leak and corrosion surveys, meter installations or replacements, valve maintenance and any maintenance and construction related to repairs or pipeline projects to ensure the system is operating safely, reliably and efficiently.

Crews also perform inspections on other equipment like pressure regulator and compressor stations. Large high pressure pipelines – transmission lines – running underground are also inspected internally. This is achieved by using highly sensitive tools that are sent into a pipeline to check for any dents or corrosion or any other irregularities.

Notes

Pipeline operations

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Pipeline and utility systems are operated separately

Each system has its own system operations:

- Interstate pipeline
- Local distribution company

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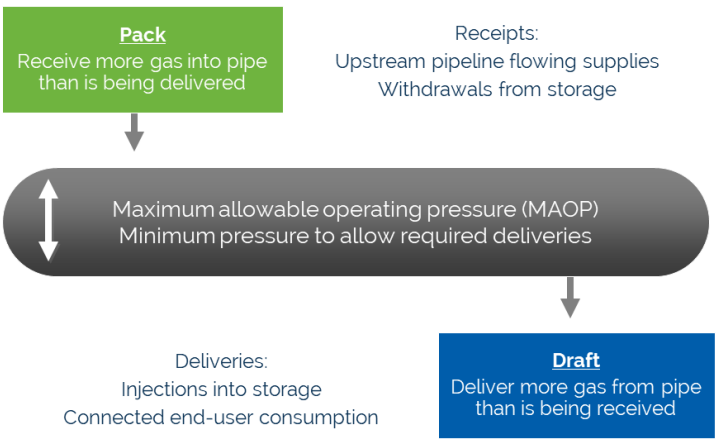
But the responsibilities of system operators are similar

Running the system to ensure reliability and integrity:

- Managing inventory (pack/draft)
- Managing storage (injection/withdrawal)
- Scheduling (daily and also intra-day)
- Daily balancing

Slide 79

Pack and draft uses pipeline storage to manage hourly and daily demand fluctuations



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Review

Slide 80

The majority of gas consumed in the U.S. is produced from:

- a) Conventional wells
- b) Shale
- c) Coal-bed methane
- d) Associated (with oil) wells

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How much of the gas supply consumed in the U.S. is produced domestically?

- a) About 50%
- b) About 60%
- c) About 70%
- d) About 80%
- e) About 90%

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What percentage of renewable natural gas (RNG) can safely be combined with natural gas flowing in a pipeline for delivery to customers?

- a) 20%
- b) 30%
- c) 40%
- d) No more than 50%
- e) There is no limit

Slide 83

Which of the following statements about LNG is false?

a) Shipping as LNG allows gas from the U.S. to reach global markets

b) Prior to shipping LNG, the source gas must be liquefied

c) Prior to shipping LNG, the source gas must be regasified

d) To liquefy natural gas, it's temperature must be dropped to about -260 F

e) When liquefied the volume of natural gas is reduced by a factor of about 600

Notes

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Answer each of the following questions from the natural gas perspective:

a) Where is natural gas found?

b) Where can gas be stored?

c) How often are gas transactions scheduled?

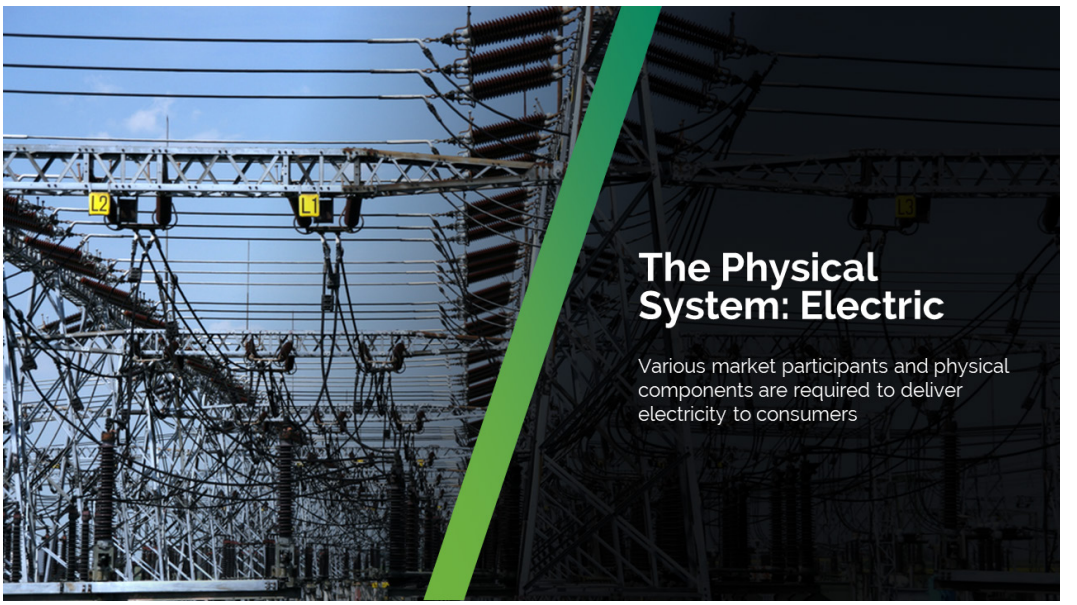
d) Who owns gas production facilities?

e) Who might own a gas transmission pipelines?

f) Who operates a gas transmission pipeline?

g) Who owns the gas distribution system?

Slide 85



Key concepts

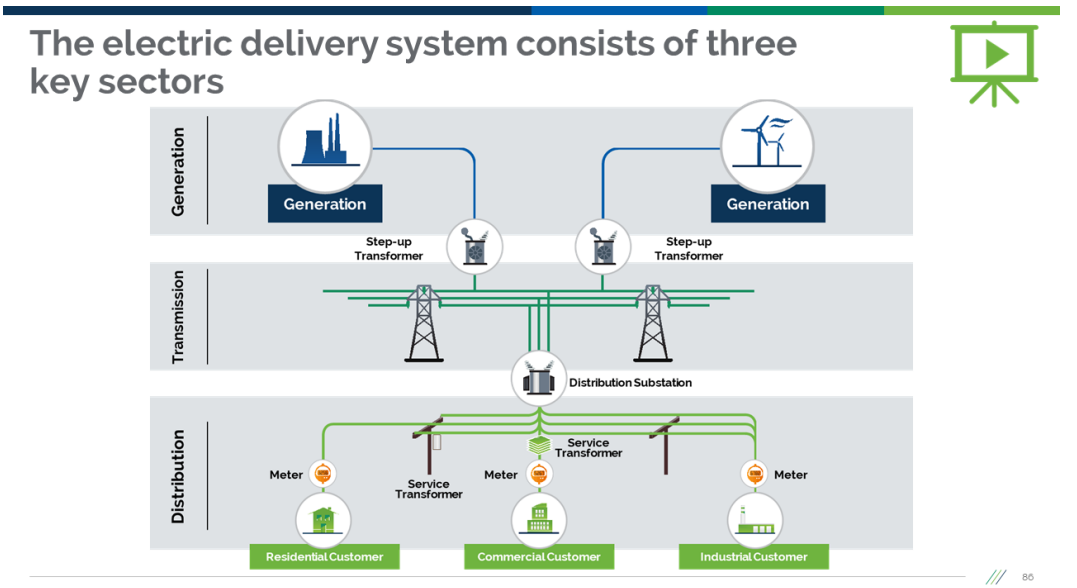
- The difference between a generator's capacity and output.
- Generation characteristics are very important in understanding how a specific type of generation will be used.
- Demand side management is an alternative to generation.
- The California ISO is the system operator for SDG&E and most of California.

Glossary of terms introduced in this module

- **Baseload:** Natural gas and electric usage that is constant throughout a specified time period. Also used to refer to the generating units that run all 24 hours of the day to serve a system's baseload demand.
- **Demand response:** Moving energy usage from peak to off-peak periods to reduce overall energy costs and/or to eliminate the need for added supply.
- **Distribution system:** The delivery of electricity over medium and low-voltage lines to consumers of the electricity. Or, a gas pipeline normally operating at pressures of 60 pounds per square inch or less that brings gas from the higher-pressure transmission line to the customer.
- **Energy efficiency:** Using less gas or electricity to perform the same amount of work or to get the same end value.
- **Independent system operator (ISO):** An independent entity that provides system operation functions including managing system reliability and transmission access; and also facilitates markets such as real-time energy and, in some cases day-ahead energy and/or capacity.
- **Intermediate load:** The electric usage range between baseload to a point between baseload and peak. This point may be the midpoint, a percent of the peak load, or the load over a specified time period.
- **Peak load:** The point of the day, month or year when gas or electric usage is at its highest.
- **System operator:** The entity that manages the transmission grid by dispatching generation and scheduling reserves and transmission. In some cases system operators may also facilitate short-term energy markets, ancillary reserves markets, and capacity markets.
- **Transmission:** The process of transporting large volumes of natural gas at high pressure over long distances. Also the process of transporting bulk power at high voltages over long distances.

The electric delivery system

Slide 86

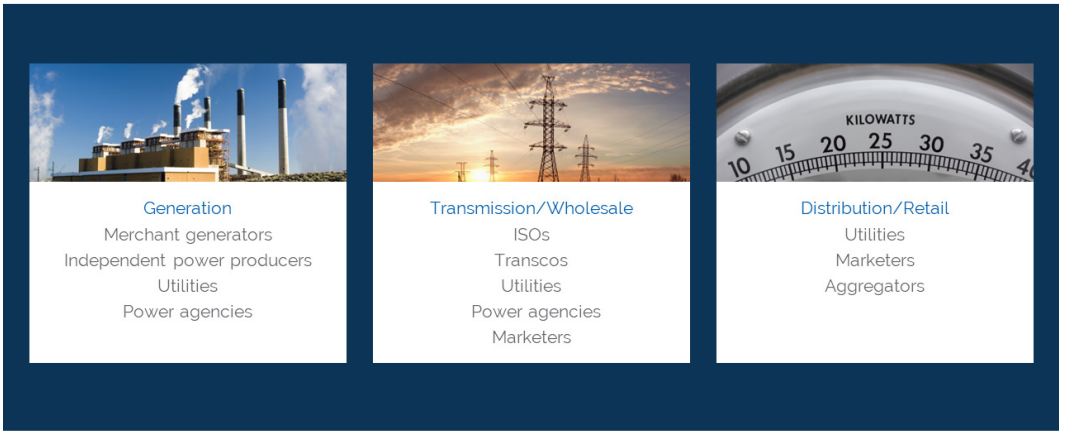


Here are the steps typically involved with bringing electricity from where it is created to where it is consumed:

- Electricity is created in generators, which have historically produced bulk electricity in locations far from where it will be consumed. Though increasingly generation is located much closer to the customer, sometimes even on the customer's premises as with rooftop solar.
- After it leaves the generator, electricity is transformed to increase the voltage.
- Electricity then travels on the transmission system which is designed to move large amounts of power over long distances at high voltage. Sometimes very large customers will take electric service directly from the transmission system.
- As it reaches areas of consumption, the voltage is reduced in a distribution substation, and the electricity is moved onto the distribution system. This system transports electricity at lower voltages to the end users who will consume it.

Slide 87

Market participants in electric delivery chain

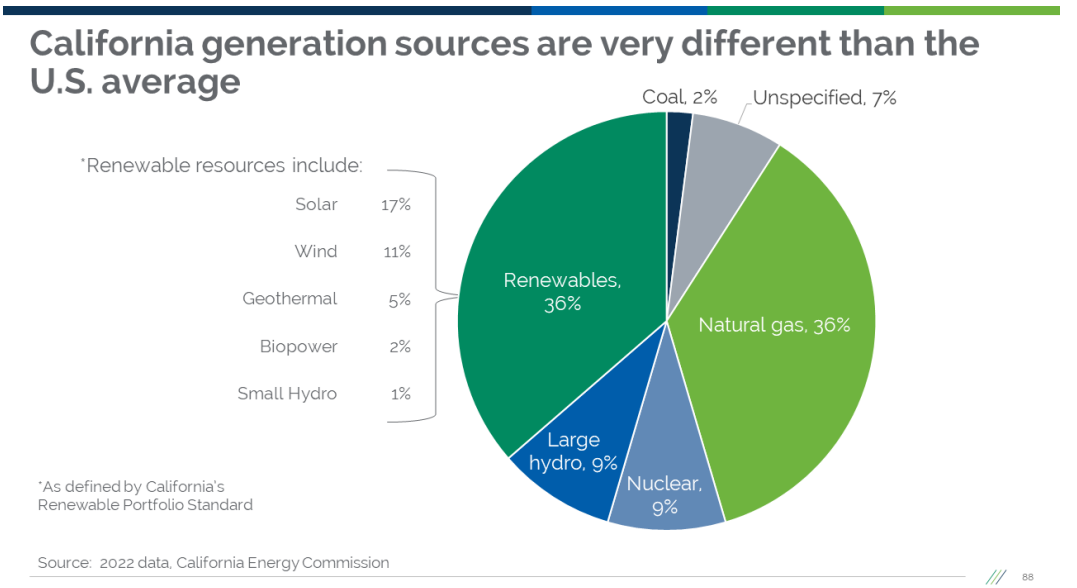


The traditional U.S. market model is simply a vertically integrated monopoly that handles all electric service functions as an integrated entity. This means the utility owns the generation and transmission necessary to serve its end-use customers, manages system operations to serve them, and is the only entity providing electric distribution and supply. But as markets are increasingly opened, there are many opportunities for additional market participants throughout the delivery chain.

Notes

Generation: sources, characteristics, and costs

Slide 88



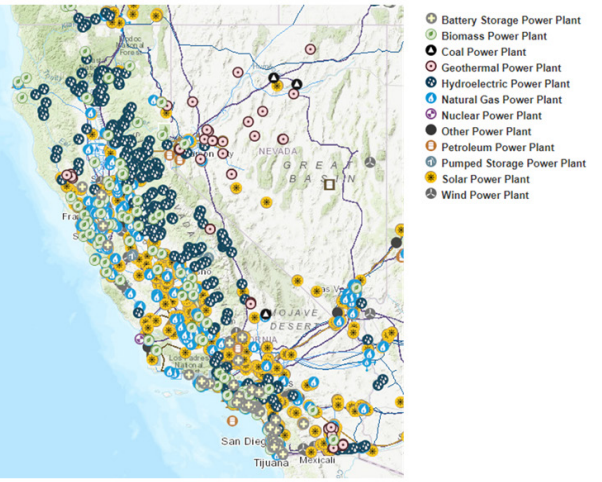
Key concept

In a chart like the one above it is important to understand the difference between a generator's capacity and its output. The percentages above show output or the actual energy generated. For units that are run most of the time (nuclear for example), capacity and output may be similar. But for units that are used mainly during peak periods (some less efficient but flexible natural gas units), capacity may be far greater than actual output. This is also the case for renewables like wind and solar since they only run when the renewable resource (the wind and the sun) are available.

The way that generation is used can vary widely by region. As you can see, California uses a lot of natural gas and renewable energy sources to generate the electricity consumed in our state. And California uses very little coal generation, almost all of which is imported from other states.

Slide 89

California power plants



Source:
California Energy Commission

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Slide 90

Generation characteristics

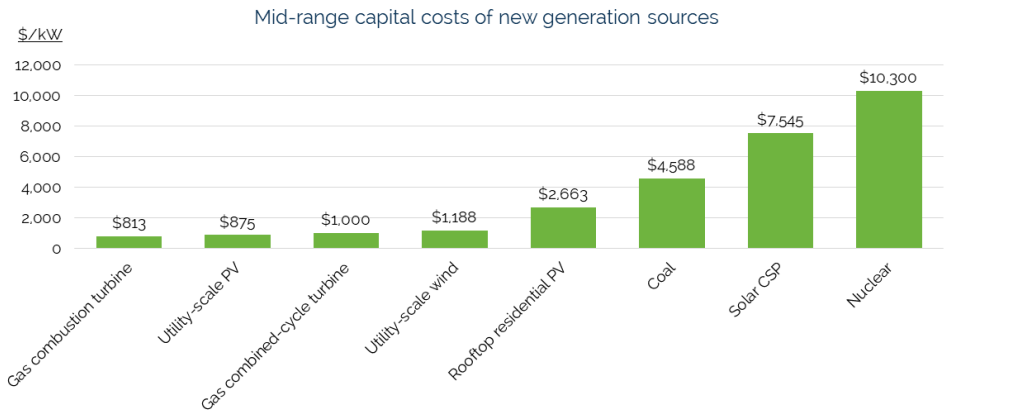
- Fixed cost
- Variable cost
- Operational flexibility
- Time to construct new units
- Environmental impact
- Location

Key concept

The way that generation is used throughout the day and year is dependent upon much more than just cost. Thus it is important to understand the characteristics that determine an electric generator's usage.

Slide 91

Capital costs vary widely by technology…

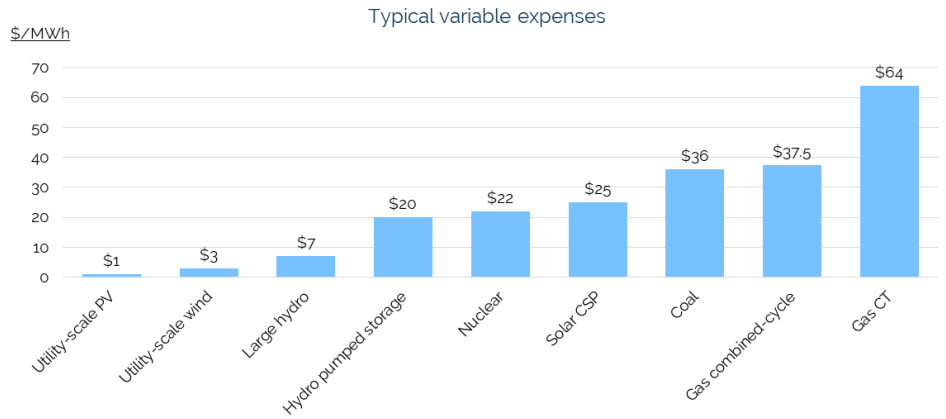


Source: Lazard Levelized Cost of Energy Analysis – Version 15.0

91

Slide 92

…as do variable expenses by fuel source and technology



Source: Compiled by Enerdynamics from various sources

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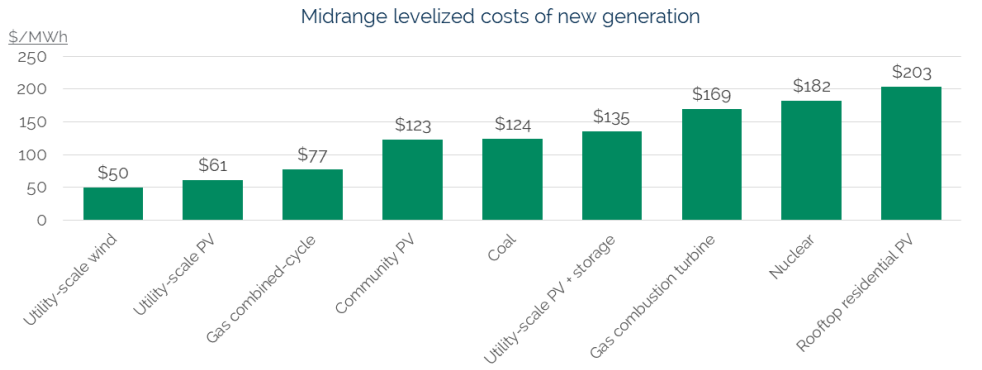
Slide 93

Renewables have become the lowest-cost source of supply



Note: These are unsubsidized numbers (before any tax benefits)

Source: : Lazard Levelized Cost of Energy Analysis – Version 17.0 (June 2024)

93

Levelized costs are meant to consider all the different costs over time incurred to create electricity from a specific generation source. These inlude the original capital cost, the variable costs that are incurred each time the generator is run, the fixed costs that are required to keep it in an operable condition, and the transmission costs of transporting the electricity to the distribution system. Levelized costs also take into consideration how often a generation type is likely to be used throughout the year (also known as its capacity factor).

Slide 94

Generation – environmental impacts

- Air pollution
- Water resources
- Nuclear radiation
- Land use

Demand side management

Slide 95

Demand side management is an alternative to generation

Energy efficiency

- Using less energy around the clock

Demand response

- Using less energy at a specific time
  - Interruptible rates
  - Behavioral programs (ex: TOU rates)
  - Economic demand response

Key concept

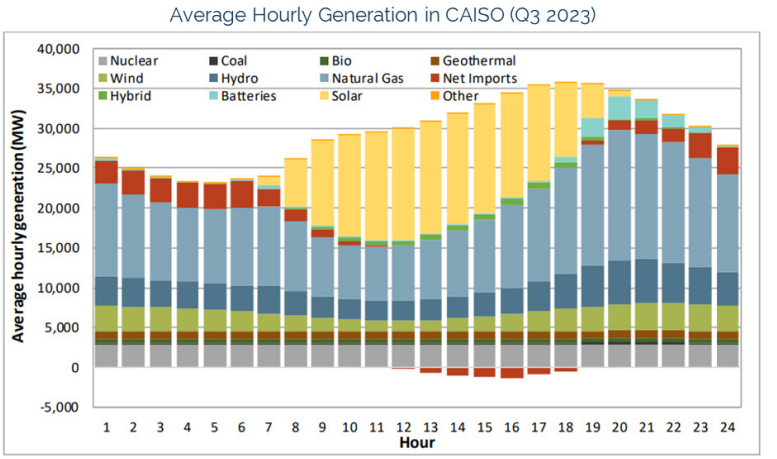
An alternative to increasing generation to match demand (at peak points of the day and across an entire year) is demand side management. Demand side management has two components: energy efficiency and demand response. Energy efficiency is using less energy across the entire year. A good example would be installing LED lights that require less energy whenever they are turned on. Energy efficient appliances are another example. Demand response is using less energy at a specific peak point of the day. An example would be a residential air conditioning program that allows a utility to shut off air conditioners at peak periods, thus reducing demand for a short period of time and the need for more expensive generation.

Switching to LED light bulbs is an example of _____ _____.

How generation is scheduled

Slide 96

Use of generation throughout the day



Source: CAISO Q3 2023 Report on Market Issues and Performance

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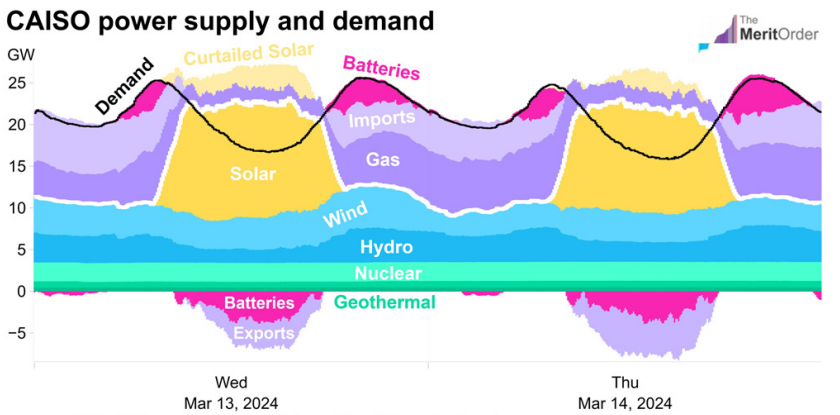
The key to understanding electric supply markets is to understand which generating units are dispatched at what times to meet the load curve (the aggregate demand of all customers in a specific region). This has a major impact on wholesale electric markets since the cost of the last unit required in any given hour (the marginal cost) often determines the market price of electricity in competitive markets.

Generating units are typically scheduled hourly (one day in advance) based on least-cost supply subject to reliability, operation, locational, and regulatory constraints. Use of generation is divided into three categories – baseload, which is the minimum load on a system across the entire day; intermediate, which is typically mid-morning until the afternoon; and peak, which is in the evening in the graph shown above.

As you can see, some generation is scheduled across every hour of the day. This includes nuclear (because it is inflexible), and bio and geothermal (because they are non-intermittent renewables). Solar and wind, because they are renewable and have a low variable cost, are generally scheduled whenever they are available. Note that the use of natural gas generation varies by period and you can see increased usage during the peak periods.

Slide 97

Renewables are becoming a key supply source in California and batteries are contributing to the peak



Prepared by Brain Bartholomew, Market Analyst at REV Renewables, @BPBartholomew

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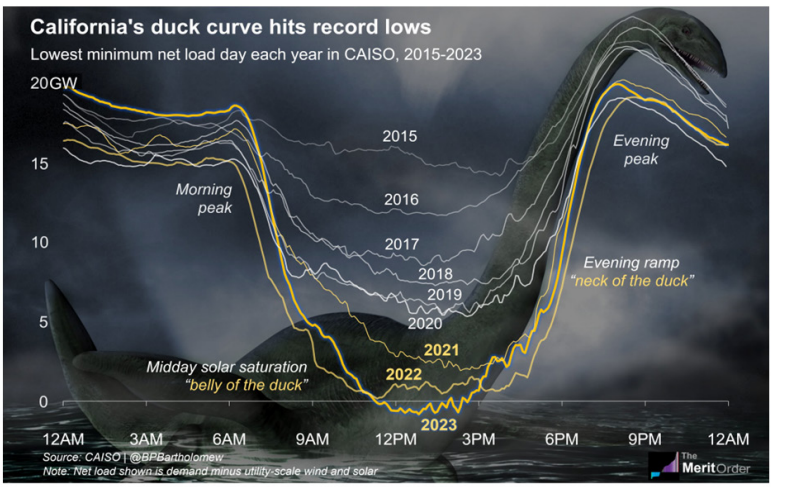
Notes

Slide 98

As renewables grow, the system needs more flexibility



98

As the amount of renewables on a system grows, system operators must revise how they schedule and run the electric grid. This is because most renewables (wind and solar) are variable and their output is not controlled by the system operator.

The Duck Curve used by the California ISO to demonstrate this effect shows the net load, which is total system demand less output of renewable generation. Net load must be met through traditional generation sources or through demand side management and storage. The Duck Curve indicates two key areas of concern:

On days without much customer demand and lots of solar generation, mid-day net load can get very low meaning that net load may drop below baseload unit output. This results in so-called over-generation.

Second, the early evening has a large increase in net load as the sun drops and customers get home from work and turn on appliances. The system must have enough flexible generating units to quickly ramp up as the sun drops.

Energy storage

Slide 99

Grid storage in California is projected to grow rapidly

California electric energy storage:

Pumped hydro:
About 2,800 MW, another 500 MW proposed near San Diego

Batteries:
About 10,300 MW of grid batteries plus additional 3,800 MW planned to come online by end of 2024

California projects 52,000 MW of battery storage needed by 2045

Compressed air energy storage (CAES):
Up to 1,000 MW proposed

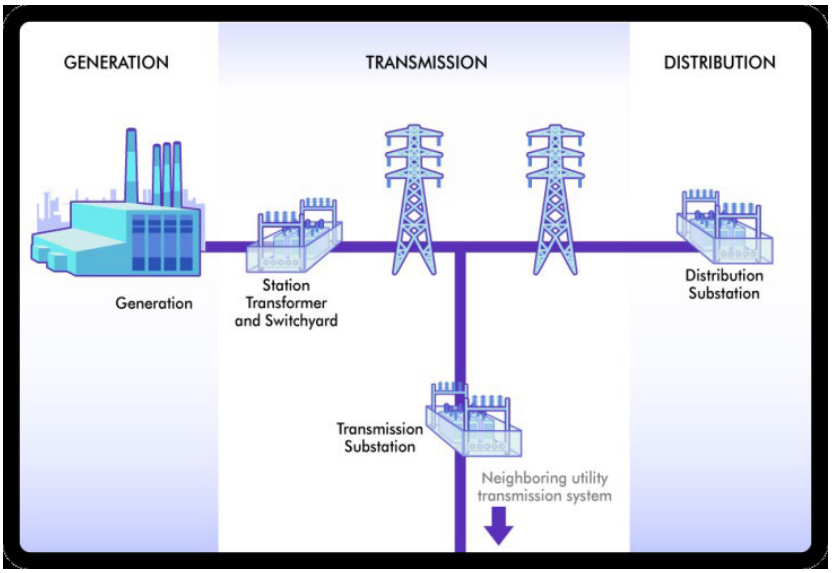
Notes

The transmission system

Slide 100

Transmission system

- Move electricity from generation to load center
- Usually above 50 kV, typical voltages include 69, 115, 230, 345, 500, and 765 kilovolts
- Lines can be either AC or DC, but AC is most common
- SDG&E's electric facilities consist of 2,089 miles of transmission lines and 161 substations



Electric transmission is the movement of large amounts of electricity over long distances at high voltage. In this process electricity is typically (though not always) moved from a central generating unit to an interconnection with an electrical distribution system, or, in some cases, directly to industrial customers. The transmission system is the electrical highway that connects supply to demand across a network called an electric grid.

Slide 101

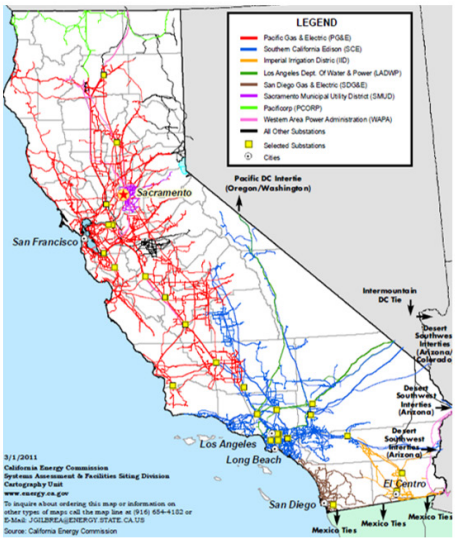
Important points about the transmission system

- Each line has rated capacity
- New transmission costs $1 million/mile to over $6 million/mile
- Underground is usually cost-prohibitive
- Barriers to construction include public opposition, permitting difficulties, and regulatory uncertainty

Slide 102

The California transmission grid

- The transmission grid is designed to move supply from out-of-state, from the hydro system in the Sierra's, and from Diablo Canyon to the load centers
- Utilities dominate ownership in their regions
- Power can move from north to south or from south to north



Source: California Energy Commission

102

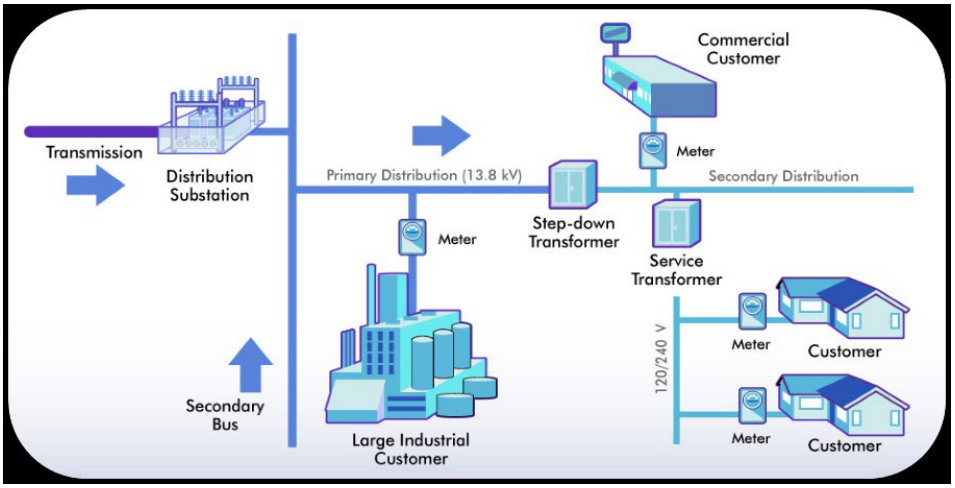
Notes

The distribution system

Slide 103

Distribution system

- Moves power from transmission to end-use customers
- Usually below 50kV
- Primary distribution typical voltages are 14.4 and 12.5 kV
- Secondary distribution typical volts are 120, 240, and 480 V
- Lines are always AC
- SDG&E's electric facilities consist of 23,591 miles of distribution lines



Electric distribution is the movement of electricity from the interconnection with the transmission system through the end-use consumer's meter. If transmission is considered the highway on which electricity travels long distances, the distribution system can be considered the streets and avenues that connect end-use customers to it.

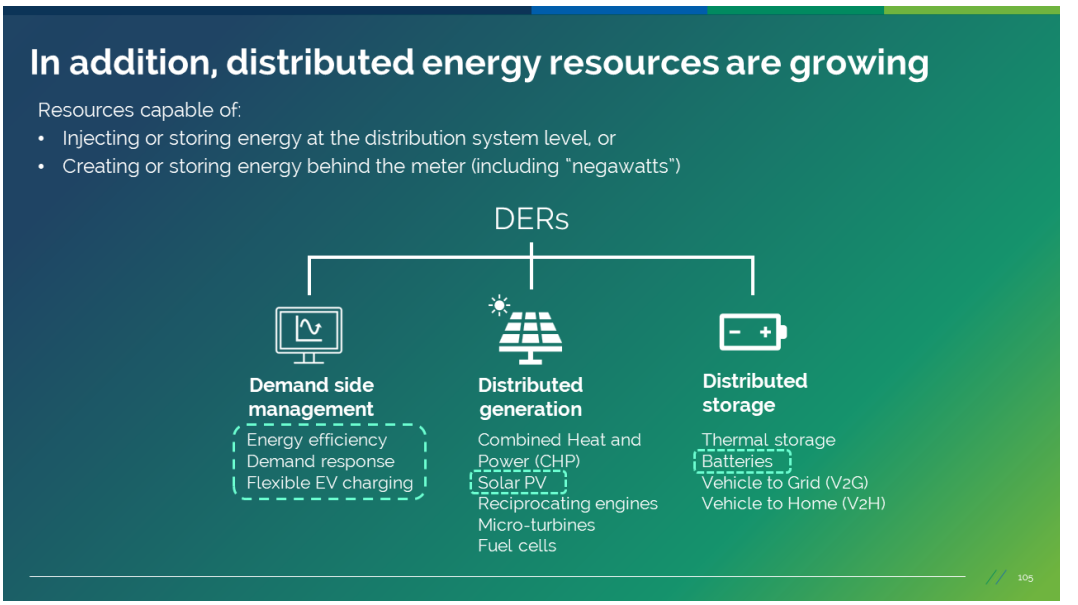
Slide 104

Important points about the distribution system

- Circuit capacity designed specific to connected customers
- Reliability and power quality are key design criteria
- Average cost of overhead around $800,000 per mile in California
- Underground cost as much as $3,000,000 per mile for SDG&E
- Underground systems have higher reliability but cost more to fix
- Relatively easy to site

Distributed energy resources

Slide 105



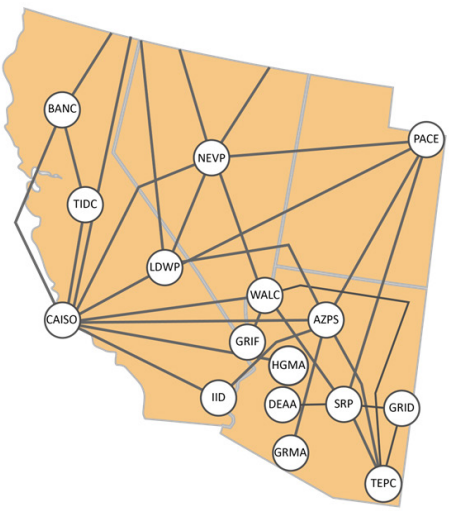
Notes

Slide 106

Who is the system operator?

Also known as control area operator or balancing authority:

- ISOs/RTOs
- Utilities
- Federal agencies



Source: California Energy Commission

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Key concept

In much of California, the system operator is the California ISO or CAISO. This means that the CAISO schedules generation and transmission for most of the state. In certain areas managed by municipal utilities or public power agencies the local utility is the system operator.

Slide 107

Operating a power system

- Forecast demand in day-ahead
- Schedule generation, reserves, transmission
- Adjust schedules as hour gets closer
- Correct imbalances in real time
- Restore systems if disturbances occur

Notes

Review

Slide 108 **The majority of power consumed in California comes from which fuel source?**

- a) Renewables
- b) Coal
- c) Natural gas
- d) Nuclear
- e) Hydro

Slide 109 **Which of the following generation types might the CAISO schedule equally each hour of the day? And why?**

- a) Nuclear
- b) Wind
- c) Solar
- d) Geothermal
- e) Coal

Slide 110 **Which of the following generation types might solar or wind displace when they are available?**

- a) Nuclear
- b) Hydro
- c) Natural gas
- d) Geothermal
- e) Imports from other states

Slide 111

On a summer day in California, at what time of day would you expect to see the greatest increase in net load?

- a) From around 9-11 am
- b) Around noon
- c) From around 1-3 pm
- d) From around 3-5 pm
- e) From around 5-7 pm

Slide 112

Answer each of the following questions from the electric perspective:

a) Where is electricity produced?

b) Where can electricity be stored?

c) How often are electric transactions scheduled?

d) Who owns production of electricity?

e) Who owns electric transmission?

f) Who schedules electric transmission?

g) Who owns the electric distribution system?

Regulation and Deregulation

Slide 113

Key concepts

- The importance of the regulatory compact
- The importance of deregulation in the natural gas and electric industries

Glossary of terms introduced in this module

- **California Public Utilities Commission (CPUC):** The state body that regulates intrastate transmission of gas and distribution and retail sales of both gas and electricity in California.
- **Federal Energy Regulatory Commission (FERC):** The federal body that regulates gas and electric wholesale sales and interstate transmission, as well as onshore LNG facilities.
- **Monopoly:** A marketplace characterized by only one seller with a unique product.
- **Retail supply:** The sale of supply directly to the end user.
- **Vertically integrated utility:** A utility that owns and is responsible for all sectors of electricity delivery: generation, transmission, system operations, and distribution.
- **Wholesale supply:** The sale of supply between two entities, neither of which is the end user, for the purpose of reselling the supply.

Notes

Why regulate?

Slide 114

What does regulation do?

- Fosters advancement of policy goals
- Enforces market behavior standards
- Enforces safety and reliability
- Approves new projects
- Sets rates
- Determines services

Notes

Who are the regulators?

Slide 115

Who are the regulators?

Federal

- The Federal Energy Regulatory Commission (FERC)
  - Electric transmission
  - Interstate gas transmission

State

- California Public Utilities Commission (CPUC)
  - Intrastate gas transmission
  - Gas and electric distribution
  - Electric generation

Local governments

- LADWP
  - All components of municipal utility systems (usually)

Slide 116

The regulatory compact (agreement)

- Regulators grant the utility an exclusive service territory
- The utility has an obligation to serve
- Rates are set to give the utility the opportunity to earn a fair return on shareholders' investment
- The utility agrees to full scrutiny of its costs and operations by the regulators
- Substantial facility investments by the utility require regulator approval

Federal is similar, but with no exclusive serviceterritory and more of market-based rates.

Key concept

The regulatory compact is an unwritten agreeement between the regulator and the regulated entity. For most utilities, the regulator grants an exclusive service territory and in return the utility agrees to very strict oversight of all of its operations.

SDG&E's federal regulator is the _____ _____ _____ _ _____.

SDG&E's state regulator is the _____ _____ _____ _____.

Types of proceedings

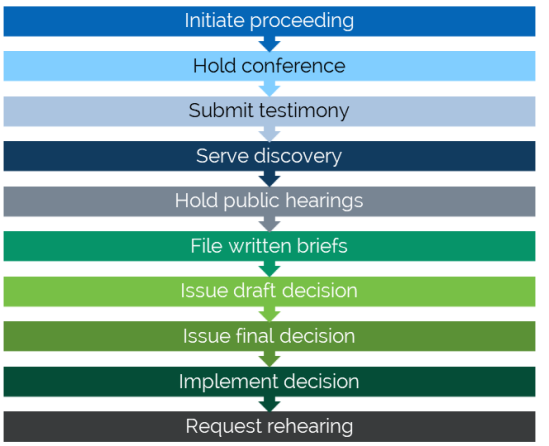
Slide 117

Types of regulatory proceedings

- Rulemakings
- Rate cases
- Certificate cases
- Complaint cases

Slide 118

The regulatory process can be lengthy and involved



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While not all regulatory cases have this many steps, some do. Given the huge resources required for a full rate case, sometimes groups of intervenors will negotiate a settlement with the utility, which if approved can avoid many of these steps.

Market restructuring

Slide 119

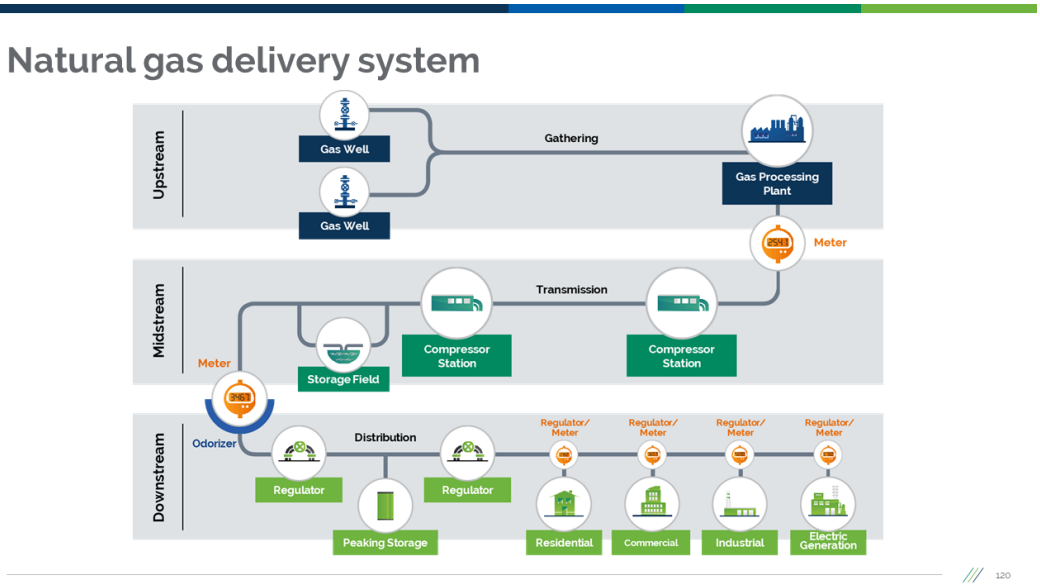
Deregulation is the move to open markets and increase consumer choice

119

Key concept

As the gas and electric marketplaces evolve, traditional concepts of regulation are also evolving. This evolution has hardly been uniform. Some states have moved forward with significant restructuring of regulatory-defined market structures while others have refused to venture beyond the traditional models. The evolution is also not uniform between the gas and electric industries. The gas industry deregulated wholesale markets long before this was attempted by the electric industry. The electric industry has attempted to follow this model, but in stops and starts as these attempts at restructuring have not always been successful (e.g. the California crisis in the early 2000s). The result is competitive wholesale markets across the U.S. on the gas side, but only in certain areas of the country on the electric side. Retail markets vary depending on state with some remaining vertically integrated while others are fully competitive. Thus an understanding of regulation at both the national and local level, as well as an understanding of how regulation may be evolving, is critical to success in marketplaces that can be both highly regulated and highly competitive.

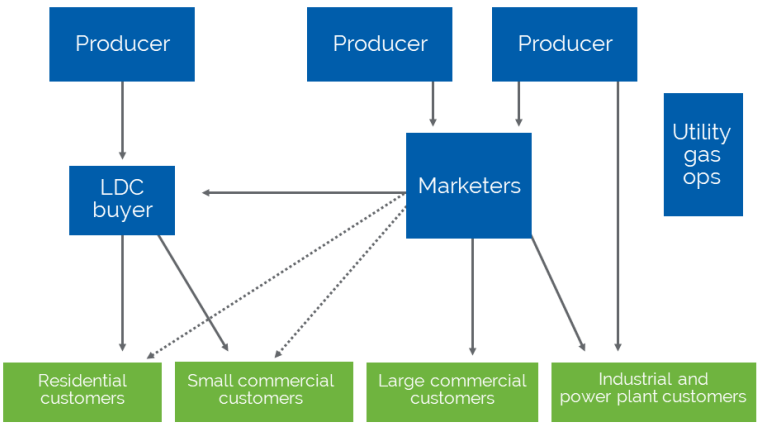
Slide 120



This graphic of the natural gas delivery system offers a good way to see which sectors of the system make sense to deregulate. Production is totally unregulated, with many producers and market pricing. Gathering and processing are similarly unregulated. Interstate transmission lines, however, are regulated by FERC. While there is some competition in this sector, the cost and difficulty of siting facilities limits this. So we need some oversight to ensure pipeline owners do not take advantage of this lack of robust competition. Storage is regulated as well, either by the state commission or FERC (depending on where the facilities are sited) with some options for market pricing. The distribution system, however, remains fully regulated. The reason for this is we still believe that it is more economical to have a single provider that is heavily regulated (mostly due to the major capital investments required for the system).

Slide 121

California natural gas market structure: Parallel competitive and utility supply with utility ops



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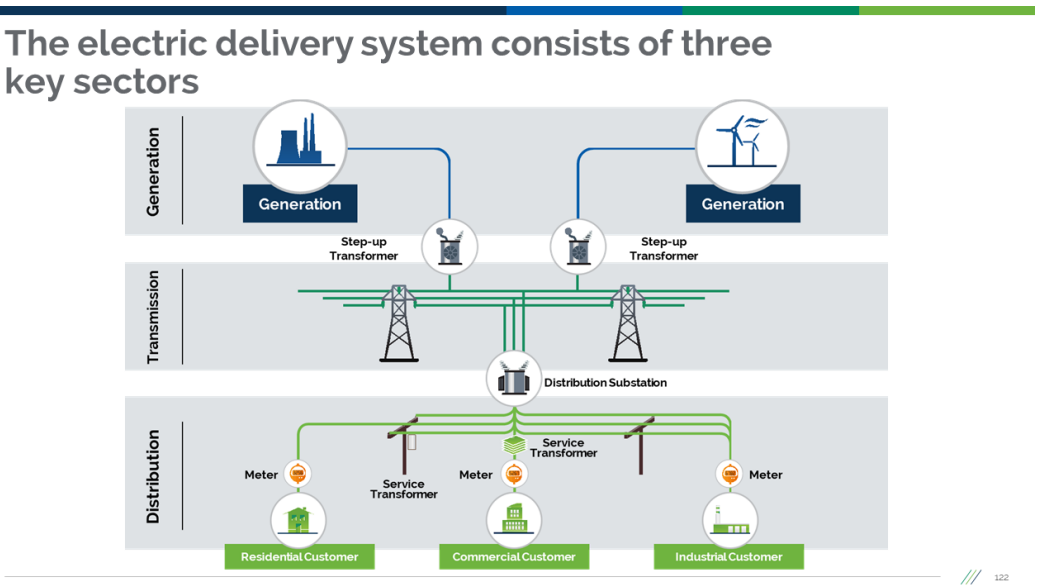
Notes

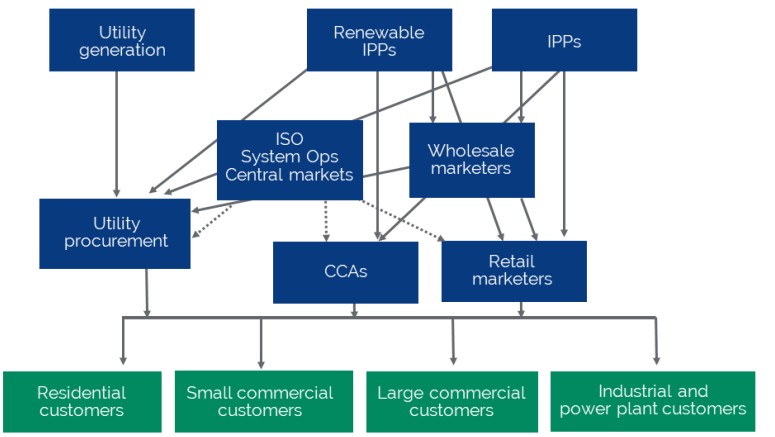
Slide 122



This graphic of the electric delivery system offers a good way to see which sectors of the system make sense to deregulate. Note that deregulation of the electric industry differs by state. In some states, the entire electric system remains vertically integrated, with the utility owning all components within its service territory. In other states, the industry is partially regulated and in some (Texas) it is fully deregulated. In many states, competitive generation is allowed and independent power producers compete with each other and, depending on the state, with utility generators. As with gas transmission, electric transmission can be competitive and there are companies whose sole purpose is to build and own transmission lines. But like the natural gas industry, distribution remains a monopoly utility function. As with the gas distribution system, it makes more sense to have one regulated company provide service than to have many (which would then require duplicative facilities).

Slide 123

California electric market structure allows for competition in some sectors



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Notes

Review

Slide 124 **Which of the following is NOT a role of the CPUC?**

- a) Define services
- b) Set rates for electric distribution
- c) Set rates for electric transmission
- d) Enforce safety and reliability
- e) Approve new projects

Slide 125 **In California all residential customers must receive electric supply from their utility.**

- a) True
- b) False

Slide 126 **In a future world where electric services include supply, flexible loads, choices for distributed generation, and home automation, who do you want to buy your services from?**

- a) Utility
- b) Apple
- c) Google
- d) Comcast
- e) None of the above

Making Money and Managing Risk

Slide 127

Key concepts

- The importance of the ratemaking process for regulated utilities
- How rates are set under cost-of-service ratemaking
- Energy companies face many risks that can prevent them from making expected returns

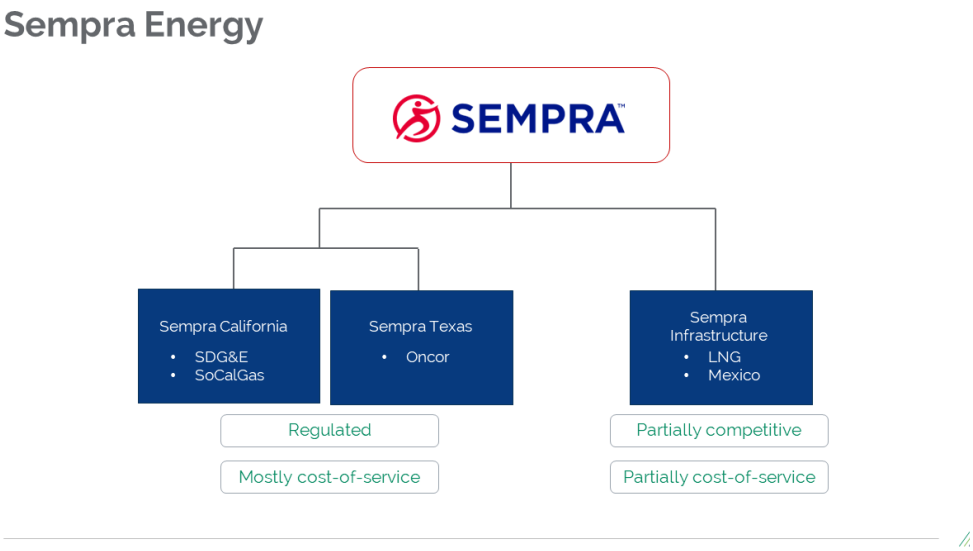
Glossary of terms introduced in this module

- **Balancing account:** A regulatory convention in which costs and/or revenues associated with a utility's expenses are tracked.
- **Cost-of-service ratemaking:** A regulatory methodology that allows utilities to charge rates designed to collect revenues equivalent to their cost of service plus a fair rate of return on capital invested by shareholders.
- **Decoupling:** A regulatory mechanism that uses balancing accounts to remove the link between utility profits and utility sales.
- **Rate design:** The development and structure of rates for regulated electric services.
- **Revenue requirement:** The revenues a utility must take in to cover its total estimated costs and allowed return.
- **Risk management:** The forecasting and evaluation of financial risks together with the identification of procedures to avoid or minimize their impacts.

Notes

The Sempra Energy companies

Slide 128



On the gas side:

SDG&E and SoCalGas own and operate the distribution systems in their service territories. SoCalGas buys gas on behalf of many of the customers of both utilities at the citygate (the interconnection between the transmission system and the distribution system) or further upstream and resells it to them at cost. Larger customers often buy their own gas from marketers and take transport-only service from the utilities.

Sempra Infrastructure builds, operates, and invests in the infrastructure critical to meet the world's energy and climate needs. Its LNG facilities and development projects on the Pacific and Gulf Coasts of North America serve the energy diversification and energy transition ambitions of our customers. It is also advancing next generation technologies like carbon sequestration and clean hydrogen. With a focus on safe and reliable integration into North America's power grids, Sempra Infrastructure operates over 1,600 megawatts of clean energy projects with a development pipeline of 3,000 megawatts of U.S.-Mexico cross-border solar, wind and battery storage projects. It also owns more than 4,500 miles of natural gas transportation and distribution pipelines and a refined products terminal network under development and operation.

On the electric side:

SDG&E owns and operates the electric distribution system in its service territory and delivers electricity to its customers. It also owns transmission and generation assets and purchases electricity on behalf of certain customers.

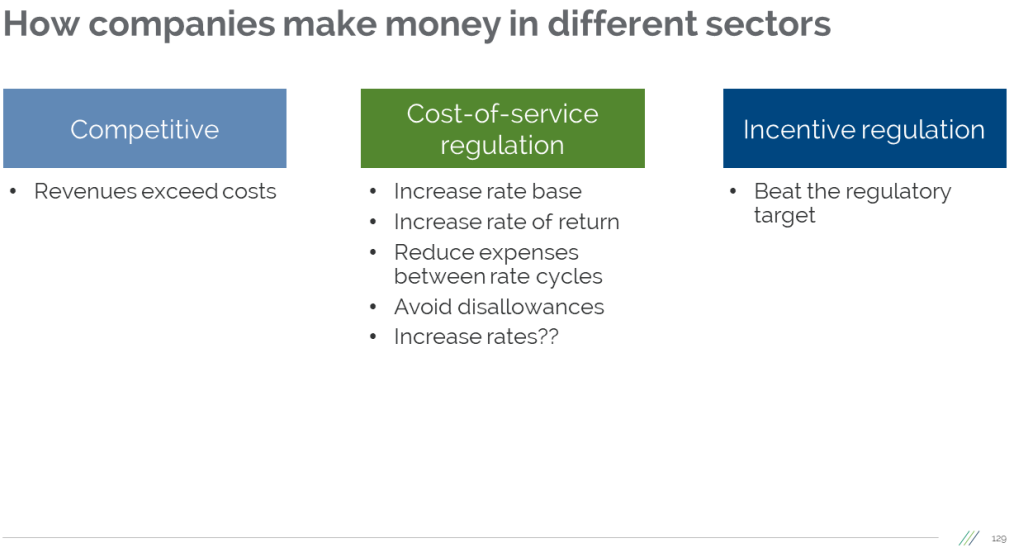
Oncor owns the transmission and distribution system in its service territory. Because ERCOT (Electric Reliability Council of Texas, which runs the transmission system in most of Texas) is deregulated, Oncor is responsible for delivery of electricity only. Retail Energy Providers (REPs) are marketers who sell commodity to Oncor's customers.

And in Mexico, Sempra Infrastructure owns and operates power generation facilities including wind and solar.

Notes

Cost-of-service ratemaking

Slide 129



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Cost-of-service pricing

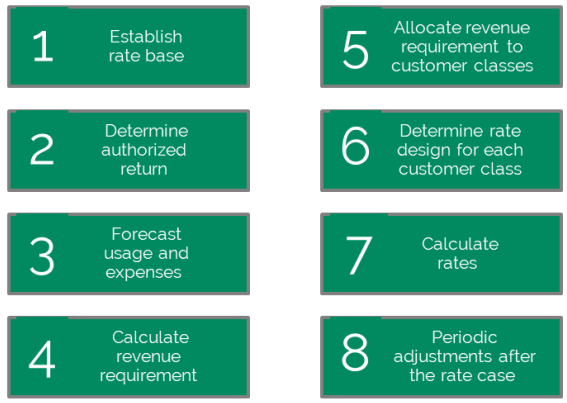
Set electricity and gas rates in a rate case based on costs and reasonable return

Key concept

One of the most important functions of the regulator is to set rates for monopoly services. The general concept of ratemaking is that monopoly entities are entitled to charge rates that will allow them to cover their costs of service, plus a reasonable rate of return (or profit) on capital invested by shareholders to build the necessary facilities to provide the service. The process of setting rates requires determining a revenue requirement that includes all the revenue the utility needs to collect to cover costs and make a reasonable return, allocating the revenue requirement to various customer classes, and then translating each allocation into specific rates for specific customers.

Slide 131

Rates are set through the ratemaking process with significant impact from various stakeholders throughout



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Key concept

As you can see the ratemaking process can be very complex, which is why most utilities would prefer to avoid holding proceedings on ratemaking (called a rate case) too often. Rate cases also require substantial resources, specifically utility employee time. And since most assumptions that were established in the last rate case, or through modification between rate cases, are open to debate and ultimately to change, rate cases can be risky for utilities as well. The requirements for each rate case vary by utility and by each state regulator's rules. For some this process can take as little as 6-9 months. And for others, it can take years.

Risks in the energy business and how they can be mitigated

Slide 132

Key concept

Sempra Energy companies and utilities face numerous risks. There are pages of them listed in the Sempra annual report and these are just a few that could have profound effects on Sempra's earnings. The important point here is that the energy (and utility) business can be risky. And earnings (even for utilities) are never assured.

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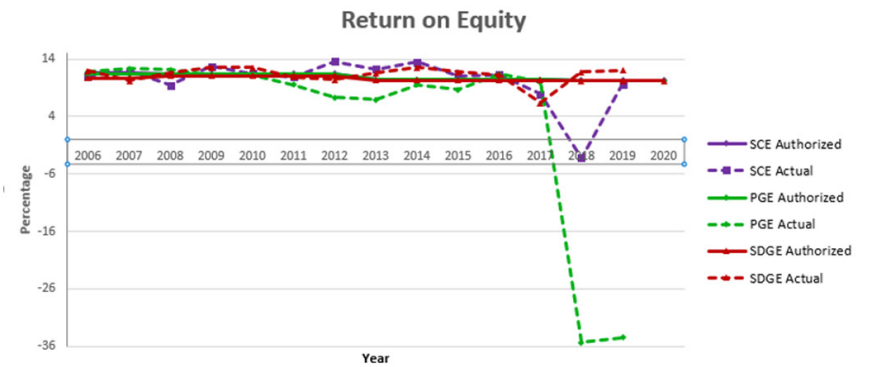
Authorized and actual ROEs for California utilities



Source: CPUC

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Notes

Price volatility

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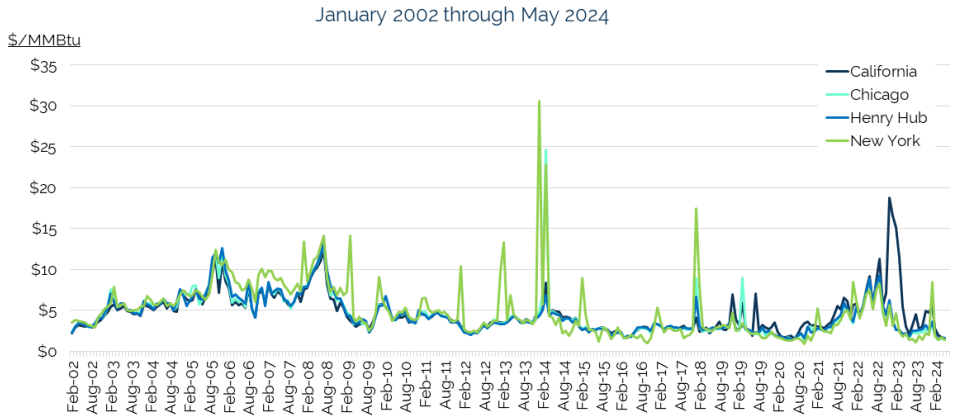
U.S. gas price volatility



Source: EIA Natural Gas Weekly Update

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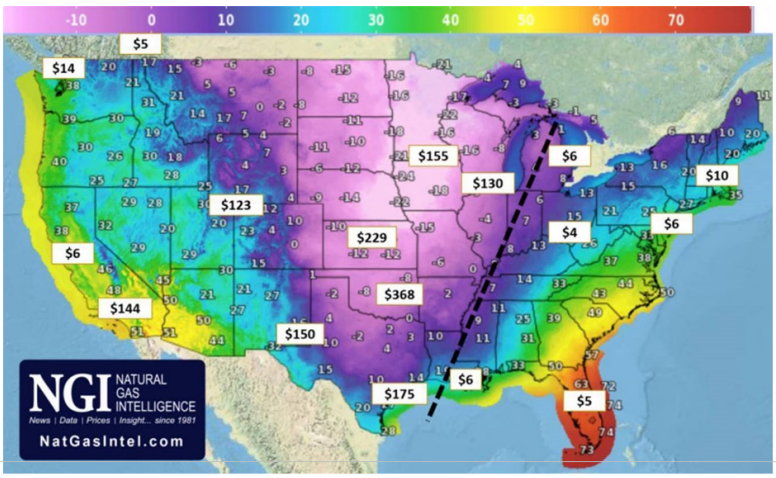
NGI daily average spot prices

prices (rounded) for gas days Feb. 13-16, 2021, and nighttime low temperature forecast for Tuesday, Feb. 16



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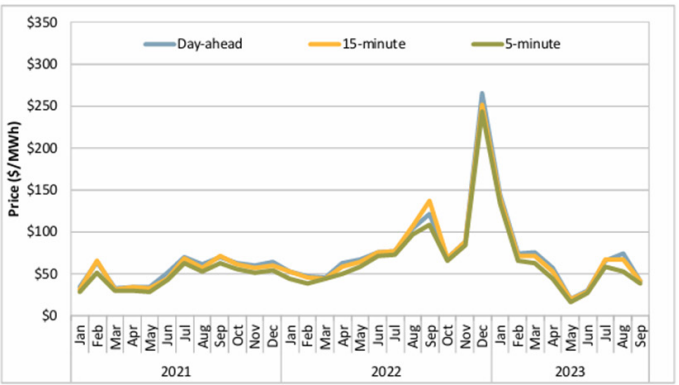
California electric price volatility

Figure 1.9 Monthly load-weighted average energy prices for California ISO (all hours)



Source: CAISO Q3 2023 Report on Market Issues and Performance

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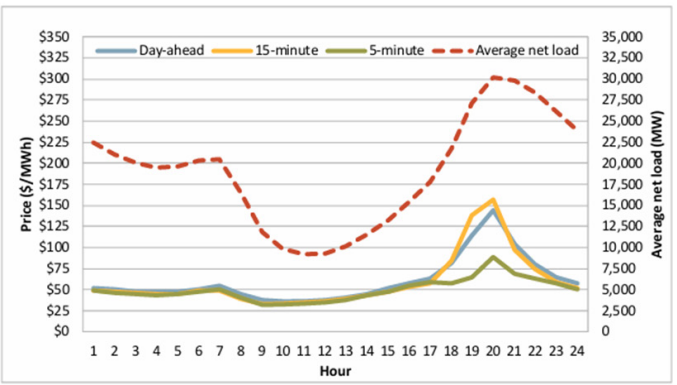
California electric price volatility

Figure 1.11 Hourly load-weighted average energy prices (July-September)



Source: CAISO Q3 2023 Report on Market Issues and Performance

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Utility earnings in the decade ahead

List the three factors that your group thinks will have the biggest impact on SDG&E earnings in the next 10 years.

1.

2.

3.

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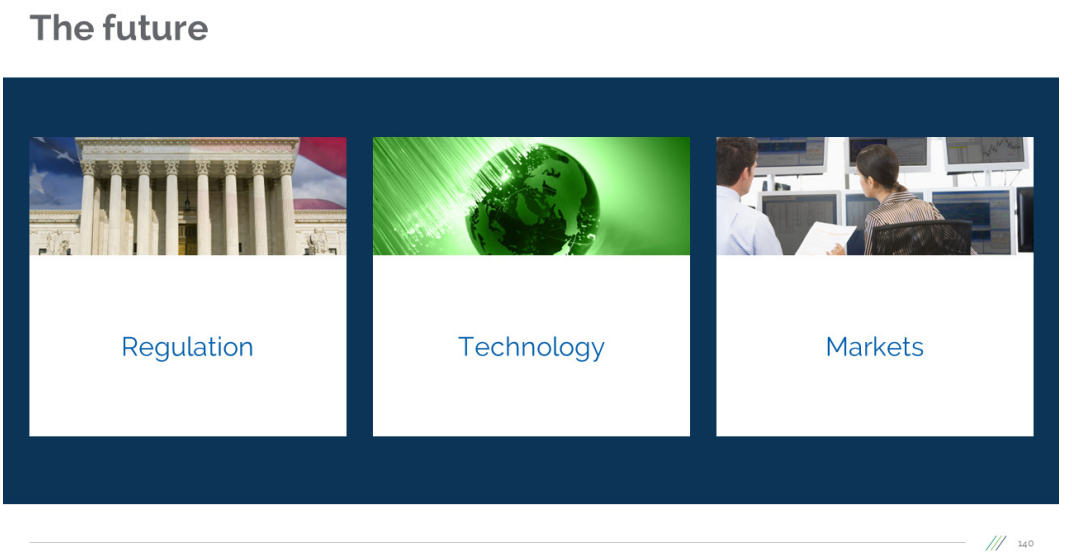

Natural gas and electric trends

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Natural gas trends for the next five years

- Prices have fallen dramatically but future price levels are uncertain
- Renewed interest in infrastructure investments to access new supplies and increase exports
- Shale gas basins continue to dominate
- Increasing exports of natural gas as LNG and by pipeline to Mexico
- Industry facing increasing pressure to reduce methane emissions
- Some regions (California, New York) begin push to reduce use of gas for power plants and building uses

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Market force #1: Flat electric loads for now, but maybe growing significantly soon

"Think I'm worried about growth? I'm worried about how the hell do I serve all of that."

~ Jim Avery, Former Chief Development Officer SDG&E Speaking on the topic of potential load growth from EVs and electrification

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Market force #2: Customers have more alternatives

"...our customers are the same people who dropped their landlines for cell phones, then switched wireless carriers to get the latest, greatest smart phones. They cut their cable TV packages to the bare minimum and stopped renting DVDs from Blockbuster..."

~ Michael T. Burr, Editor-in-Chief of Public Utilities Fortnightly

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Market force #3: Supply sources are changing rapidly

Renewables have become the low-cost option, battery storage has become a viable alternative to peaking capacity.

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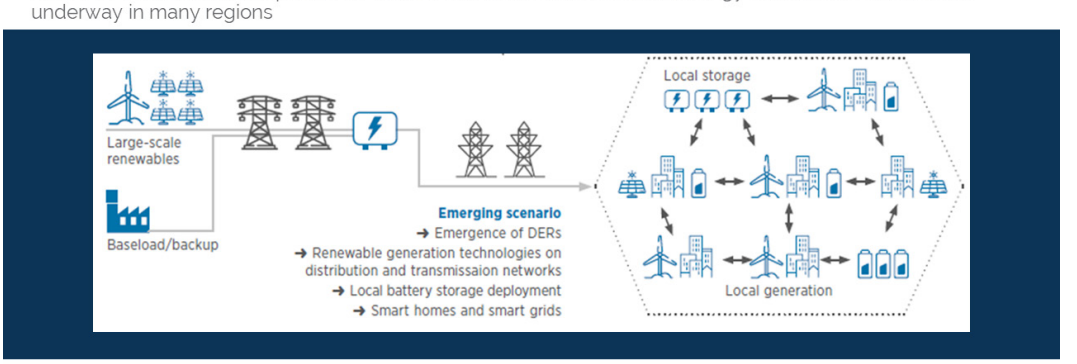
Market force #4: The grid will become increasingly decentralized

A shift from centralized dispatchable units to decentralized distributed energy resources (DERs) is well underway in many regions



Graphic from ISO NE 2019 State of the Grid report

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Market force #5: Climate change response is a critical issue

"After today's crises pass, utilities will see the financial community looking at their portfolios for vulnerabilities to other systemic risks and climate is the most obvious one."

~ James Newcomb discussing climate aligned portfolios to address climate-related risks in Utility Dive

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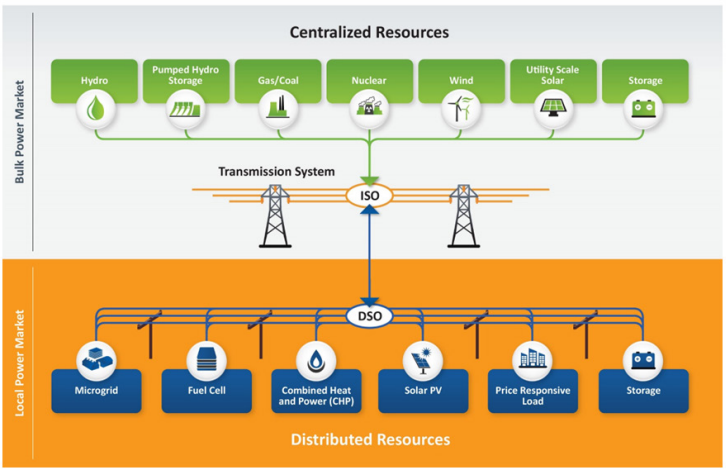
The future – a different grid



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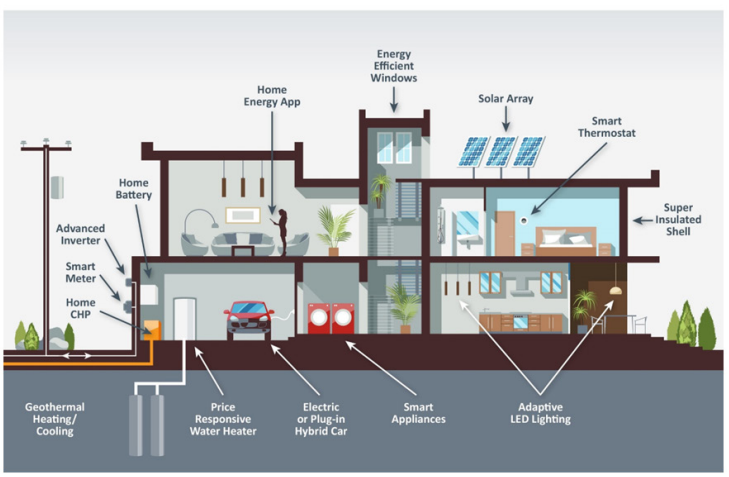
The future – smart houses



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Notes

Thanks for attending!

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Stay connected after class!

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Energy Units and Conversions

Mcf = Thousand Cubic Feet

MMcf = Million Cubic Feet

bbl = Barrel

gal = Gallon

Btu = British Thermal Unit

MMBtu = Million Btu

GJ = gigajoule (metric measure of energy)

Dth = decatherm

kW = kilowatt

kWh = kilowatt hour

MW = megawatt

MWh = megawatt hour

toe = tons of oil equivalent

1 therm	=	100,000 Btu
1 Dth	=	10 therms
10 therms	=	1 MMBtu
1,000,000 Btu	=	1 MMBtu
1 Dth	=	1 MMBtu
1000 Mcf	=	1 MMcf
1000 MMcf	=	1 Bcf
1 MMcf	=	1,015 MMBtu*
1 GJ	=	0.95 MMBtu
1 bbl	=	42 gal (U.S. gal)
1 bbl	=	34.97 gal (Imperial gal)
1 bbl	=	0.136 toe
1000 kWh	=	1 MWh
1000 kW	=	1 MW

*This conversion varies with the energy content of the gas.

For more detailed conversion information, please see: www.spe.org/industry/docs/UnitConversion.pdf

Natural gas delivery system

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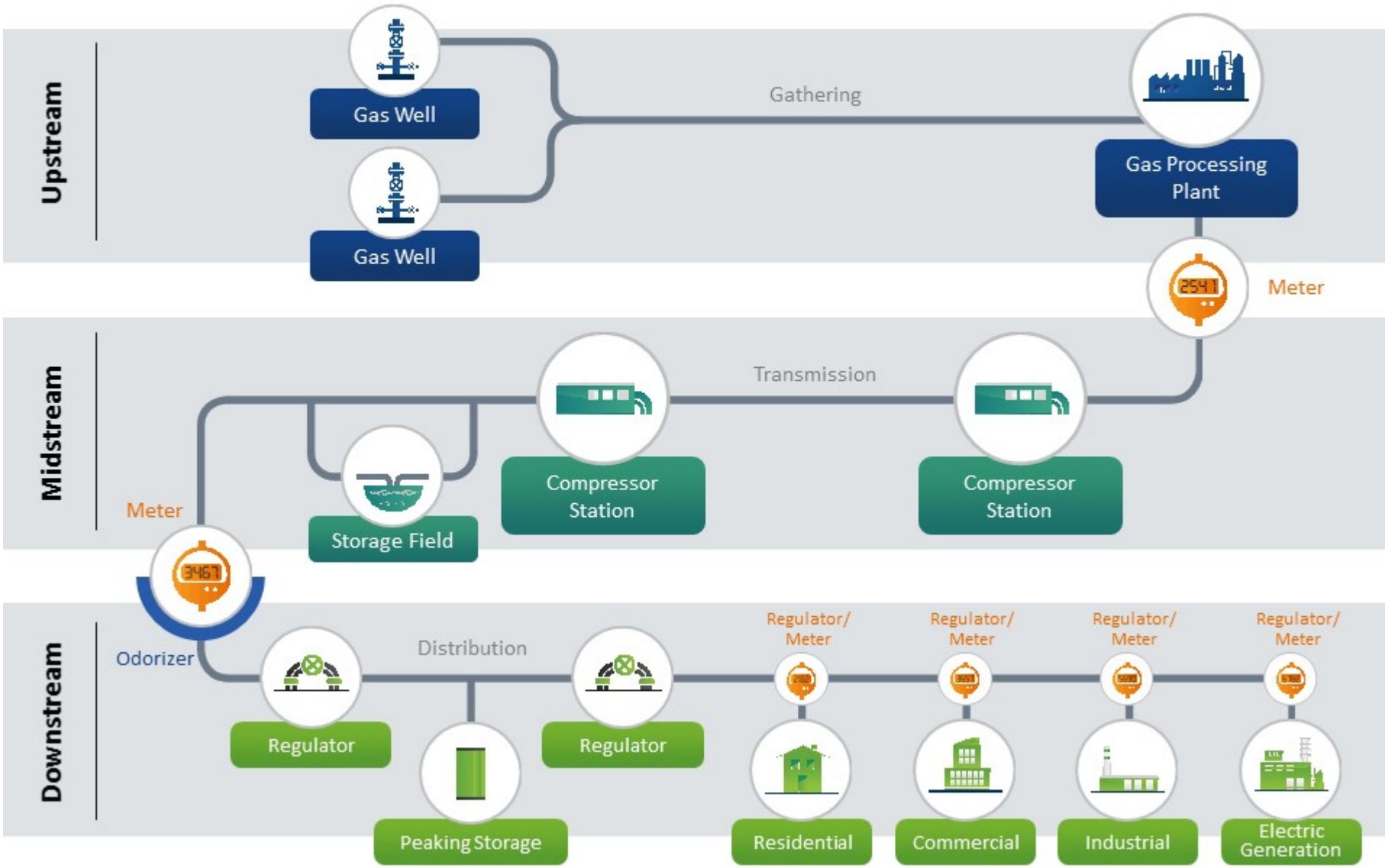

LNG delivery system

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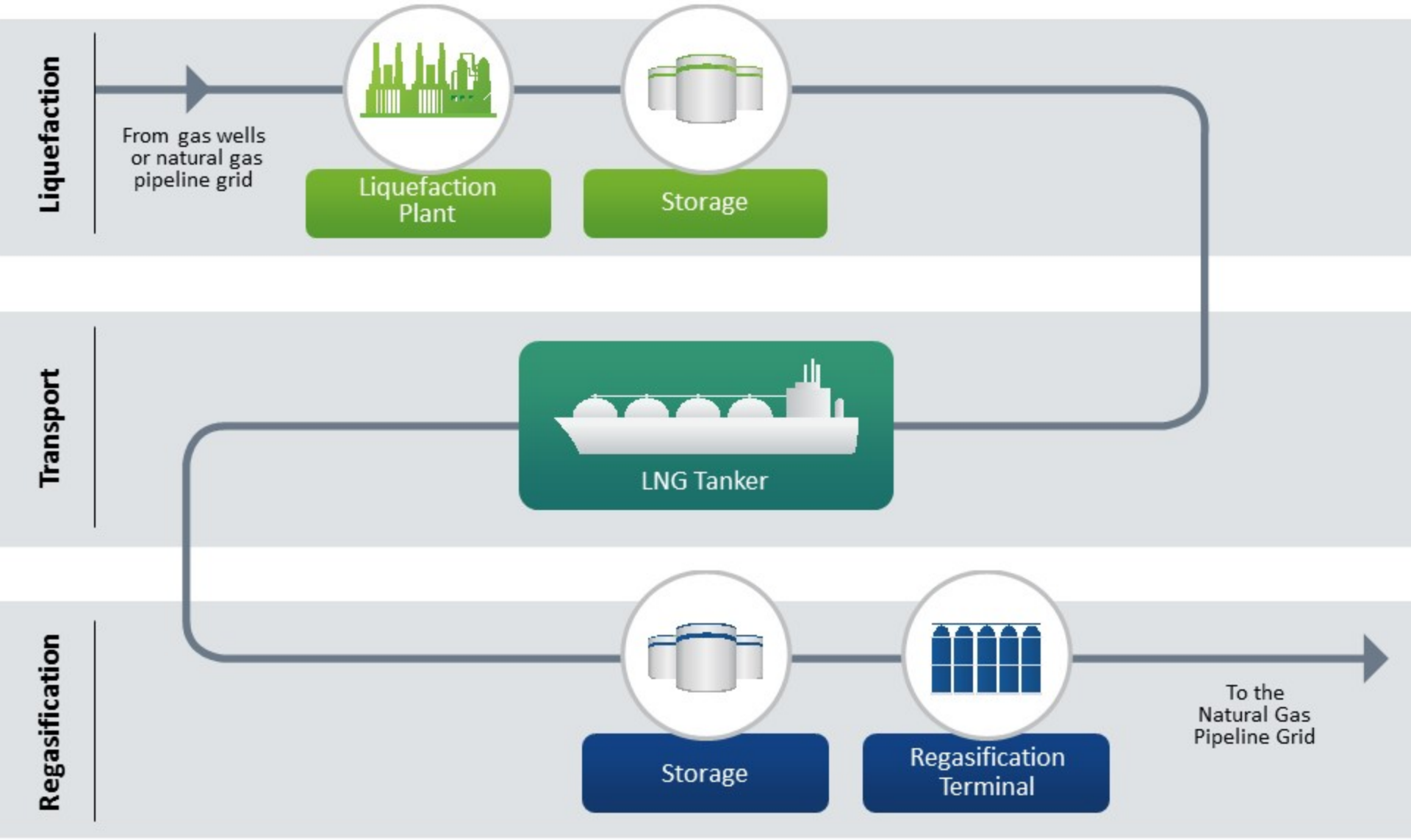

Electric delivery system

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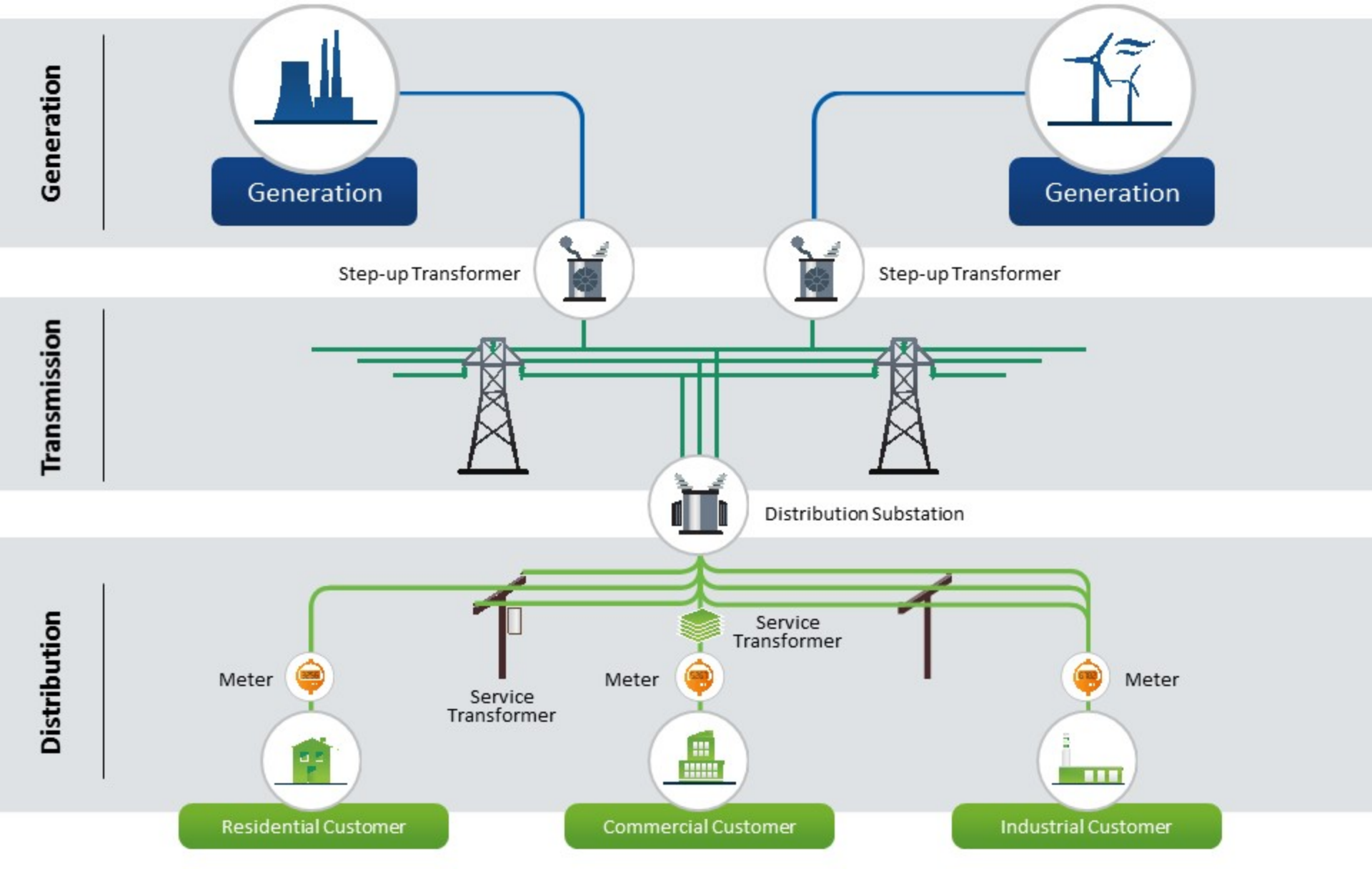

Grid of the Future

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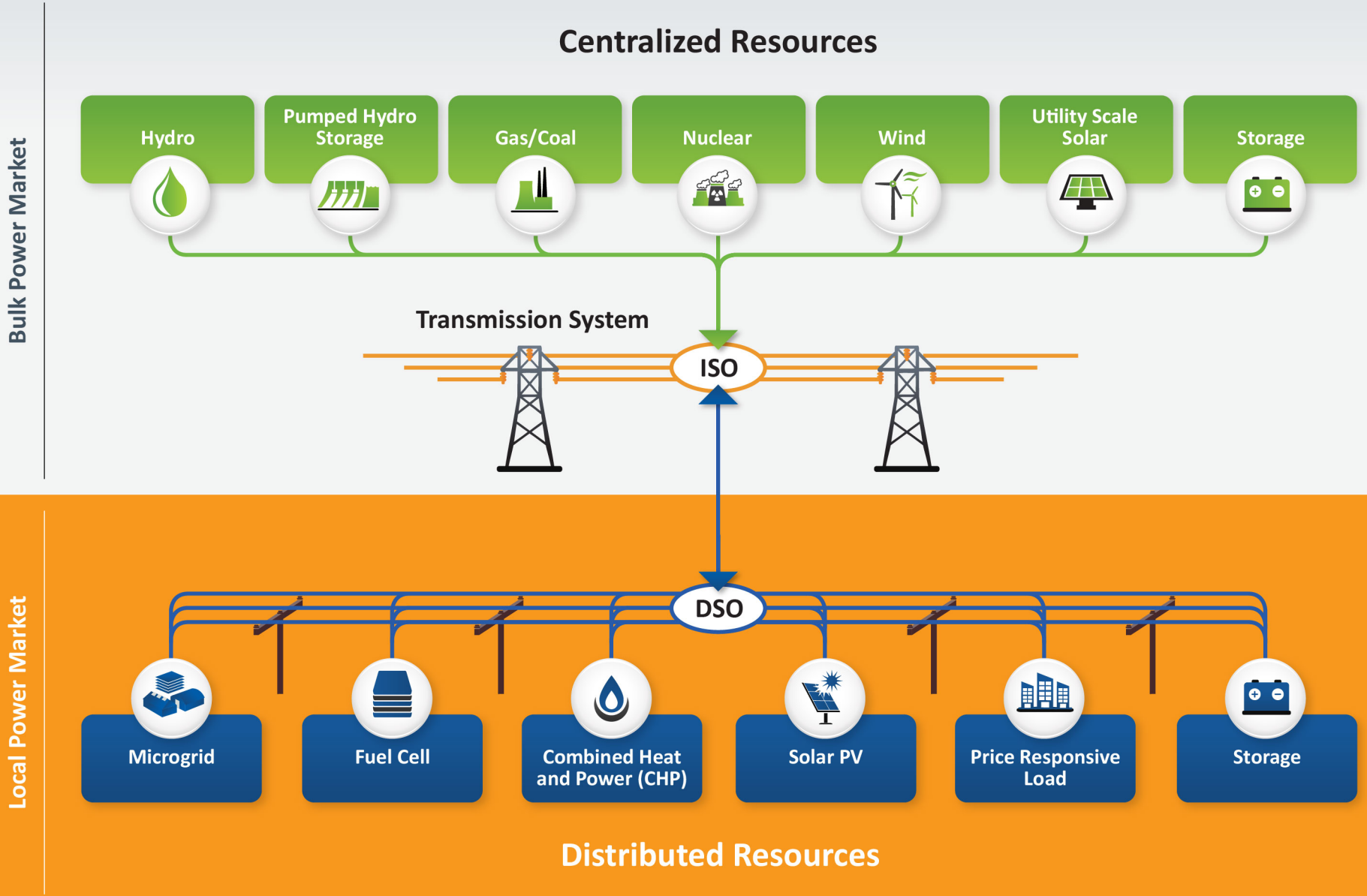

House of the Future

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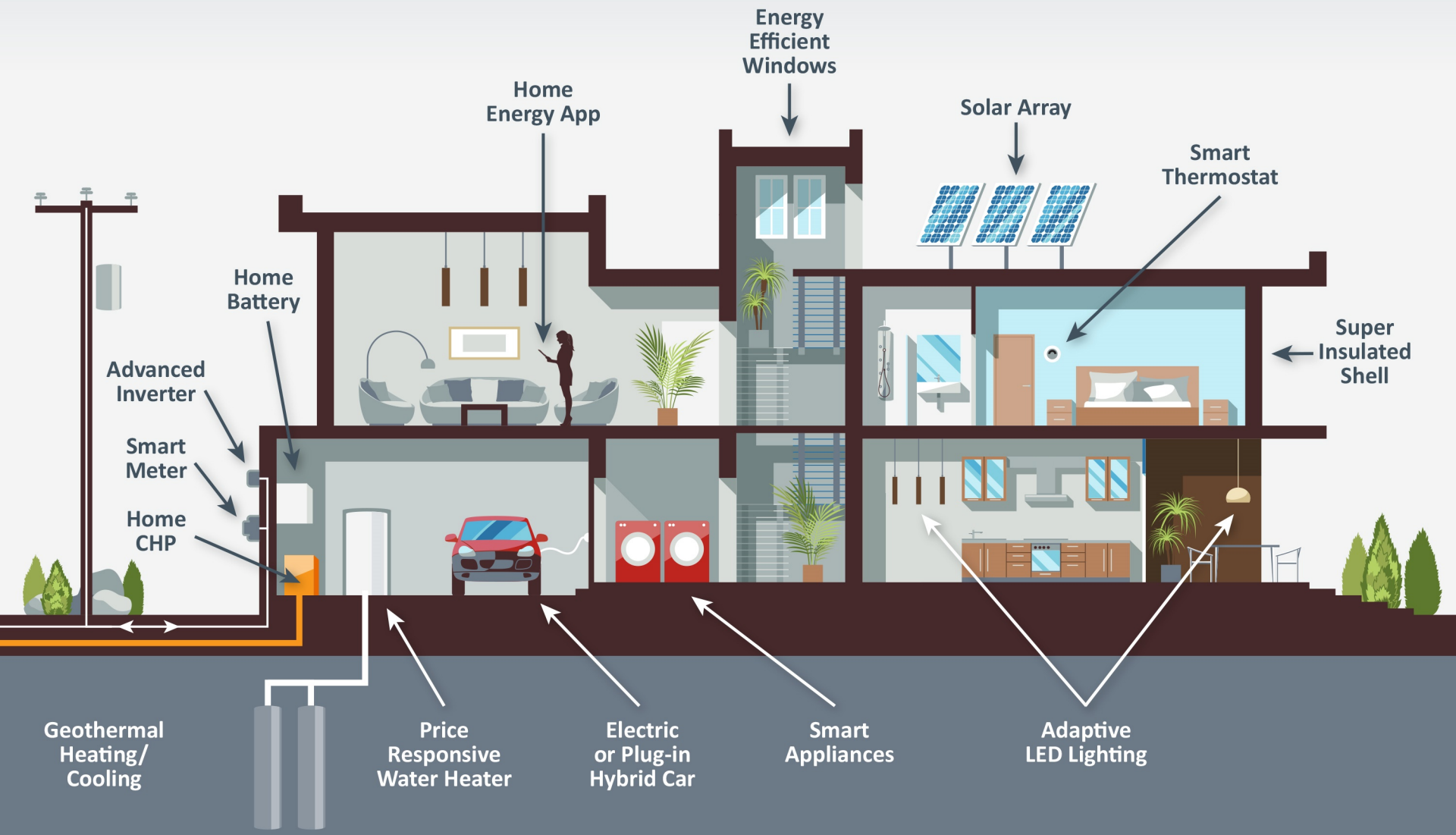

Microgrid of the Future

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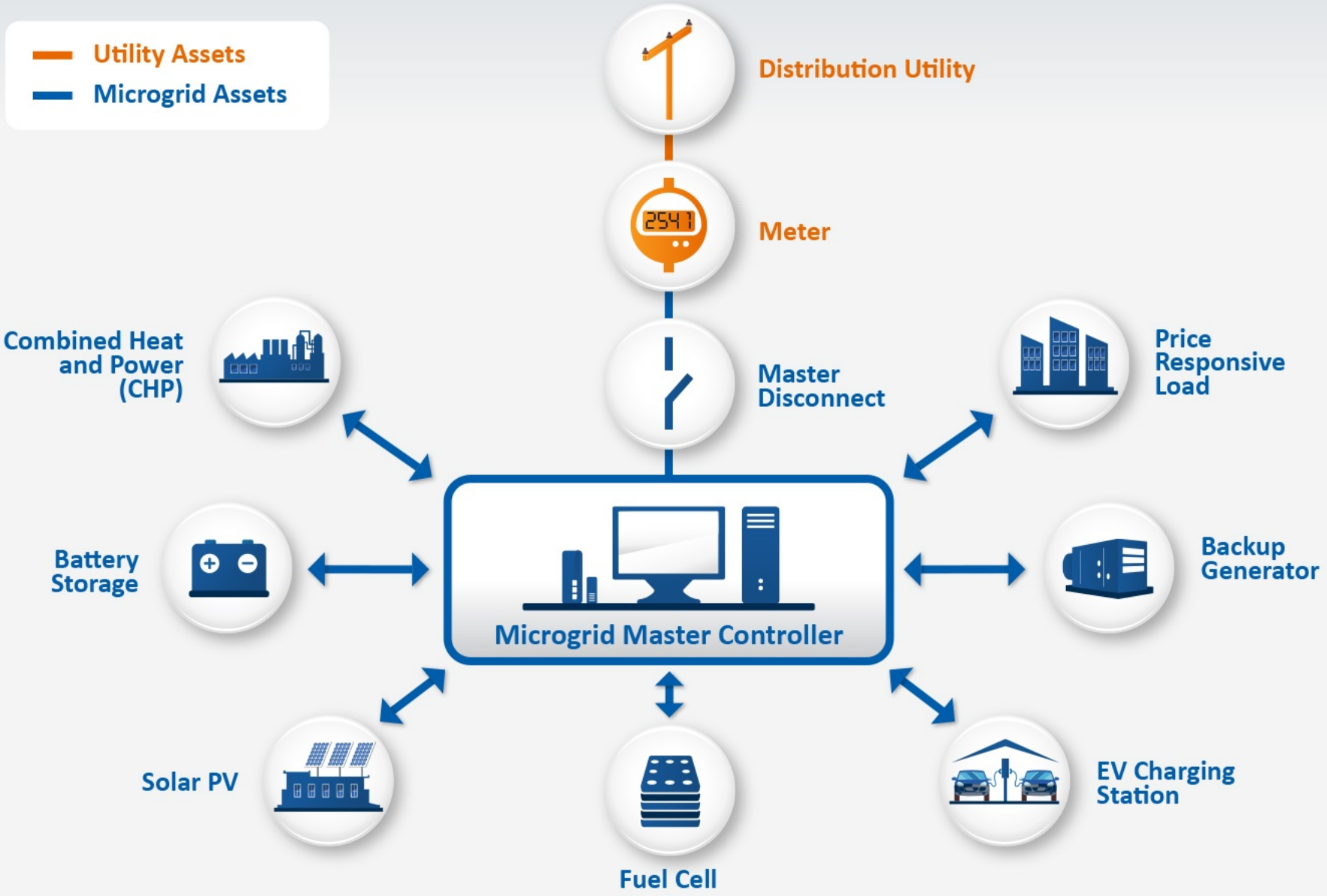
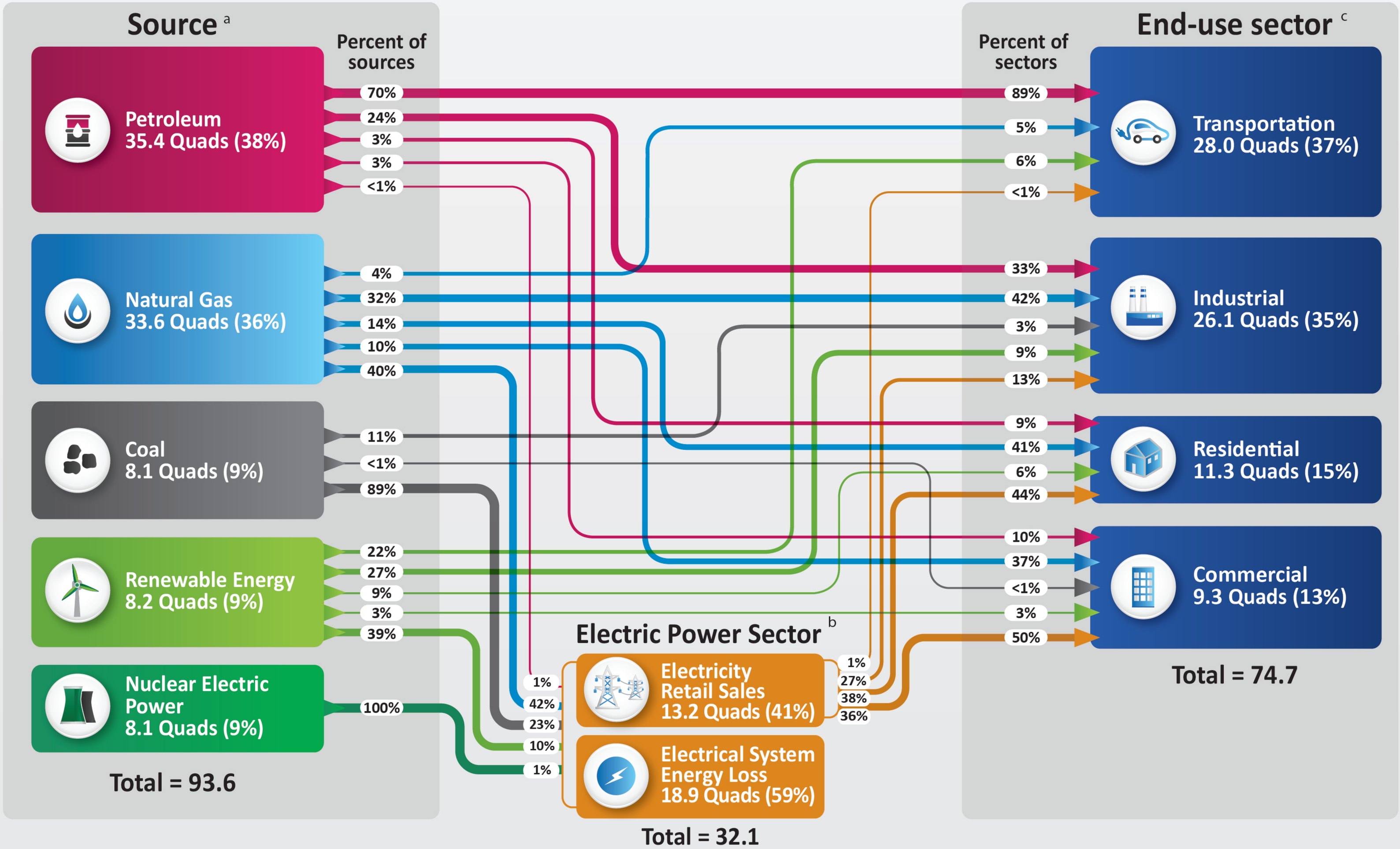


U.S. Primary Energy Consumption by Source and Sector, 2023

(Quadrillion Btu - Quads)



[a] Primary energy consumption. Each energy source is measured in different physical units and converted to common British thermal units (Btu). See EIA's Monthly Energy Review (MER), Appendix A. Generation from noncombustible renewable energy sources are converted to Btu using the "Captured Energy Approach." See MER Appendix E

[b] The electric power sector includes electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public. Energy consumed by these plants reflects the approximate heat rates for electricity in MER Appendix A. The total includes the heat content of electricity net imports, not shown separately. Electrical system energy losses are calculated as primary energy consumed by the electric power sector minus the heat content of electricity sales to ultimate consumers. See Note 1, "Electrical System Energy Losses," at the end of MER Section 2.

[c] End-use sector consumption of primary energy and electricity sales to ultimate consumers, excluding electrical system energy losses. Industrial and commercial sectors consumption includes primary energy consumption by CHP and electricity-only plants contained within the sector.

Note: Note: Sum of components may not equal total due to independent rounding. All source and end-use sector consumption data include other energy losses from energy use, transformation, and distribution not separately identified.

Sources: U.S. Energy Information Administration (EIA), Monthly Energy Review (April 2024), Tables 1.3, 1.4c, and 2.1a-2.6.

Gas and Electricity Glossary

Abandoned well — A gas well that is not in use because it was originally a dry hole or because it has ceased to provide gas in economic quantities.

Advanced Metering Infrastructure (AMI) — An integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers

Aggregator — An entity that contracts with multiple end-use customers and combines their loads into one block of demand in wholesale markets (either for the purpose of serving that load with supply, or, in electricity markets, for providing a block of load management resources).

An entity that collects smaller packages of gas from producers and markets them in larger packages.

Allocation — The methodology used to assign a percentage of revenue requirement to each customer class, or to each rate component, during ratemaking.

The priority system used by a pipeline to distribute gas service among customers when available capacity is less than nominated volumes.

Alternating current (AC) — An electric current that reverses its direction in a conductor at regular time intervals.

Alternative fuel vehicle — A vehicle that can operate on a fuel other than gasoline or diesel fuel.

Amps — Short for ampere, the unit of measure commonly used to express the rate of current flow in an electric circuit.

Ancillary services — The services in addition to electric supply that are required to deliver electricity to end users and to maintain system reliability. These include automatic generation control (also known as frequency regulation), reserves, voltage support, and black start.

Apparent power — The amount of power that comprises both real and reactive power, measured in volt-amps (VA), kilovolt-amps (kVA), or megavolt-amps (MVA).

Aquifer — A geologic formation containing water. Natural gas often is found in the presence of aquifers.

As-available service — See **interruptible service**

Associated gas — Natural gas found in contact with or dissolved in crude oil.

At-risk construction — A pipeline expansion or new construction that accepts (on behalf of its owner) the risk of attaining enough revenue to cover costs and a sufficient profit (as opposed to a project that has an agreement from regulators to allow it to recover sufficient revenues in rates from existing customers).

Automatic meter reading (AMR) — The process of collecting meter data remotely through a communications system that sends the data through an automated system.

Backhaul — A transaction in which gas is delivered upstream of the point at which it was received into the system. Since gas cannot physically move both ways in a pipe, backhaul service is a paper transaction rather than actual physical movement of gas.

Backup generator — A generating unit that is used only when the primary source of power is unavailable.

Balancing — The act of matching volumes of gas received by a pipeline or LDC to the volumes of gas removed from the pipeline or LDC at the delivery point (which can include volumes consumed by an end-use customer).

The act of matching volumes of electricity delivered into the grid or removed from the grid to the volume of electricity scheduled in the day-ahead or intra-day market.

Balancing account — A regulatory convention in which costs and/or revenues associated with certain utility, pipeline, or electric transmission line expenses are tracked for future regulatory review.

Balancing authority — An entity responsible for scheduling electric supply to match forecasted demand, maintaining supply/demand balance within a specific region called the Balancing Authority Area, and maintaining frequency within acceptable tolerances at interconnections with other areas.

Balancing power — See **imbalance energy**

Baseload — Natural gas or electric usage that is constant across a period of time (such as a day, a week, a month or a year).

Generating units that run all 24 hours of the day.

Basis differential — The difference in price between an index and the cash price of the same commodity. Often basis is used to refer to the difference in price between an index based at a trading hub and the cash price at another physical location.

Battery — A device that converts chemical energy directly to electric energy from substances contained within one or more battery cells.

Bid week — The period near the end of each month when the bulk of contracts for monthly gas supply for the following month are finalized.

Bilateral contract — A private agreement between two parties.

Biofuel — Liquid fuel produced from biomass feedstock.

Biomass — Organic non-fossil material of biologic origin such as plant matter or animal waste.

Black start — Generation that can start up without energy from the grid.

Blackout — The loss of power to a portion of the electric distribution or transmission system.

British thermal unit (Btu) — The quantity of heat required to raise the temperature of one pound of water by one degree Fahrenheit.

Broker — A third party that earns a profit by matching a buyer and a seller of commodities such as gas or electricity. Unlike marketers, brokers do not take ownership of the commodity.

Bundled service — Gas or electric sales service and distribution service packaged together in a single transaction. Usually provided by the gas or electric utility, which, on behalf of its customers, buys supply and delivers it to the customer.

Burnertip — The point where gas is consumed.

Butane — A liquid component of natural gas that is typically extracted at a processing plant and soldseparately.

Bypass — The purchase and transport of natural gas by an end user through a direct connection to an interstate pipeline rather than the LDC (thereby avoiding LDC charges).

CAISO — The California ISO, a system operator providing services to large portions of California and some parts of other western states.

Cap rock — An impermeable rock layer that prevents natural gas from escaping out of a trap.

Capacitor — A device that stores electrical charge and is used to improve power factor and/or help with voltage regulation.

Capacity — The maximum electric power output of a generating unit (measured in MW) or themaximum amount of power that lines or equipment can safely carry.

Electric generation that is available in a specific region or market to ensure reliability.

The maximum amount of natural gas that can be produced, transported, stored, distributed, or utilized in a given period of time.

Capacity brokering — The assignment of rights to receive firm gas transportation service.

Capacity factor — The ratio of actual energy produced by a generating unit over a period of time to the energy that would have been produced had the unit run at its rated capacity for the full period of time.

Capacity payment — A payment for making electric generation capacity available to another party or to the market.

Capacity release — The right (authorized by FERC Order 636) of a firm transportation holder to assign that capacity on a temporary or permanent basis to a third party.

Capital — Money expended for long-term assets.

Carbon dioxide (CO2) — A by-product of fossil fuel combustion and also an impurity sometimes found in natural gas. Carbon dioxide is a significant greenhouse gas.

Centralized generation — Generation connected to the high voltage electric transmission grid.

Certificate case — Regulatory proceeding held to approve or deny construction of new facilities requested by utilities.

Circuit — A complete path through which electricity travels; comprises a source of electron flow, a conductor, and load.

Circuit breaker — A device that interrupts electricity flow to a circuit by isolating the circuit from the source of electricity.

Citygate — The point at which gas is received into the LDC distribution system.

Coal — A combustible fossil fuel that is a mineral solid consisting mostly of carbonized vegetable matter found in underground deposits and used as fuel.

Coal gas — Also known as manufactured gas, coal gas is a combustible fuel produced by burning coal.

Coalbed methane — Natural gas produced from a coal seam or coal bed.

Cogeneration — The use of fuel to produce electricity as well as another product such as steam or hot water.

Collections — The act of getting customers to pay their bills.

Combined-cycle gas turbine (CCGT) — A power plant that uses a gaseous fuel to drive two types of turbines in succession: first a combustion turbine fueled by the gas and then a steam turbine fueled by steam created from water heated with the waste heat from the combustion turbine.

Combined heat and power (CHP) — A plant designed to produce both heat and electricity from a single fuel source.

Combustion turbine (CT) — A technology for generation that uses air and gaseous fuel to drive a gas turbine, also known as a single-cycle gas turbine.

Commercial customer — An end user that uses power or gas to create a service. Sometimes also used by electric utilities to refer to manufacturing customers smaller than a certain size (commonly smaller than 500 kW).

Commodity — Anything that is bought and sold in a highly competitive market. Commodities typically have many buyers and sellers, are very liquid, and subject to fluctuation in price according to supply and demand.

Electric or gas supply.

Complaint case — A regulatory proceeding held to evaluate a complaint that a utility failed to properly follow regulatory rules.

Compressed natural gas (CNG) — Natural gas that is compressed to a pressure around 3,000 to 3,600 pounds per square inch (psi) for use in vehicles and other applications. CNG must be stored in high-pressure vessels.

Compressor station — A facility that propels gas through transmission lines or into storage by increasing the pressure of the gas stream.

Compressor — Machinery in a compressor station that is used to increase the pressure of natural gas on a pipeline system.

Condensate — Light liquid hydrocarbons typically recovered from a natural gas stream at the wellhead. Condensate mostly consists of pentanes and heavier hydrocarbons.

Conductor — A material that allows electrons to move easily from one atom to another, thereby facilitating electric flow. Typically used to describe a wire that conducts electricity in any part of the electrical grid.

Confirmation — The notification received by a customer from a pipeline indicating how much of a specific nomination has been scheduled to flow.

Congestion — A condition that occurs when the amount of requested transactions across an electric transmission path exceeds the physical capacity of that path.

Congestion cost — The cost to a market participant who utilizes a congested path.

Congestion management — The process of allocating electric transmission capacity, or setting a price for use of that capacity, when congestion occurs.

Control area operator — The entity that performs system operations in a specific region, also called a system operator.

Co-op — See **rural electric co-op**

Core customers — Gas residential and small commercial customers who lack alternatives to gas service.

Cost of capital proceeding — The regulatory process that sets the authorized return on debt and return on equity for a utility company. The authorized returns are used in the ratemaking process for the utility.

Cost-of-service regulation — A regulatory methodology that allows utilities to charge rates designed to collect revenues equivalent to their cost of service plus a reasonable rate of return on their capital investments.

Cost of service (COS) — The total amount of money including return on invested capital, operation and maintenance costs, administrative costs, taxes, and depreciation expense required to provide a utility service.

Counterparty — One of the participants in a contract.

Creditworthiness — An evaluation of a customer's or trading partner's ability to financially perform its contractual obligations.

Cubic foot (Cf) — A common gas volume measurement. The amount of gas required to fill a volume of one cubic foot under stated conditions of temperature, pressure, and water vapor.

Current — The rate of flow of electrons through a conductor commonly measured in amperes (amps).

Current transformer (CT) — A device used in metering that allows inexpensive meters to measure large amounts of electricity. A CT reduces the current flowing to the meter by a specific ratio so the meter is not exposed to the larger amount of current actually moving in the electrical system.

Curtailment — Cutting gas service to customers when supply is not sufficient to meet demand.

Cutting a scheduled electric transmission service when line capacity is not sufficient to carry the scheduled flow.

Cutting scheduled deliveries to the grid from a power plant due to system physical conditions.

Cushion gas — A volume of gas that must always be present in a storage field to maintain adequate pressure to cycle gas.

Customer charge — A fixed monthly amount paid by a customer regardless of actual demand or consumption.

Customer choice — The ability of an end-use customer to choose its gas or electricity supplier.

Customer class — A group of end users with similar characteristics; used to segment customers for the purpose of setting rates.

Cycling — Injecting and withdrawing gas from storage.

Debt — Money that is borrowed and must be paid back.

Debt/equity ratio — The percent of capital funded through debt compared to capital funded through equity.

Decoupling — A regulatory methodology that removes the impact of throughput or usage on some or all of a utility's revenues. Decoupling removes some or all revenue risk by tracking revenues that differ from authorized revenues and adjusting future rates so that utilities receive, and customers pay, only the authorized amount.

Deliverability — The amount of natural gas a well, field, pipeline, or distribution system can supply in a given period of time.

Delivery point — The location on a pipeline or transmission system to which gas or electricity is transported.

Delta configuration — A way of connecting three-phase electric lines, achieved by connecting three independent transformer or generator windings head to toe (end to end).

Demand — The total amount of electricity used at any given moment in time, usually measured in kW or MW.

Demand charge — For a gas pipeline or storage facility, the portion of a transportation or storage rate that reserves space on the facility and is paid regardless of whether service is taken or not. Also known as a reservation charge.

The portion of an electric end-user charge that is based on the maximum demand recorded over a specified period of time (typically 15 minutes).

The portion of a gas end-user charge that is based on the maximum contractual quantity the customer is authorized to use.

Demand curve — A graph showing demand plotted across time.

Demand side management (DSM) — The act of reducing energy usage or moving energy use from peak to off-peak periods to reduce overall energy costs.

Deregulation — The process of decreasing or eliminating government regulatory control over industries and allowing competitive forces to drive the market.

Direct current (DC) — An electric current that flows in one direction only.

Dispatch — The act of a system operator ordering a generating unit to come on line at a specific output level.

Dispatch stack — A list, typically in order from least cost to highest cost, of power plants scheduled to run at a specific point in time in order to match supply to electric demand.

Distributed generation (DG) — Generation located at an end-use customer's facility or in very close proximity to the facility on the distribution system.

Distribution — The delivery of electricity from the transmission system to the customer meter over medium- and low-voltage lines (typically with a voltage of 50 kV or lower).

The delivery of natural gas from the transmission pipeline to the customer meter through medium- to low-pressure lines typically operating at pressures at or below 60 pounds per square inch (psi).

Distribution substation — A substation located on the distribution system, usually where the transmission grid meets the distribution system or where distribution voltage is reduced from a primary feeder to a secondary feeder.

Divestiture — The selling of assets by a regulated utility as part of deregulation.

Downstream — Commercial gas operations or facilities that are closer to the customer; typically used to refer to gas distribution operations or facilities.

Dry gas — Natural gas that doesn't contain liquid hydrocarbons.

Economic demand response — Programs that offer end-use customers the opportunity to modify their electric usage in response to price signals or other economic rewards.

Electric co-op — See **rural electric co-op**

Electrical power — The rate of work that can be accomplished by electricity; commonly measured in units of watts, kilowatts, or megawatts.

Also commonly used to refer to electricity in general.

Electricity — The flow of electrons through a conductor.

Electronic bulletin board (EBB) — An electronic service that provides information about a pipeline's rates, available capacity, etc., and on which third parties can bid for capacity.

Emergency flow order (EFO) — An order by a pipeline to users of natural gas to balance supply delivered into a pipeline with supply withdrawn from the pipeline, in order to maintain the integrity of the system.

End user — The ultimate consumer of gas or electricity.

Energy — The capacity for performing work. On the electrical system this is defined as demand over time measured in kWh or MWh. On the gas system, energy is measured in units of british thermal units (Btus) or joules.

Energy efficiency — The act of using less electricity to perform the same amount of work or to get the same end value.

Energy services company (ESCO) — A company that provides services to end users relating to their energy usage. Common services include energy efficiency and demand side management.

Enhanced oil recovery (EOR) fields — Reservoirs in which secondary recovery techniques are used to extract oil.

ERCOT (Electric Reliability Council of Texas) — The independent system operator providing system operations to large parts of Texas.

Ethane — A liquid component of natural gas that is typically extracted at a processing plant and sold separately. Some ethane may be left in the natural gas stream to boost the energy content of the gas.

Equity — Money that is invested by shareholders, typically through purchase of stock.

Exploration — The process of finding natural gas.

Expense — Money expended on short-term assets or other non-capital expenditures.

Fault — A failure or interruption in an electrical circuit.

Federal Energy Regulatory Commission (FERC) — A federal agency of the U.S. government that regulates the interstate transmission of electricity, natural gas, and oil. FERC also reviews proposals to build liquefied natural gas (LNG) terminals and interstate natural gas pipelines as well as licensing hydropower projects.

Federal power agency — An agency of the U.S. government that markets the output of electric generating units owned by the federal government.

Feeder line — An electrical distribution line or a gas distribution pipe that carries supply to another line rather than to an end user.

Feedstock — Raw material such as natural gas used to manufacture chemicals.

Financial services company — An entity that provides risk management and financing services.

Financial transmission right (FTR) — A right to receive financial compensation for congestion costs on a specific electric transmission path.

Firm service — The highest priority transportation or storage service that is the last to be interrupted in times of shortage.

Firm supply — Gas or electric supply acquired in a contract that requires the supplier to pay liquidated damages in the event the supplier fails to deliver.

Forward market — A market in which delivery of the item purchased is at some future point in time. In electric markets, the delivery is at least two days away from the day of purchase.

Fossil fuel — Any fuel created by the decomposition of organic matter, including natural gas, oil, and coal.

Four-wire service — A three-phase service from the utility to a customer that has three-phase wires connected at a common point at the transformer plus a ground.

Frequency — How often the direction of flow reverses in an AC circuit, commonly measured in Hertz (Hz).

Fuel cell — A device that converts chemical energy directly to electric energy from a fuel source that is external to the cell.

Fuel oil — A liquid or liquefiable by-product of crude oil, heavier than gasoline and naphtha, burned as a fuel.

Futures contract — A supply contract between a buyer and seller whereby the buyer is obligated to take delivery and the seller is obligated to provide delivery of a fixed amount of commodity at a predetermined price and location. Futures are bought and sold through an exchange.

Gas Industry Standards Board (GISB) — An industry group comprising pipelines and created by the FERC whose mission is to standardize operating and scheduling procedures nationwide. Now part of the North American Energy Standards Board (NAESB).

Gas marketer — The middleman between a gas supplier and an end user. A marketer takes title to the gas supply and resells it to end users.

Gathering system — A system of small pipelines that collects gas from individual wells for delivery to a mainline system.

Generating unit — A combination of connected generators and other equipment that produces electric power. Synonymous with power plant.

Generation — The creation of electricity by transforming other forms of energy to produce electrical current (amperage) to flow.

The amount of energy produced in a given amount of time, expressed in kWh or MWh.

Generator — The part of a power plant that converts the mechanical power of a spinning shaft to electricity. Often the term is used to indicate the whole power plant including the source of mechanical power.

Generator operator — Entity that owns, maintains, and operates generating units.

Geothermal — Heat extracted from reservoirs in the earth.

Global warming — The warming of the earth's atmosphere due to increased concentrations of greenhouse gases.

Green power — Electricity generated using renewable fuels, usually excluding large hydro power.

Greenhouse gas — A gas that is transparent to solar radiation but blocks infrared radiation. This allows solar energy into the Earth's atmosphere, but prevents long-wave radiant energy from leaving. The net result is to trap absorbed radiation thus warming the Earth's surface. Greenhouse gases include water vapor, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride.

Grid — Usually used to describe the interconnected electric transmission system, although sometimes used with distribution (distribution grid) to describe the distribution system.

Heat rate — The amount of fuel required to generate a specified amount of electricity, usually expressed in terms of Btu/kWh or MMBtu/MWh.

Heating value — The amount of energy content contained within a specific volume of natural gas. Commonly measured in units of Btu per Mcf.

Hedge — The initiation of a transaction in a physical or financial market to reduce risk.

Henry Hub — A pipeline interconnect in Louisiana where a number of interstate and intrastate pipelines meet. The standard delivery point for the NYMEX (CME) natural gas futures contract.

High voltage direct current transmission lines (HVDC) — Transmission lines that use DC power instead of AC, with a voltage of 200 kV or higher.

Homogenous products — Products that the customer sees as basically the same.

Horizontal drilling — Gas or oil drilling technique in which the well bore is horizontal when it penetrates the reservoir.

Hub — A physical location where multiple gas pipelines interconnect and where buyers and sellers can make transactions.

A physical location where multiple electric transmission lines interconnect and where buyers and sellers can make transactions.

Hybrid meter — A meter that combines a rotating disk-based mechanical counter with a solid-state register.

Hydro power — Electricity generated by water falling across a water turbine.

Hydrocarbon — Chemical compound containing carbon and hydrogen.

Imbalance — The discrepancy between the amount of energy a customer contracts to transport or consume and the actual volumes transported or consumed.

The discrepancy between the amount of electricity an entity schedules to deliver into or receive from the grid and the actual amount the entity delivers or receives.

Imbalance energy — Power bought or sold by the electric system operator during an operating hour to keep the system supply in balance with demand.

Impermeable rock — Rock that does not allow gas or fluid to migrate through it.

Incentive ratemaking — A form of ratemaking that rewards utility shareholders for achieving goals set by the regulator.

Independent power producer (IPP) — A generation company that is not part of a regulated vertically integrated utility company. IPPs typically sell much of their output under a long-term bilateral contract.

Independent system operator (ISO) — An independent entity that provides system operation functions including managing system reliability and transmission access; and also facilitates markets such as real-time energy and, in some cases, day-ahead energy and/or capacity.

Index — A calculated number designed to represent the average price of gas bought and sold at a specific location.

A calculated number designed to represent the average price of electricity bought and sold at a specific location during a specified period of time.

A published number used as a reference to determine a contractual sales price.

Induction meter — A mechanical meter with a rotating disk counter and dial register.

Inductive load — Loads that require both real and reactive power such as motors and fluorescent lights.

Industrial customer — An end user that uses gas or electricity for manufacturing or production of a product. Sometimes defined by utilities simply by size.

Injection — The process by which natural gas is placed into a storage facility or into a pipeline.

Insulator — A material with high resistance to electricity, meaning that electricity cannot easily travel through it.

Integrated gas combined-cycle (IGCC) — A power plant that takes solid coal, converts it into synthetic gas, and then uses the gas to power a combined-cycle gas turbine.

Integrated resource plan (IRP) — The process by which a utility forecasts future demand, evaluates all its options for satisfying that demand and then develops a supply plan for serving it.

Interconnection — The facilities that connect two gas pipelines or two electric lines.

The facilities where a generator connects to the electric grid.

Interruptible rates — An electric rate schedule whereby the end-use customer agrees to not use power during certain hours when instructed by the system operator (used by the system operator as a means of maintaining reliability). In return, the customer receives a rate discount.

Interruptible service — Also called as-available service, this storage or pipeline service is only available after all firm customers have been served and system conditions permit additional volumes to be moved.

Interstate pipeline — A federally regulated pipeline that is engaged in moving gas across state lines.

Intertie — An electric transmission interconnection permitting passage of current between two or more electric utility systems.

Intrastate pipeline — A pipeline that is regulated by the state public utilities commission. Intrastate pipelines cannot transport gas outside the state in which it is regulated.

Inverter — A device that converts direct current (DC) electricity to alternating current (AC).

Investor-owned utility (IOU) — A regulated monopoly utility that is owned by shareholders and run as a for-profit entity.

ISO New England — The system operator for multiple states in the U.S. Northeast.

Kilovolt-amps (kVA) — A thousand volt-amps.

Kilovolt-amps reactive (kVARs) — A thousand volt-amps reactive.

Kilovolt (kV) — A thousand volts.

Kilowatt-hour (kWh) — A unit of energy equal to 1,000 watt-hours.

Kilowatt (kW) — A unit of demand equal to 1,000 watts.

Kinetic energy — Energy available from an object as a result of motion.

Lease facility — The facility in a gas production area where gas from a specific lease is collected, where condensate and water are separated from the gas, and where gas is metered as a basis for compensating lease participants and royalty holders.

Linepack — The inventory of natural gas in a pipeline.

Liquefied natural gas (LNG) — Natural gas that has been chilled to the point that it liquefies. LNG is used as a means to store and transport natural gas.

Load — An amount of end-use demand.

Load factor — The ratio of the amount of gas or electricity used over a period of time in comparison to the amount the customer would have used if they had consumed the energy for the full period of time at their maximum demand.

Load center — A location on an electrical grid where there is a large amount of load, typically requiring that electricity be moved into the location by transmission lines.

Load serving entity (LSE) — An entity that sells electric supply to an end user.

Local distribution company (LDC) — The regulated distribution company that moves natural gas from the interstate pipeline to end-use customers and often provides bundled gas supply service to residential and small commercial customers. Also called a gas utility.

Locational marginal pricing (LMP) — A method of setting prices in an ISO market whereby prices at specific locations on the grid are determined by the marginal price of generation available to that specific location.

Loop flow — Flow of electricity that follows the path of least resistance on the transmission grid. The actual path may include parallel paths around the assumed contractual path.

Looping — Increasing capacity on a pipeline system by adding another pipeline that is parallel to existing lines.

Mainline system — A gas pipeline normally operating at pressures greater than 60 pounds per square inch, transporting gas from other mainline lines or gathering systems to lower pressure distribution and local transmission systems. Also known as a transmission line or backbone system.

Management information system (MIS) — An organized way of continually gathering analysis to provide managers with information they need to make decisions.

Manufactured gas — A combustible fuel produced by burning coal. Manufactured gas historically was used primarily in lighting. No longer in common use in the U.S.

Market-based rates — Charges for energy services that are determined by market forces rather than being set by the regulator.

Market center — A physical location where buyers and sellers make transactions (this may or may not also be a hub).

Market power — The ability of a market participant to artificially elevate prices over a period of time.

Market segmentation — A two-step process of identifying broad product markets and dividing them up to select target markets and develop suitable marketing mixes.

Marketer — An entity that buys gas or electricity, arranges for its transportation, and then resells it to end users or other gas purchasers.

Marketing — The performance of activities that seek to accomplish the organization's objectives by anticipating customer needs and profitably satisfying those needs through delivering products and services.

Marketing affiliate — Typically a non-regulated marketing company with corporate ties to a regulated pipeline, LDC, or an electric utility. Regulated companies are prohibited from favoring marketing affiliates in any business transactions.

Megawatt-hour (MWh) — A unit of energy equal to 1,000,000 watt-hours or 1,000 kilowatt-hours.

Megawatt (MW) — A unit of demand equal to 1,000,000 watts or 1,000 kilowatts.

Mercaptan — A harmless odor injected into natural gas giving it the smell of rotten eggs.

Merchant generator — A generation unit or company that is not part of a regulated monopoly vertically integrated utility and that is subject to market pricing for sales. Sometimes used synonymously with the term independent power producer (IPP).

Meter — A device used to measure the amount of gas or electricity flowing through a point on the system.

Methane — The main component of natural gas.

Midstream — Commercial gas operations that are generally associated with the transmission or storage aspect of the industry. Also sometimes applied to processing and gathering functions.

Mileage-based rates — Rates based on the actual distance natural gas is transported.

MISO — The Midcontinent ISO, a system operator serving portions of the Midwest and Southeast in the U.S. as well as providing reliability services to the Canadian province of Manitoba.

Monopoly — A marketplace characterized by only one seller.

Mothballing — Temporarily removing a power plant from service but not permanently shutting it down.

Muni — See **municipal utility**

Municipal utility — A utility owned and operated by a municipality or a group of municipalities.

Native load — The end-use customer load of a specific utility.

Natural gas — A combustible gaseous mixture of simple hydrocarbon compounds, primarily methane.

Natural gas liquids (NGLs) — A group of hydrocarbons including ethane, propane, normal butane, isobutane, and natural gasoline that are normally liquid at atmospheric pressure and temperature. NGLs are commonly removed from the natural gas stream at the wellhead and/or the processing plant and are marketed as valuable fuels.

Netback — A calculation determining the amount of money a seller will realize in the producing area once all transportation charges have been subtracted from the market price.

Netforward — A calculation determining the total cost of gas in the market once the price in the producing area plus all transportation charges have been added.

New York Mercantile Exchange (NYMEX) — An organization that runs the market for trading of commodity futures and options, owned by the CME Group.

Nitrogen oxides (NOx) — A group of highly reactive gases consisting of one nitrogen molecule and two or more oxygen molecules; a significant contributor to the formation of ground-level ozone that can cause smog.

No-notice service — A transportation service that allows customers to receive gas on demand and without an advance nomination.

Nomination — A request to transport a specific quantity of gas on a specific day under a specific contract.

Noncore customers — Relatively large gas customers who have alternative fuel capability or are willing to be interrupted during gas supply shortages. Typically include large commercial, industrial, cogeneration, and electric generation customers.

Non-performance — Failure to deliver according to the terms of a contract.

North American Electric Reliability Corporation (NERC) — An international, independent, self-regulated, not-for-profit organization whose mission is to promulgate electric operation and planning standards and ensure the reliability of the bulk power system in North America.

North American Energy Standards Board (NAESB) — An industry group of energy companies created to standardize operating and scheduling procedures for natural gas and electricity across North America.

Notice of proposed rulemaking (NOPR) — A document released by a regulatory agency in which the agency sets forth a proposed revision to its rules and gives market participants notice concerning the regulatory proceeding that will consider these revised rules.

New York ISO — The system operator providing services to the state of New York.

Nuclear power — Electricity generated using the heat of nuclear fission.

Odorization — The process of adding an artificial odor to natural gas so that leaks can be detected.

Off-peak — The period of a day, week, month, or year when demand is at its lowest.

Ohm (Ω) — The basic unit of resistance in an electrical circuit.

Ohm's Law — Physical law that quantifies the relationship among voltage, current, and resistance in an electrical circuit.

Open access — The requirement that pipelines transport or store gas for any creditworthy party on a non-discriminatory basis.

The requirement that a transmission system transmits electricity for any creditworthy party on a non-discriminatory basis.

Option — A contract that gives the holder the right, but not the obligation, to purchase or sell the underlying product at a specific price within a specified time period in return for a one-time premium payment.

Order 636 — An order issued by FERC in 1992 laying out the final blueprint for interstate gas industry deregulation including the unbundling of gas sales and transport services, implementation of capacity release, recovery of transition costs, and changes in transportation rate design.

Output — The amount of energy put onto the grid by a power plant over a specific period of time, usually measured in MWh.

Overhead facilities — Electrical facilities that are installed on transmission towers or distribution poles.

Peak demand — The maximum demand for natural gas or electricity in a given period of time.

Peaking units — Generating units normally run only during times of peak demand on a system.

Performance-based ratemaking (PBR) — A form of incentive ratemaking in which a utility's actual performance (either financial or service-wise) is compared against specified baselines. The utility can attain extra earnings if the baseline is exceeded, but can lose earnings if the baseline is not achieved.

Permeability — The ease with which a fluid or gas can pass through rock.

Permeable rock — Rock that has spaces through which gas or fluid can migrate.

Photoelectric effect — A natural phenomenon where certain materials produce an electric flow when they are struck by sufficient amounts of light.

Photovoltaic cells (PV) — A cell containing material that converts light into electricity.

Pig — A device used to clean and inspect the inside of a pipeline.

PJM — An ISO in the U.S. that is the system operator for parts of Mid-Atlantic, Northeast, and Midwest states.

Potential transformer (PT) — A small transformer used to reduce the voltage of electricity flowing through the meter allowing the meter to measure large amounts of electricity.

Power — See **electrical power**. Power is synonymous with demand in kW or MW.

A synonym for electricity.

Power factor — The ratio of real power to apparent power in an electrical system or circuit.

Power plant — A combination of connected generators and other equipment that produces electric power. Synonymous with generating unit.

Power pool — An entity formed by multiple utilities to coordinate dispatch of generating units owned by the utilities to optimize coordinated system operations among the utilities.

Power purchase agreement (PPA) — A contract for the sale/purchase of electricity.

Power quality — A measure of the level of voltage and/or frequency disturbances.

Price volatility — The movement of market prices over time.

Primary distribution — A voltage on the distribution system that is lower than transmission voltage and higher than secondary voltage ranging from 600 volts to 50 kV. Common voltages include 4160V, 12.5 kV, 25 kV, 36 kV, and many others.

Pro-rata allocation — Methodology that allows all customers to receive the same proportion of gas available as their share of total firm contracted volumes.

Producer — An entity that operates wells to bring gas from reservoirs into the gathering system.

Production — The process of extracting gas.

The process of generating electricity.

The amount of gas or electricity produced in a given period of time.

Propane — A liquid component of natural gas that is typically extracted at a processing plant and sold separately.

Proved natural gas reserves — The quantity of natural gas that is economically recoverable with the use of current technology.

Public Service Commission (PSC) — The state agency that regulates the activities of investor-owned utilities (and also municipal utilities in some states).

Public utility — A regulated entity that supplies the general public with an essential service such as electricity, natural gas, water, or telephone.

Public Utilities Commission (PUC) — See **Public Service Commission**

Public utility district (PUD) — A utility run by a local governmental agency or a group of governmental agencies other than a municipality.

Quadraplex — A four-wire conductor bundle used for overhead service drops consisting of three insulated wires and one uninsulated ground.

Ramp rate — The speed at which a power plant can increase its power output; usually stated in terms of MW per minute.

Rate — A regulated price charged by a regulated entity such as a utility.

Rate base — Working capital plus net capital investment in facilities, equipment, and other property a utility has constructed or purchased to provide utility services to its customers, less accumulated depreciation.

Rate case — The regulatory proceeding in which a utility's rates are determined.

Rate design — The development and structure of rates for regulated electric services.

Rate of return on equity (ROE) — Earnings divided by the equity portion of the rate base. ROE can be stated as actual ROE, which is based on actual earnings, or authorized ROE, which is the return authorized by the regulator during a cost of capital proceeding and used to set rates.

Rate of return - overall (ROR) — The amount of revenue left to pay debt and earnings after all expenses, taxes, and depreciation have been paid divided by the size of the rate base.

Rate schedule — The commission-approved document setting out rates and terms of service specific to a certain service and service provider.

Rated capacity — The maximum power in megawatts that a power plant is designed to provide to the grid without reducing its design life.

Reactive loads — Electric consuming devices such as fluorescent lights and motors that cause the electrons in the circuit to lag behind the voltage in time due to the way they use electricity.

Reactive power — The form of electric power that is measured in volt-amps reactive (VAR), kilovolt-amps reactive (kVAR), or megavolt-amps reactive (MVAR).

Real power — The form of electric power that is measured in watts (W), kilowatts (kW), or megawatts (MW).

Receipt point — The point on a pipeline system at which gas is taken into the system.

Reciprocating engine — An engine that converts pressure to rotating movement by using pistons to turn a crankshaft.

Regional transmission organization (RTO) — An ISO that operates over a regional geographic area and fits specific criteria defined by FERC.

Regulation — The myriad of rules or orders issued by state or federal agencies that dictate how gas or electric service is provided to customers.

Ramping a generating unit up or down in real time to match supply to demand and maintain system frequency within acceptable tolerances.

Regulator — The governmental entity that sets the rules and orders that make up regulation.

Reliability — A measure of how often electrical service is interrupted.

Renewable energy — Electricity that is generated from a source that is naturally replenished in a reasonably short period of time such as solar, wind, geothermal, biomass, and hydro. Sometimes the term is not applied to large-scale hydro due to assumed environmental impacts of large hydro projects.

Renewable fuel — A fuel that is naturally replenished such as wind or solar.

Reservation charge — See **demand charge**

Reserves — Generation capacity that is available to the system operator if needed but that is not currently generating electricity.

The quantity of natural gas existing in underground formations.

Reservoir — An underground deposit of natural gas.

Residential customer — An end user that uses gas or power in a home.

Resistance — A measure of the strength of impedance to the movement of electricity through a conductor commonly quantified in units of ohms.

Resources — Quantities of gas – discovered or undiscovered – that reasonably can be expected to exist.

The amount of available electric capacity in a specific region or market.

Restructuring — Changes in regulatory rules that result in change in control, ownership, or regulatory mechanisms applicable to specific industry sectors.

Retail access — The opportunity for an end user to buy gas or electric supply from someone other than its regulated utility distribution company.

Retail competition — The opportunity for multiple electric suppliers to compete to sell gas or electric supply service to end-use customers.

Retail marketer — A firm that sells products and services directly to end users.

Retail merchant — A firm that sells products and services directly to end users.

Return — The amount of money included in the revenue requirement to provide earnings and/or to pay back debt.

Return on investment (ROI) — Ratio of net profit after taxes to the investment used to make the net profit.

Revenue requirement — The revenues a utility must take in to cover its total estimated costs and allowed return.

Rulemaking — A regulatory proceeding held to establish new market rules.

Rules — Commission-approved general terms of service included in tariffs.

Rural electric co-op — A utility owned by its customers that usually serves rural areas.

Scheduling — The process of confirming nominations and, if necessary, using priority rules to determine which gas can flow under system constraints.

The process of determining which generating units will be generating or on reserve status for a specific hour. Also, the process of determining which requested transactions across a transmission line will be allowed to occur.

Secondary distribution — A voltage on the distribution system that is at the level typically used by customers such as 120V, 208V, 240V, 277V, 480V, or 2,400V.

Service — Gas system components that connect the distribution system to the customers including the service line, the meter, and the pressure regulator.

Electrical components that connect the service transformer to the customer including the wires that run into the facility, the meter that measures electric deliveries, and the protective devices that ensure the safety of the service and circuits within the customer facility.

Service conductor — The wires that connect a customer facility to the utility distribution system.

Service configuration — The way that the distribution facilities including the service transformers are connected to provide service to a customer. Key parameters include whether the service is two-wire, three-wire, or four-wire; whether the service is single-phase or three-phase; and if three-phase, whether the service is delta or wye.

Service drop — Overhead conductors used to connect the distribution system to a customer facility.

Service lateral — Underground conductors used to connect the distribution system to a customer facility.

Service territory — The geographical area served by a utility.

Service transformer — The transformer that converts the voltage of the primary distribution line to the voltage on the secondary distribution line required by a customer.

Service voltage — The voltage delivered by the utility to a customer facility.

Shipper — Any party that contracts with a pipeline for the transportation of natural gas and retains title while it is transported.

Short circuit — An interruption in the flow of electricity due to an undesired conductor coming in contact with the electrical flow.

Shut-in well — A well that has been completed but is not currently producing gas.

Simple-cycle gas turbine — See gas combustion turbine.

Single-phase power — Power produced using a single independent coil of wire in the generator. Power with one voltage curve that travels on a single phase conductor.

Small hydro — Hydroelectric power facilities with an installed capacity of 10 MW or less.

Smart meter — An advanced solid state meter that includes remote communication of data and may also provide remote control capabilities.

Solid state meter — A meter that measures consumption electronically, stores data digitally, and has an electronic register.

Speculating — The initiation of a transaction in a physical or financial market with the goal of making a profit due to market movement.

Spot market — The short-term market for natural gas.

The short-term market for electricity; usually refers to day-ahead, intra-day, and/or real-time markets.

SPP — Southwest Power Pool, the independent system operator providing system operations in multiple states in the central U.S.

Steam turbine — A turbine whose blades are spun by the kinetic energy in moving steam.

Storage — A means of maintaining gas in reserve for future demand, either through injection into an underground storage field or by holding it within the pipeline or an above-ground storage vessel.

The capture of electrical energy produced at one time for use at a later time.

Stranded costs — Utility costs that result from assets acquired under prior regulatory rules that are in excess of the market value of those assets.

Substation — An electric facility containing switches, transformers, and other equipment used to adjust voltages, direct flow, and monitor circuits.

Sulfur dioxide (SO2) — A gas made of sulfur and oxygen that is a significant contributor to the formation of acid rain.

Supply — Electricity available to the grid.

Natural gas available to any given pipeline system.

Supply basin — A geographical area where numerous natural gas reservoirs are located.

Switchyard — An enclosed area that includes the switching facilities and transformers that connect a power plant to the transmission system.

System operator — The entity that manages the transmission grid by dispatching generation and scheduling reserves and transmission. In some cases system operators may also facilitate short-term energy markets, ancillary reserves markets, and capacity markets.

System peak — The maximum load on an electrical system during a given period of time.

Take-or-pay — A contractual provision that requires a buyer to pay for service whether it was utilized or not.

Tariffs — Commission-approved terms of service for a regulated entity including rate schedules, rules, approved contracts, and service territory.

Therm (Th) — A unit of heating value. One therm is equivalent to 100,000 Btu.

Three-dimensional (3-D) seismic technology — Similar to a CAT scan, technology that uses sound waves to paint a three-dimensional picture of the earth's geologic formations.

Three-phase power — Power produced using three separate independent coils of wire in the generator. Three-phase power has three separate independent voltages with different timing and with each phase running through a separate conductor.

Three-wire service — A single-phase electric service from the utility to a customer facility that consists of three conductors: two hot conductors and one ground.

Throughput — The volume of gas flowing through a pipeline or delivered to a customer.

Time-of-use (TOU) meter — A meter capable of registering and recording the amount of usage in multiple defined time periods such as peak and off-peak.

Trading arrangements — The set of rules that specify how the system operator will acquire the necessary services to maintain system reliability, will allocate transmission access, and will facilitate markets.

Trading point — A physical location where buyers and sellers make transactions (this may or may not also be a hub or market center).

Transco — The abbreviation for transmission company, a regulated entity that owns onlytransmission facilities.

Transformer — A device used to change voltage. A step-up transformer increases the voltage while a step-down transformer decreases it.

Transmission — The transport of electricity over high-voltage power lines from generators to the interconnection with the distribution system.

The process of transporting large volumes of natural gas over long distances.

Transmission line — A power line with a voltage greater than 50 kV or 50,000 volts.

Transmission operator — The entity responsible for scheduling and operating a transmission system.

Transmission owner (TO) — The entity that owns a transmission line or transmission system.

Transmission system operator (TSO) — The entity responsible for scheduling and operating a transmission system and sometimes for facilitating real-time markets.

Transmission substation — A substation located on the transmission grid, usually where two or more separate transmission lines interconnect.

Triplex — A conductor bundle used for overhead service drops consisting of two insulated wires and one uninsulated wire.

Turbine — A machine with blades that are rotated by the movement of liquid or gas thus converting the kinetic energy of the liquid to mechanical energy of a rotating shaft.

Two-wire service — An electric service from the utility to a customer facility that consists of two conductors; it may include two hot conductors or one phase conductor and one ground.

Unbundling — The separation of a pipeline company's or LDC's transportation service from gas procurement service.

The separation of an electric utility's distribution service from electric supply service.

Underground facilities — Electrical facilities that are installed below ground level.

Underground service entrance (USE) cable — A conductor bundle that is used for underground service laterals that can be directly buried in the ground.

Upstream — Commercial gas operations that are associated with the production aspect of the industry.

Usage — The same as energy in kWh or MWh.

Usage charge — A component of a pipeline's or LDC's rate structure charged on a per unit of usage basis.

Utility distribution company (UDC) — A regulated utility that provides distribution services to end users.

Value-added services — Services related to electrical supply that are in addition to supply itself.

Value at risk (VAR) — A measure of potential earnings loss due to adverse market movements with a specified probability and specified level of volatility over a particular period of time.

Vertical integration — The ownership of all sectors of electric delivery (generation, transmission, system operations, and distribution) within one entity.

Volt — A unit of measure of voltage.

Volatility — See **price volatility**

Volt-amps reactive (VAR) — A unit of measure of reactive power.

Voltage — The electrical force that moves electricity through conductors, technically the difference in electrical potential between any two conductors or between a conductor and ground.

Watt (W) — A unit measure of power or demand.

Watt's Law — Law that quantifies the relationship among current, voltage, power, and power factor in an electrical circuit.

Well — The hole drilled into the earth's surface to produce natural gas.

Wellhead — The point where gas is pumped from the reservoir and enters the gathering system.

Wet gas — Natural gas that produces a liquid condensate and/or contains significant quantities of natural gas liquids (NGLs) when it is brought to the surface.

Wheeling — The transmission of power across a utility system on behalf of a third party.

Wholesale trading — The buying and selling of power between parties that are not ultimate end users.

Wind turbine — A turbine that is spun through the kinetic energy in wind.

Working gas — Natural gas in a storage field.

Wye configuration — A way of connecting three-phase electric lines, achieved by connecting three independent transformer windings at a common point.

Zone rates — Rates based on the distance gas is transported.

Gas and Electric Acronyms

A – Amp

AC – Alternating current

AGA – American Gas Association

AGC – Automatic generation control

ALJ – Administrative law judge

AMI – Advanced metering infrastructure

AMR – Automated meter reading

Bcf – Billion cubic feet

BPA – Bonneville Power Administration

Btu – British thermal unit

CAISO – California Independent System Operator

CCGT – Combined-cycle gas turbine

Cf – Cubic foot

CGA – Canadian Gas Association

CHP – Combined heat and power

CME – Chicago Mercantile Exchange

CNG – Compressed natural gas

COS – Cost of service

CO2 – Carbon dioxide

CPCN – Certificate of Public Convenience and Necessity

CT – Combustion turbine

DC – Direct current

DG – Distributed generation

DOE – U.S. Department of Energy

DSM – Demand side management

Dth – Decatherm

EEB – Electronic bulletin board

EDI – Electronic data interchange

EFO – Emergency flow order

EIA – Energy Information Administration

EMF – Electromagnetic field

EOR – Enhanced oil recovery

EPA – Environmental Protection Agency

EPCA – Environmental Policy Conservation Act of 1965

EPMC – Equal percentage of marginal cost

ERCOT – Electric Reliability Council of Texas

ERO – Electric reliability organization

ESCO – Energy services company

ESP – Energy services provider

EWG – Exempt wholesale generator

FERC – Federal Energy Regulatory Commission

FPA – Federal Power Act

FPC – Federal Power Commission

FRCC – Florida Reliability Coordinating Council

FTC – Federal Trade Commission

FTR – Financial transmission right

GISB – Gas Industry Standards Board

GJ – Gigajoule

GNP – Gross national product

GRI – Gas Research Institute

GW – Gigawatt

GWh – Gigawatt-hour

HVAC – Heating, venting, and air conditioning

HVDC – High voltage direct current

Hz – Hertz

ICE – Intercontinental Exchange

IGCC – Integrated gas combined cycle

INGAA – Interstate Natural Gas Association of America

IOU – Investor-owned utility

IPAA – Independent Petroleum Association of America

IPP – Independent power producer

IRP – Integrated resource plan

ISO – Independent system operator

ISO-NE – ISO New England

IT – Interruptible transportation

kV – Kilovolt

kVA – Kilovolt-ampere

kVAR – Kilovolt-ampere reactive

kW – kilowatt

kWh – Kilowatt hour

LDC – Local distribution company

LMP – Locational marginal price

LPG – Liquefied petroleum gas

LSE – Load-serving entity

MAIN – Mid-America Interconnected Network

MAOP – Maximum allowable operating pressure

MAPP – Mid-Continent Area Power Pool

Mcf – Thousand cubic feet

MDQ – Maximum daily quantity

MFV – Modified fixed variable

MIS – Management information system

MISO – Midcontinent Independent System Operator

MMBtu – Million British thermal units

MMcf – Million cubic feet

MMDth – Million decatherms

MRO – Midwest Reliability Organization

MW – Megawatt

MWh – Megawatt hour

NAESB – North American Energy Standards Board

NARUC – National Association of Regulatory Utility Commissioners

NEA – National Energy Act of 1978

NEB – National Energy Board (of Canada)

NERC – North American Electric Reliability Corporation

NGA – Natural Gas Act of 1938

NGL – Natural gas liquid

NGPA – Natural Gas Policy Act of 1978

NGSA – Natural Gas Supply Association

NGV – Natural gas vehicle

NIMBY – Not in my backyard

NOPR – Notice of Proposed Rulemaking

NOx – Nitrogen oxide

NPPC – Northeast Power Coordinating Council

NRC – Nuclear Regulatory Commission

NUG – Non-utility generator

NYMEX – New York Mercantile Exchange

O&M – Operations and maintenance

OAT – Open access transmission

OATT – Open access transmission tariff

OBA – Operational balancing agreement

OTC – Over the counter

PBR – Performance-based ratemaking

PJM – Pennsylvania New Jersey Maryland

POLR – Provider of last resort

PSC – Public Services Commission

Psi – Pounds per square inch

Psig – Pounds per square inch gauge

PUC – Public utilities commission

PUD – Public utility district

PUHCA – Public Utilities Holding Company Act of 1935

PURPA – Public Utilities Regulatory Policies Act of 1978

PV – Photovoltaic

QF – Qualifying facility

R&D – Research and development

REA – Rural electric agency

REC – Retail electric company

RF – ReliabilityFirst

ROE – Return on equity

ROI – Return on investment

ROR – Rate of return

RPS – Renewable portfolio standard

RTO – Regional transmission operator

SCADA – Supervisory control and data acquisition

SEC – Securities and Exchange Commission

SERC – Southeastern Electric Reliability Council

SEPA – Southeastern Power Administration

SFV – Straight fixed variable

SMD – Standard market design

SO2 – Sulfur dioxide

SPP – Southwest Power Pool

SWPA – Southwestern Power Administration

TCC – Transmission congestion contract

Tcf – Trillion cubic feet

TCR – Transmission congestion right

TRE – Texas Reliability Entity

Th – Therm

TLR – Transmission loading relief

TO – Transmission owner

TOU – Time-of-use

TSO – Transmission system operator

TVA – Tennessee Valley Authority

UDC – Utility distribution company

UPS – Uninterruptible Power Supply

USE – Underground service entrance

USGS – United States Geological Survey

V – Volt

VA – Volt-ampere

VAR – Value-at-risk, volt-ampere reactive

W – Watt

WACOG – Weighted average cost of gas

WAPA – Western Area Power Administration

WECC – Western Electricity Coordinating Council