International Energy Agency

Efficiency in Fossil Fuel Electricity Generation

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Agenda

Overview of fossil fuels in the energy mix and electricity generation

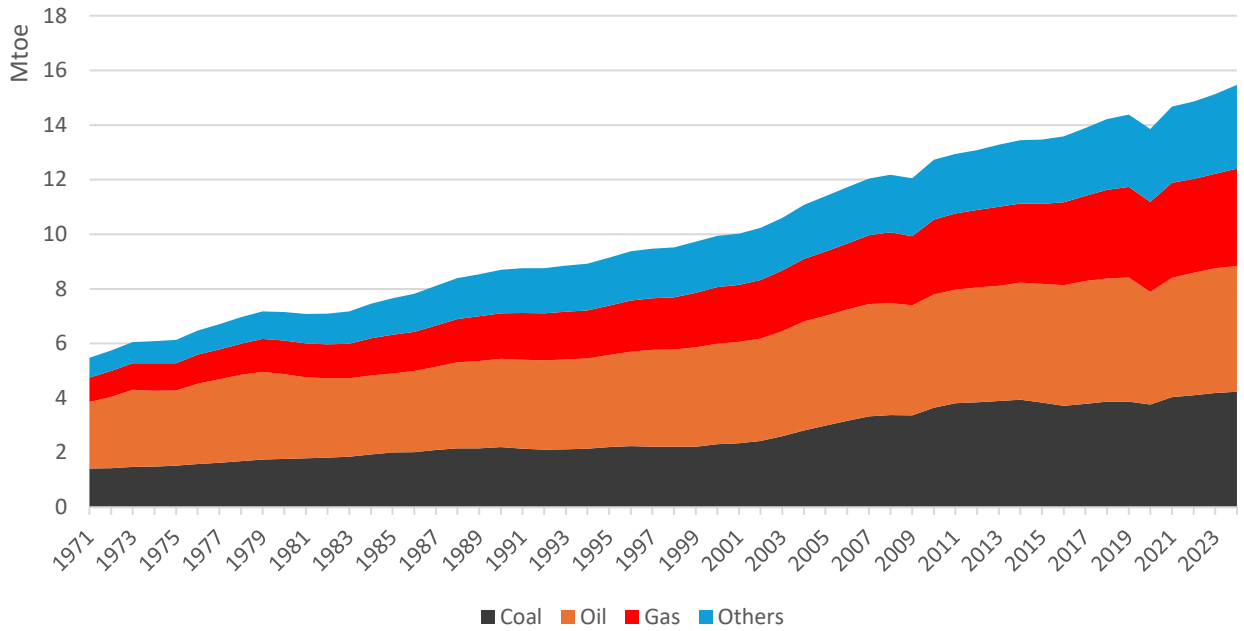
Overview of efficiency of fossil fuel electricity generation

A few notes on efficiency of coal power plants

Key takeaways

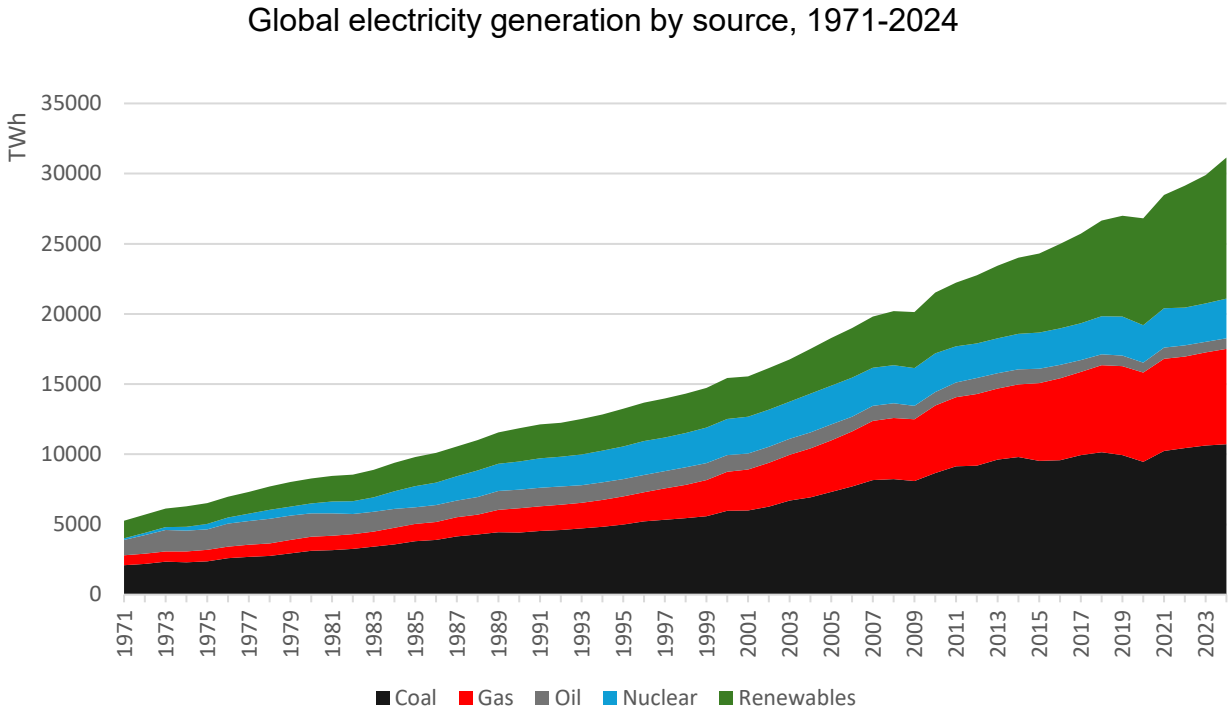
Today’s energy landscape is dominated by fossil fuels

Global primary energy supply by source, 1971-2024



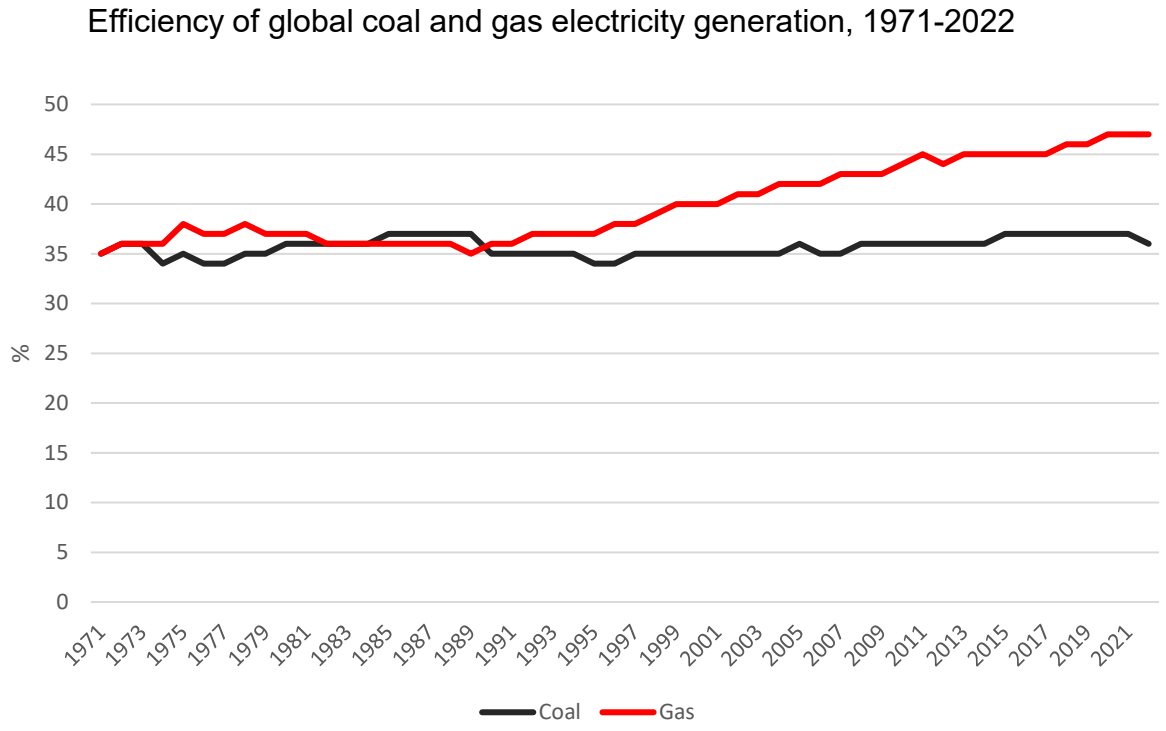
Whereas the share of fossil fuel in the primary energy mix is being reduced, the reality of today’s energy system is that fossil fuel account for majority of energy supply

Electricity generation is dominated by coal and gas



Whereas wind and solar PV are making fast progress, and expectations on nuclear have improved recently, coal is still largest source of electricity. Together with gas, they generate more than half of the world's electricity.

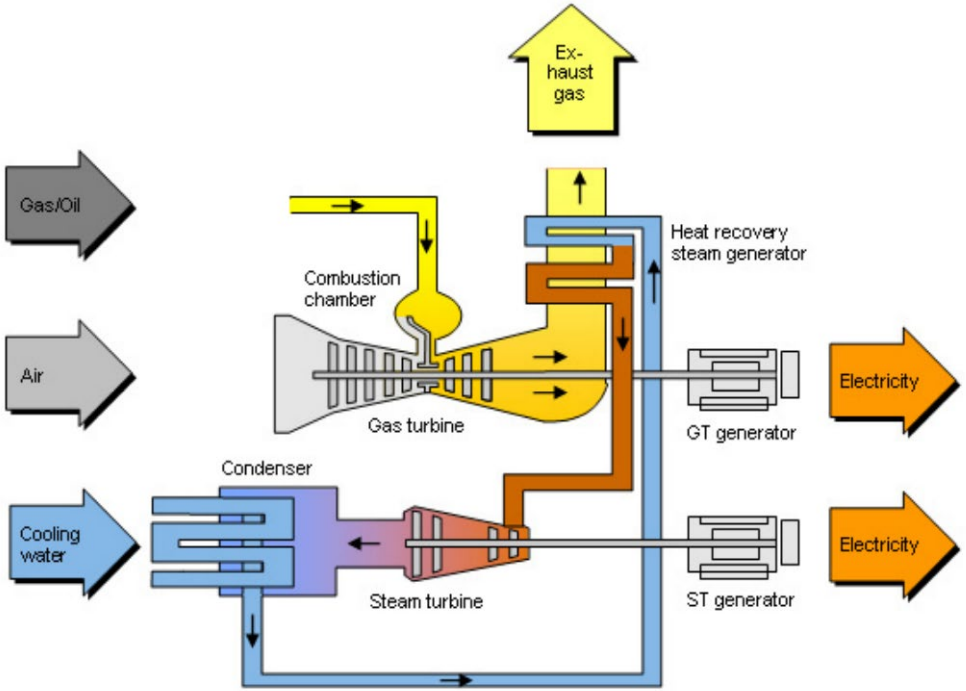
Gas power generation is gaining efficiency



Global average efficiency of both gas and coal power generation is far from best available technologies. Gas efficiency is improving owing to increasing use of CCGTs

CCGTs have higher efficiency than coal plants

Scheme of a combined cycle gas turbine

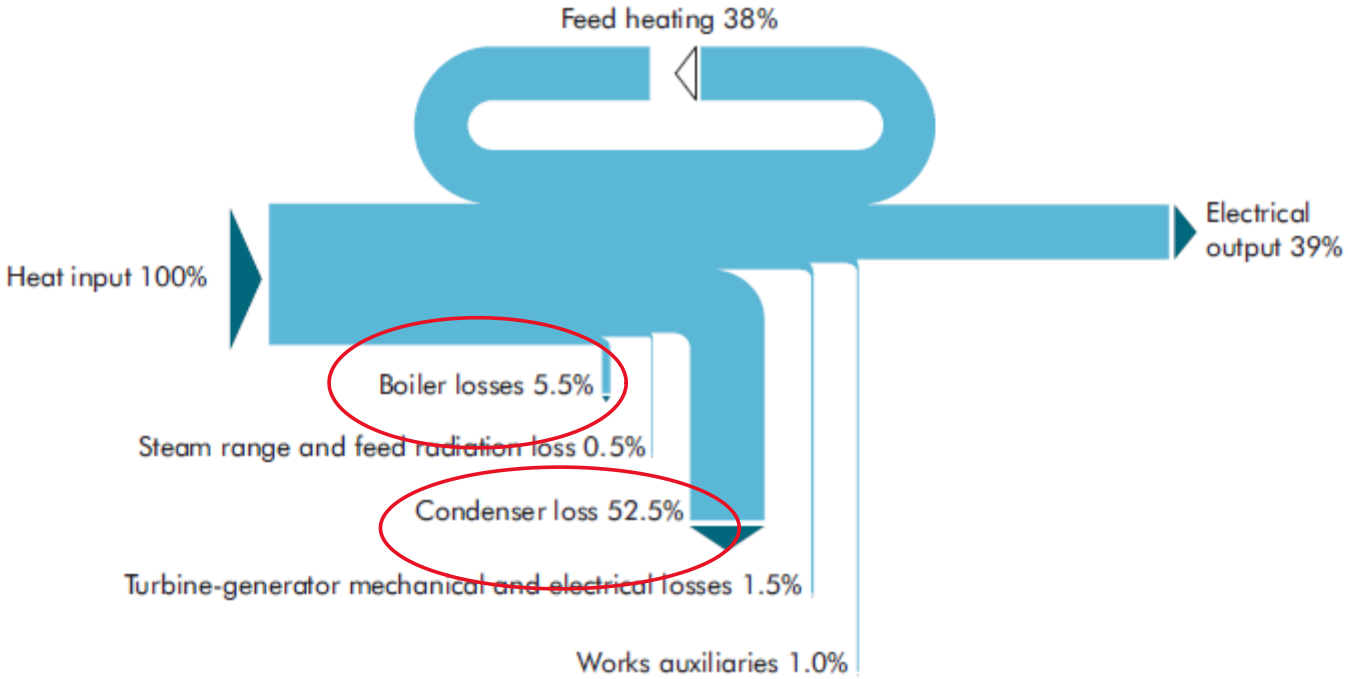


https://iea-etsap.org/E-TechDS/PDF/E02-gas_fired_power-GS-AD-gct.pdf

Residual heat of flue gas from the gas turbine is used to generate electricity with a steam turbine, augmentating efficiency compared with other arrangements

Where are the losses in a coal power plant?

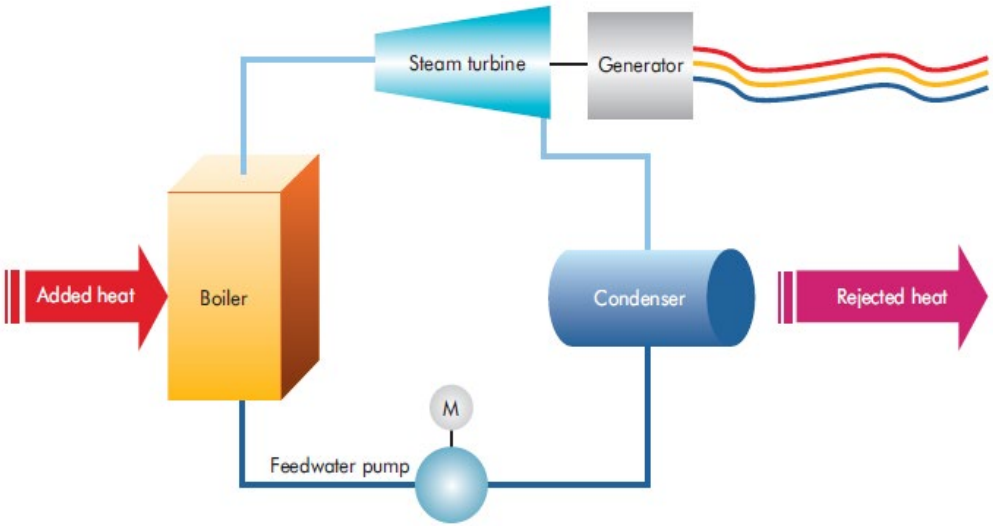
Example of energy flows in a typical subcritical coal power plant



Thermodynamics sets a physical limitation to efficiency. However, a big margin exists for efficiency improvement.

Understanding the water-steam cycle

Simplified scheme of a thermal power plant



The higher pressure and temperature of steam and the lower pressure and temperature of the condenser, the higher efficiency of the water – steam cycle

Many opportunities to increase efficiency of existing plants

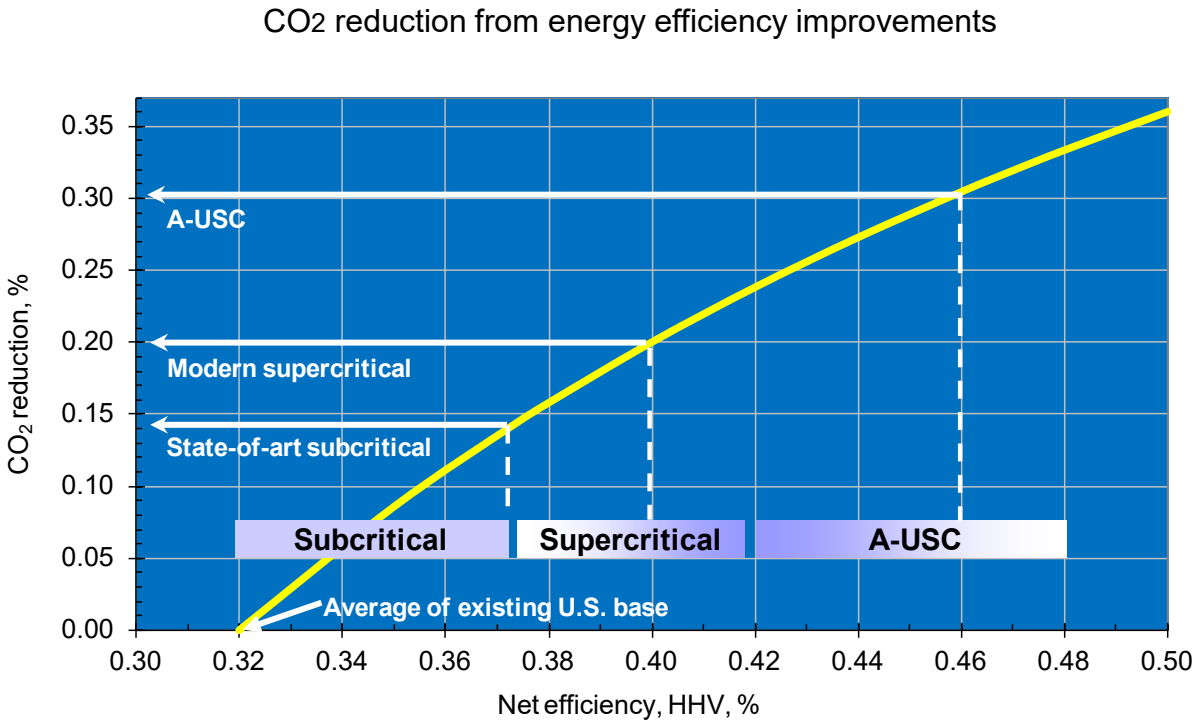
Boiler losses

- Heat losses
  - 1. Flue gas
  - 2. Solid residue sensible heat content
  - 3. Evaporation of H2 and moisture in fuel
  - 4. Moisture in the air
  - 5. Incomplete combustion
  - 6. Frictional losses, radiation and convection
  - 7. Steam leaks
  - 8. Unburned carbon in the ash

- Good practices
  - 1. Cleaning of boilers
  - 2. Soot blowing
  - 3. Water treatment
  - 4. Draft control
  - 5. Excess air control
  - 6. Loading of boiler
  - 7. Boiler insulation
  - 8. Quality of fuel

Whereas the design is very important, good practices can improve efficiency of the plant

Higher efficiency means smaller CO_2 footprint



Higher efficiency means to use less fuel to generate the same electricity, and therefore, to release less CO2 per unit of electricity generated

Many factors impact on efficiency

- Fuel moisture content
- Fuel ash content
- Fuel sulphur content
- Use of closed-circuit, once-through or coastal cooling water systems
- Normal ambient air temperature and humidity
- Use of flue gas cleaning technologies (in particular, CO2 capture)
- Use of low-NOx combustion systems
- Operating load
- Transient operation
- Maintenance practices

The issues about reporting efficiencies

- Use of different procedures and standards
- Use of different plant boundaries
- Use of different operating conditions during tests
- Expression of results on different bases
- Different determination of fuel calorific value
- Differences in duration of assessments
- Differences in the timing of assessment with maintenance cycle
- Errors in measurements, data collection and processing
- Random performance and measurement effects

Key takeaways

- Fossil fuels still account for majority of primary energy.
- Coal and gas power plants account for more than half of the world's electricity generation
- Higher efficiency in electricity generation can save money, increase the output of a unit and reduce CO_2 footprint.
- Despite the design parameters are key, good practices can increase efficiency significantly
- There are many factors with an impact on efficiency of a coal power plant
- Efficiency reporting is subject to many issues. Comparison of different efficiency values must be done with care