Gas Turbine Combined Cycle

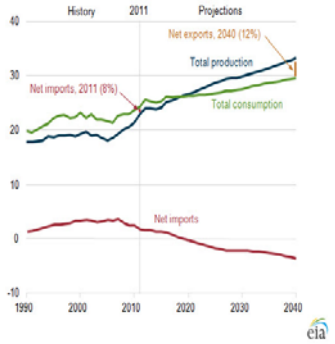
(Natural Gas) U.S. Standards

Justin Sandler
GTCC Fact Sheet

How it Works & Consumption

- Gas Turbine Combined Cycle burns natural gas in a combustor, using the resulting energy to drive a shaft. Not all energy can be captured so the exhaust is used to heat steam in a steam generator, which powers another steam turbine. Both turbines drive a generator shaft which converts the energy into electricity.

Figure 89. Total U.S. natural gas production, consumption, and net imports, 1990-2040 (trillion cubic feet)



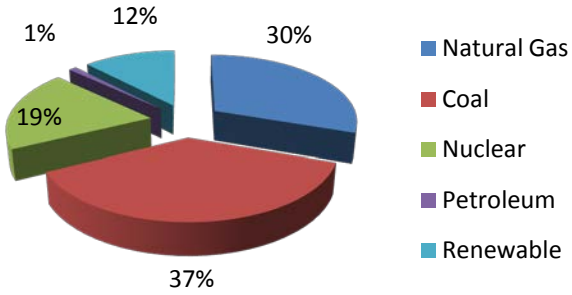
- Over the past few decades natural gas usage has increased, as well as plant efficiencies. This means while plants begin to have more an output we continually use more and more energy each year
- GTCC plants provide a more and more sustainable form of energy. At least, until a cleaner less wasteful form of energy is found.
- Across most energy suppliers the efficiencies of these plants are ~60% and plant technology and has gradually increased over the years.
- Power is supplied and used in the U.S. almost instantaneously, for lack of adequate means of energy storage.
- These turbine plants are regulated by the grid, supplying more energy to areas with higher demand to maintain constant energy flow, however when these plants cant keep up rolling blackouts occur

Comparative Gas Turbine Plants

U.S. Average costs, for plants entering service in 2018

Plant type (Gas Turbine)	Capacity Factor (%)	Levelized Cost ($/MWh)
Conventional Combined Cycle	87	67.1
Advanced Combined Cycle	87	65.6
Advanced Combined Cycle with CCS	87	93.4
Conventional Combustion Turbine	30	130.3
Advanced Conventional Combustion Turbine	30	104.6

U.S. Electricity Generation in 2012



Emissions & Trends

Emissions: One of the largest issues electricity generation is its emissions. Fossil Fuels are not clean burning substances so alternative means must be implemented for emission controls:

• Increased efficiency would reduce emissions because of the need for less fuel

• Carbon Capture and other filtration systems also work at the cost of more energy.

• Net electricity generation In 2012 by natural gas was ~1.22*10^12 kWh

Emissions (kg/kWh)

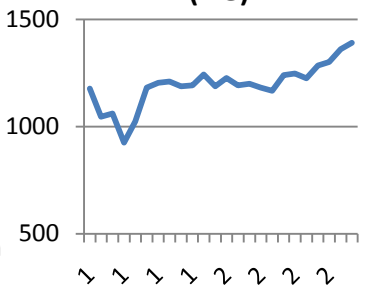
CO2: 0.298

Methane: 0.109

NO2: 0.00287

No sulfur emissions or particulate matter in a natural gas combustion Process.

Million Metric Tons CO2 (NG)



Issues

Stored Energy vs. Climate Change: Amongst the types of fossil fuels Natural Gas has the highest heating value. With that in mind a more efficient plant can extract a large amount of energy; however, natural gas has a high carbon content which creates more CO2 than coal relatively.

Advances in Technology: Today's engineering practices are far superior to older engineering design. The creation of advanced materials increases efficiencies and proper process control decrease the losses within the plant for pressure and heating systems, maximizing output.

Environmental Impact: The environmental impact of GTCC is not as bad as other plants, comparatively. Limited amounts of water are used mainly for cooling and discharged water is usually regulated to avoid preventable ecological damage. The main problem comes from natural gas extraction which dislodges animals from their natural habitat or can even poison aquifers during hydraulic fracking.

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How it Works & Consumption

"How Combined Cycle Works."*ge-flexability.com.* General Electric Company. Web. 13 April 2014.

- Provided the information for the description of both cycles

"Electricity Generation Technologies: Natural Gas." *epa.gov. U.S.* Environmental Protection Agency, 9 September 2013. Web. 12 April 2014.

- Used to find the chart located on the front page
- More relevant information about natural gas turbine combined cycles, general efficiencies and trends

Energy Generation in the US

"Electricity in the United States" eia.gov. U.S. Energy Information Administration, 5 November 2013. Web. 12 April 2013.

- This site provided me with the breakdown of electricity generation in the U.S.

Emissions & Trends

"Carbon Dioxide Emissions From Energy Consumption by Source." Chart. *eia.gov.* U.S. Energy Information Administration, 2014. Web. 12 April 2014

- This supplies the data for the table

"Electricity in the United States" eia.gov. U.S. Energy Information Administration, 5 November 2013. Web. 12 April 2013.

- Provided the Values for Net Electicity generation which was used to find net natural gas energy production

Rubin S. Edwards. *Introduction to Engineering and the Environment*. New York*:* McGraw-Hill, 2001. Print.

- Used heating values and composition to calculate kilograms per megawatt-hour

Comparative Gas Turbine Plants

"Levelized Cost of New Generation Resources in the Annual Energy Outlook 2013." *eia.gov*. U.S. Energy Information Administration, 28 January 2013. Web. 13 April 2004.

- Provided the values for the table

Issues

"Electricity Generation Technologies: Natural Gas." *epa.gov. U.S.* Environmental Protection Agency, 9 September 2013. Web. 12 April 2014.

- Provided information impact of turbine plants and extraction of natural gas

Cengel, Yunis A., and Michael A. Boles. "Thermodynamics: An Engineering Approach. 7th Ed." New York: McGraw-Hill, 2011. Print

- Explains the theory and advances in modern combined cycle turbines