

# Coal in Europe: a rich past – what future?

Rainer Reimert

Thirty-First Annual Pittsburgh Coal Conference

October 6 - 9, 2014

Engler-Bunte-Institut, KIT



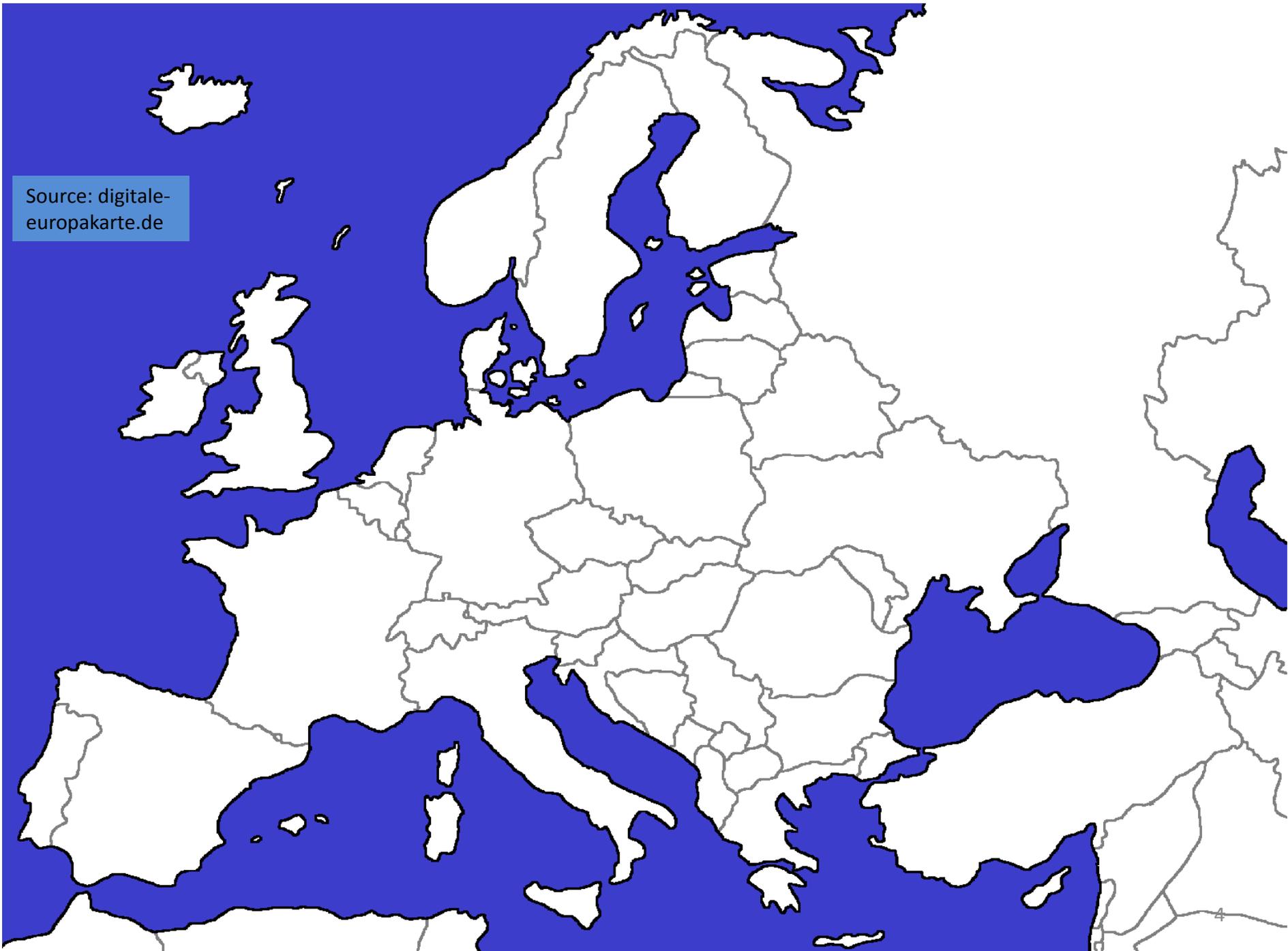
Source: Knauers  
großer Weltatlas 1999



# Europe

- Some 40 states, thereof 28 in European Union

Source: digitale-europakarte.de



# Europe

- Some 40 states, thereof 28 in European Union
- From 25 West to 60 East, and from 35 to 80 Nord
- Around 450 Million Inhabitants  
(excl. Russian Federation and Turkey)

# A restricted Bird's Eye View on Coal in Europe

## Coal deposits in Europe



# **A restricted Bird's Eye View on Coal in Europe**

The rich past

The challenges

The transition

The future

# The early times

## Solutions:

### Human being needs:

Food, (water)

Agriculture, water pipes

Heat

Wood

(Cooling)

(water evaporation, venting)

Mechanical work

Men, animals, wind, hydro

### Luxury needs

Light

Volatiles, vegetable oils

Metals

Mining, metallurgy, wood



**All solutions based on renewable energies**

# Early Times Metallurgy: Ore Roasting



Source: Agricola, G.: Zwölf Bücher  
Vom Berg- und Hüttenwesen, S.238,  
Berlin 1928

# The early use of coal

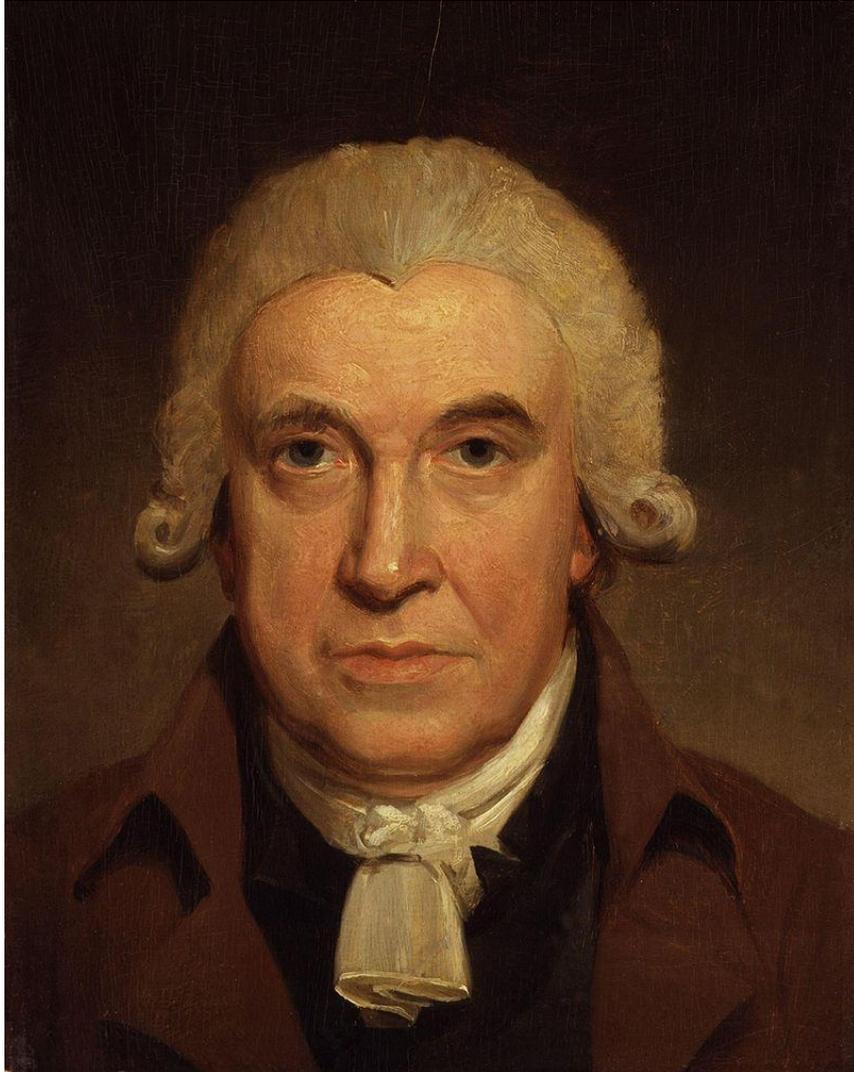
- 13. century: Heating with hard coal in England
- 1530: Coal production in England: 200 kt/year
- Around 1630: Increase to 1.5 Mt/year



**A slow to moderate increase of about 2 %/year**

However, the use of 1.5 Mt of coal per year equals carbon-wise the annual growth of wood on some 100,000 ha

# The rich past – inventions- and innovations-based



## James Watt

30.01.1736 (greg.) – 25.08.1819  
Resp. 19.01.1736 (jul.)

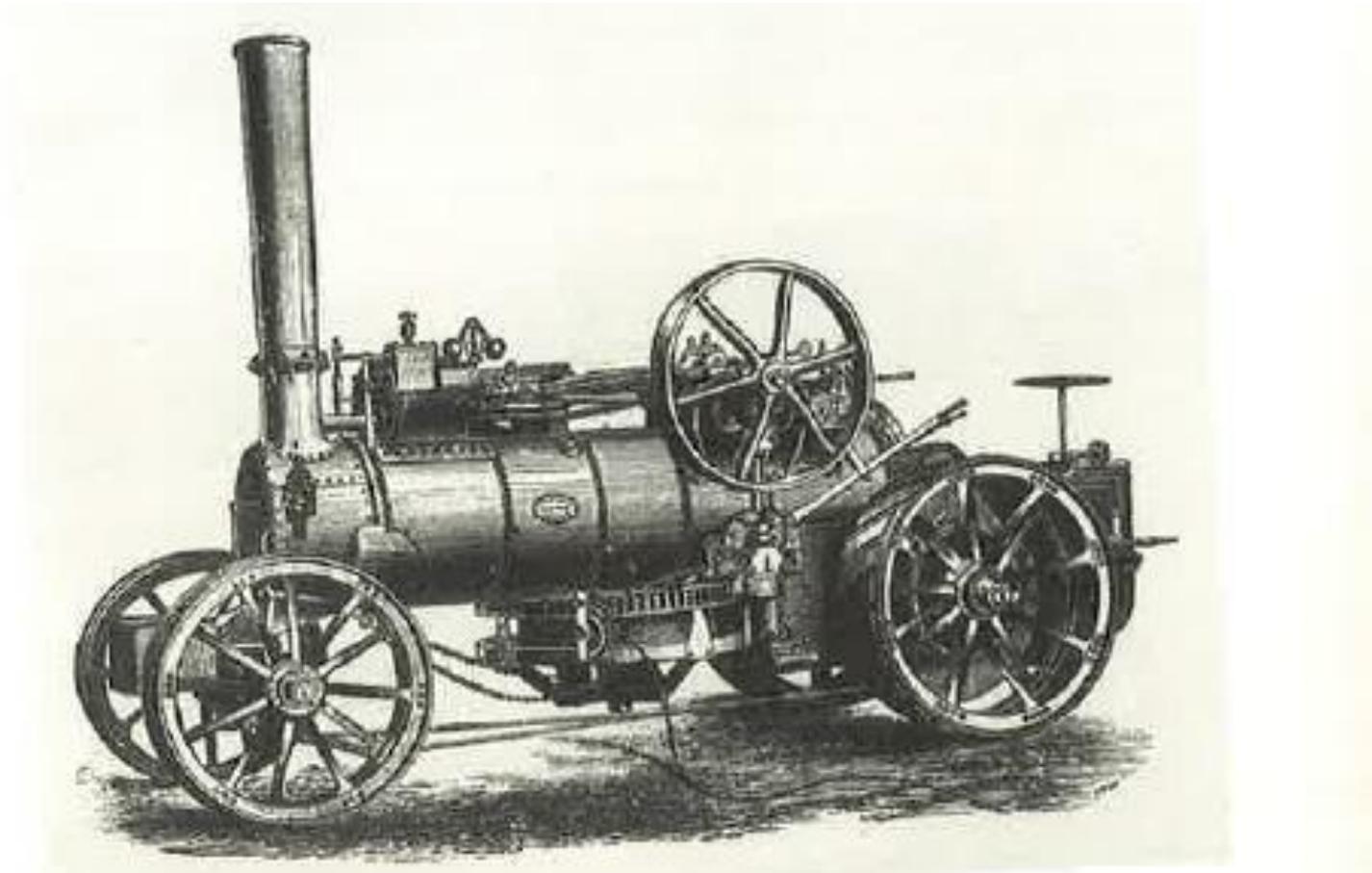
Patent for steam engine 1769  
Efficiency about 3 %

In 1758 blast furnace put in  
use in England



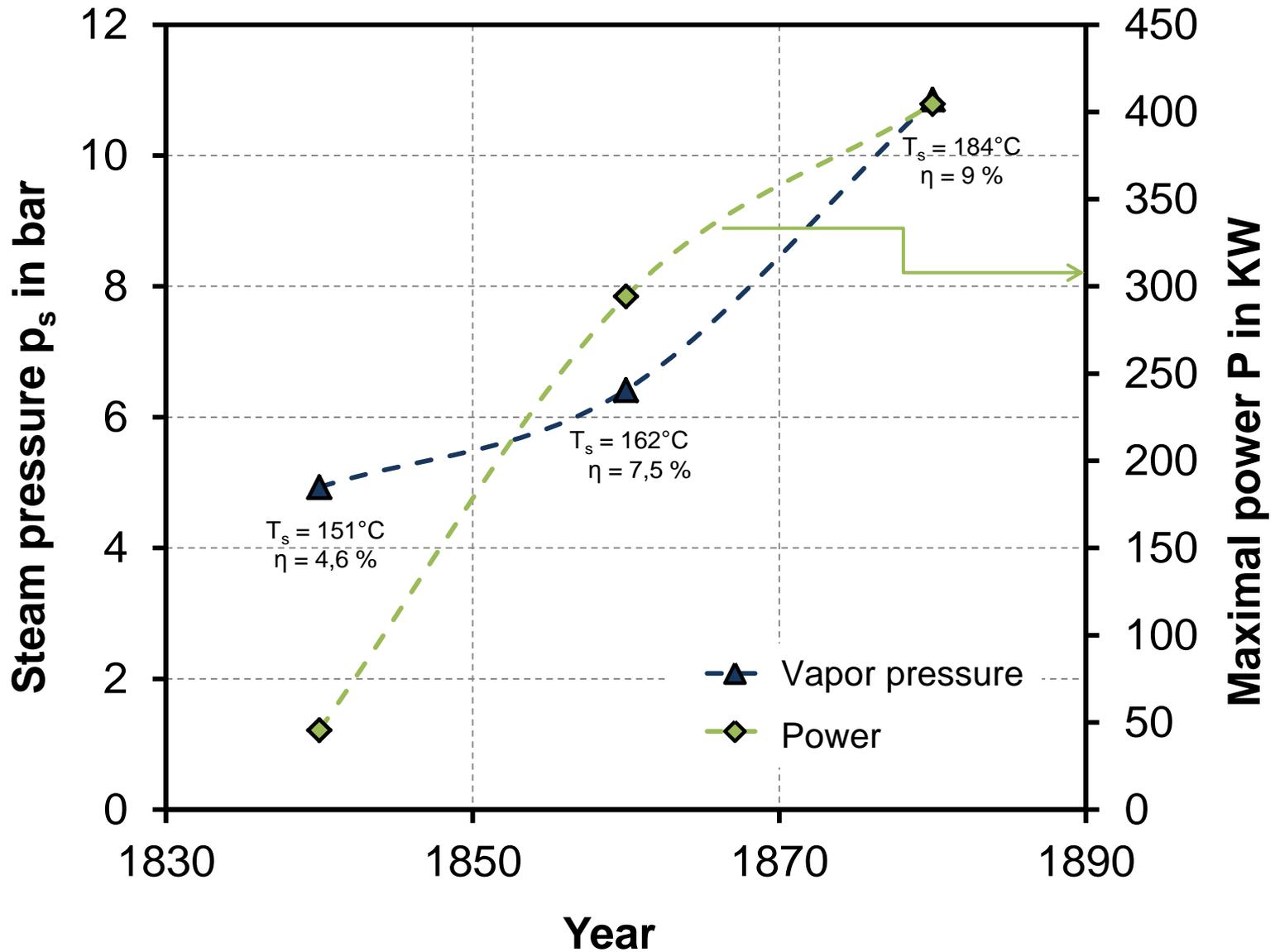
**A strong increase in coal usage.  
Begin of the “industrial revolution”**

# Steamers – mobile steam engines



Source: Propyläen Technik Geschichte: 1840 bis 1914

# Development of steam engine performance



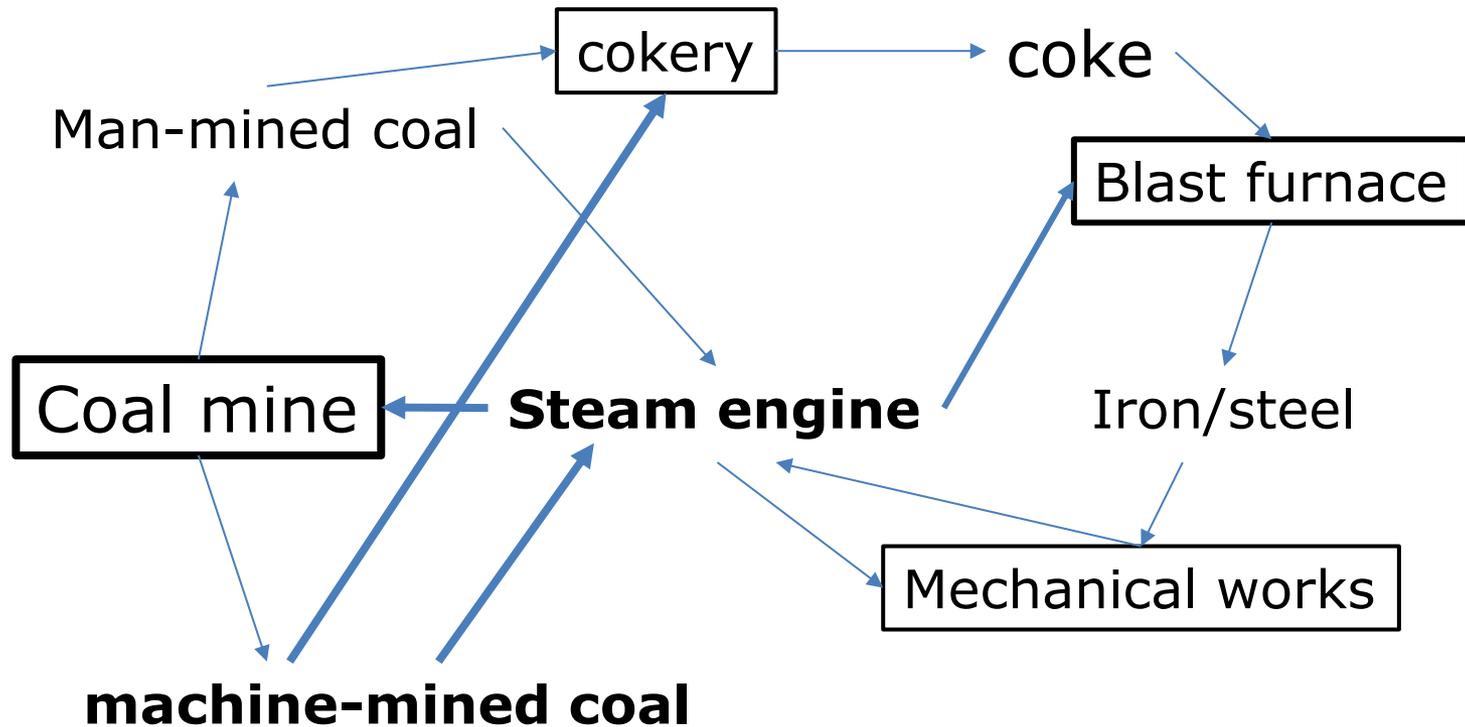


## **Sir Henry Bessemer**

19.1.1813 – 14.3.1898

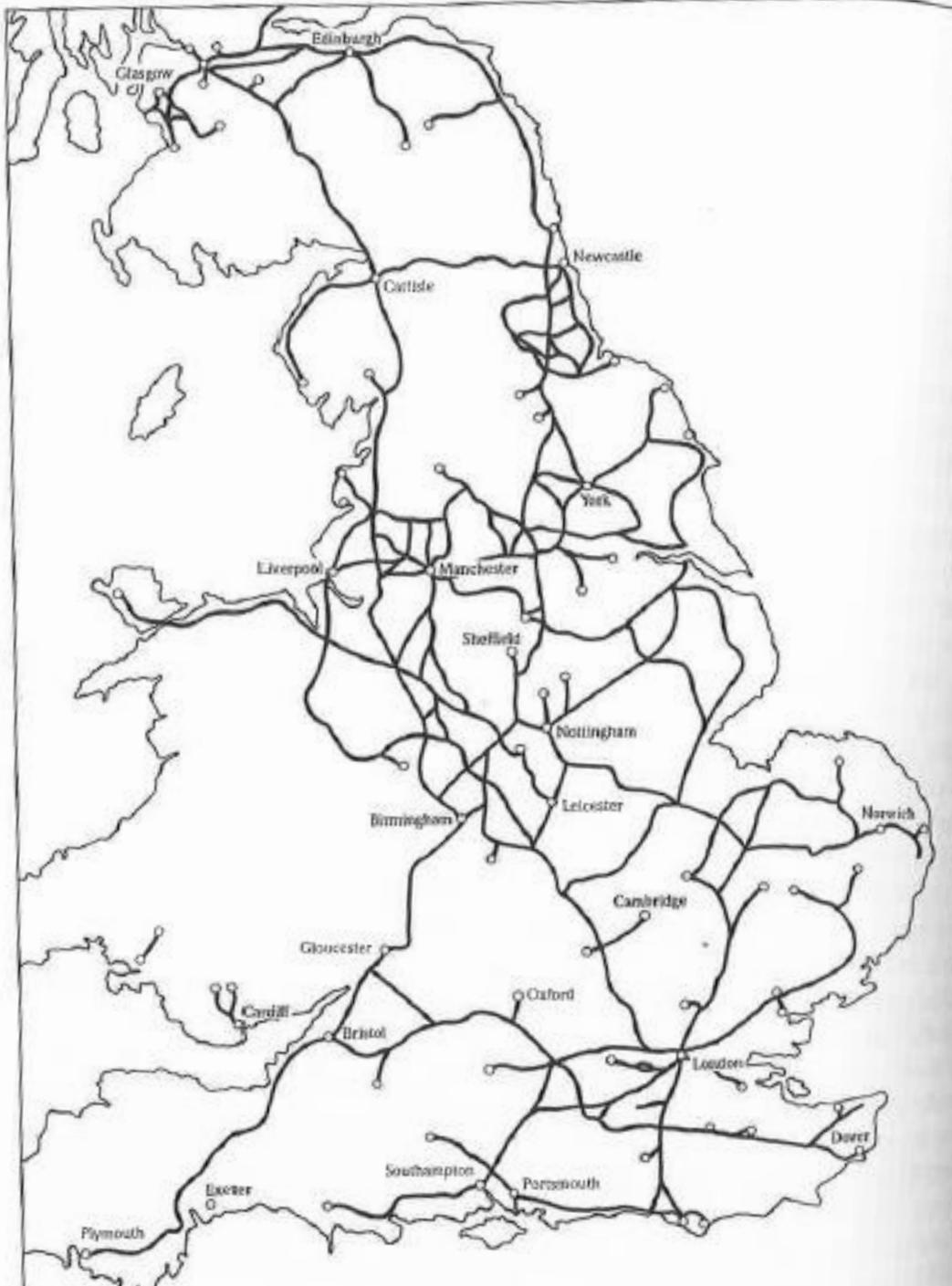
Improved process to remove  
Carbon from pig iron (1856 - 1859)

# Interdependencies



RAILWAY

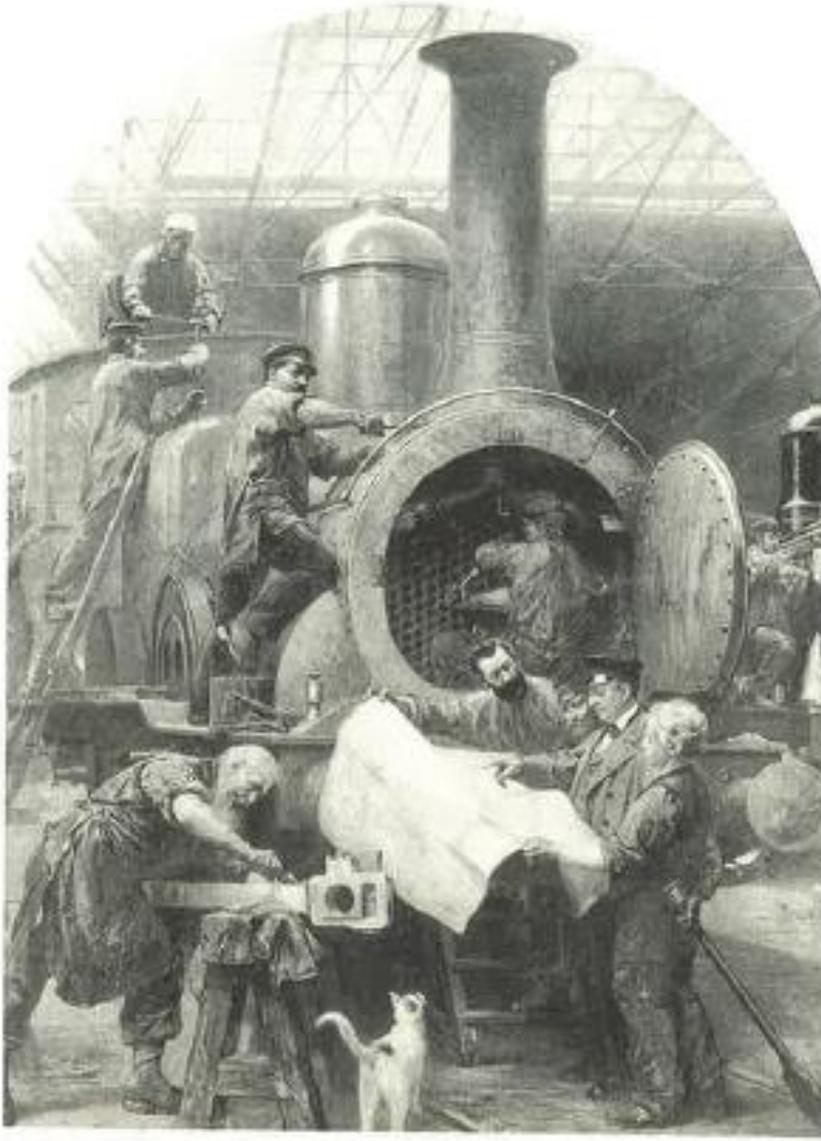
# Railway grid in Great Brittan at 1849



# Locomotive on route Paris – Rouen Photo from 1843



# Locomotive under construction 1875 at Borsig, Berlin



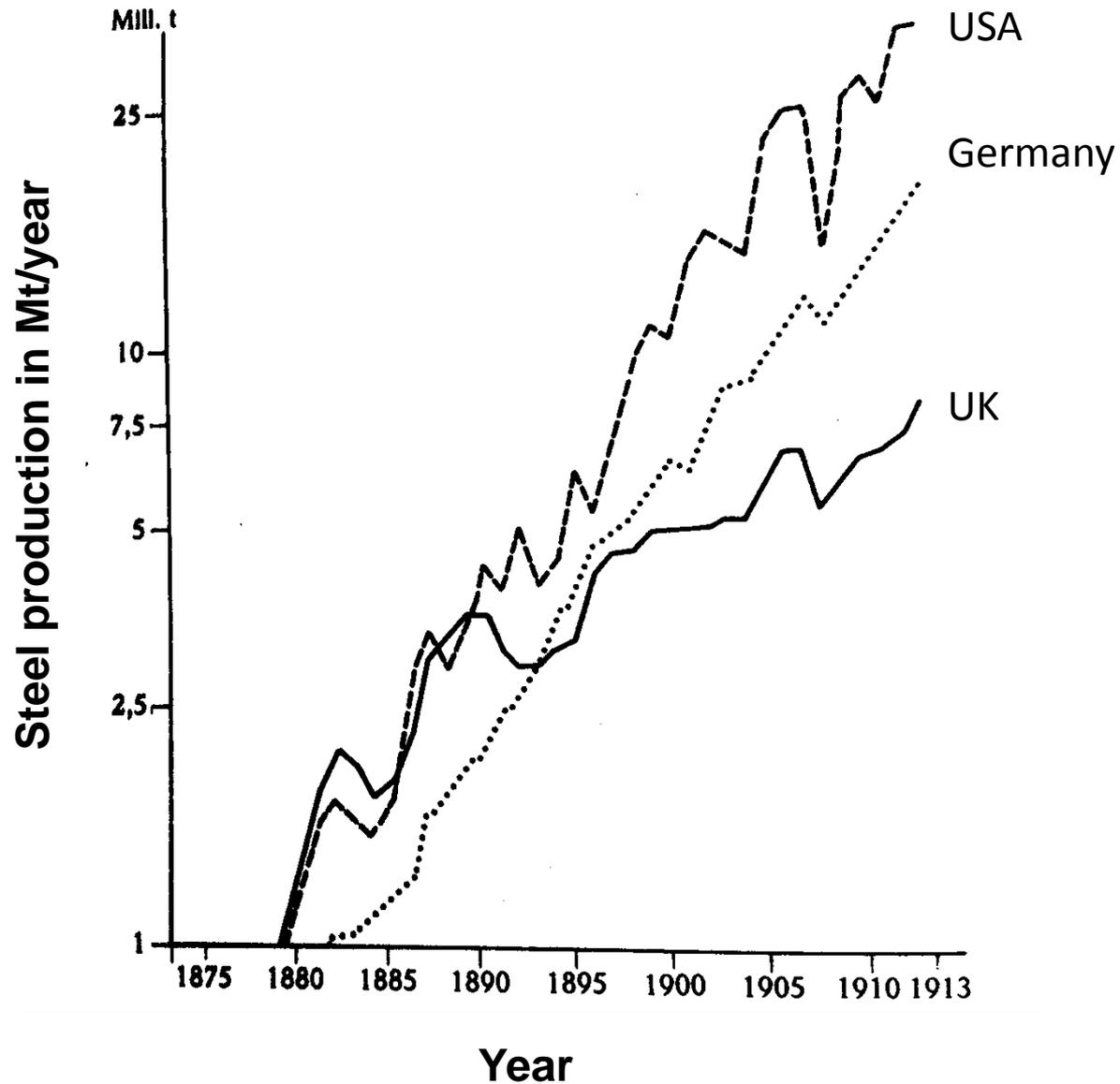
Efficiencies:

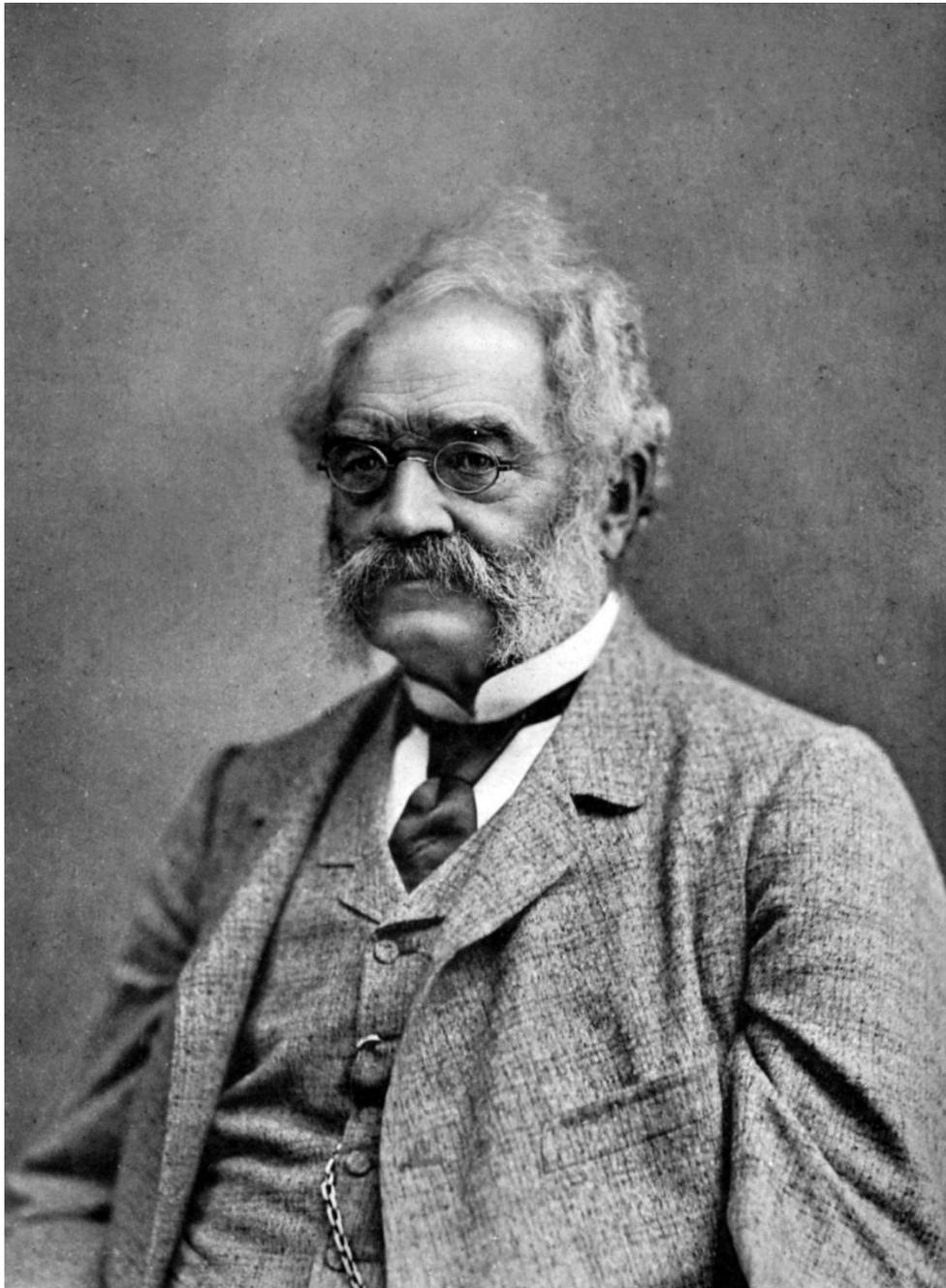
- 5 % in 1900
- 8 % in 1930

Power:

2.2 MW in 1926

# Rapid growth of steel production





## Ernst Werner von Siemens

13.12.1816 – 6.12.1892

1866: Self-inducing generator

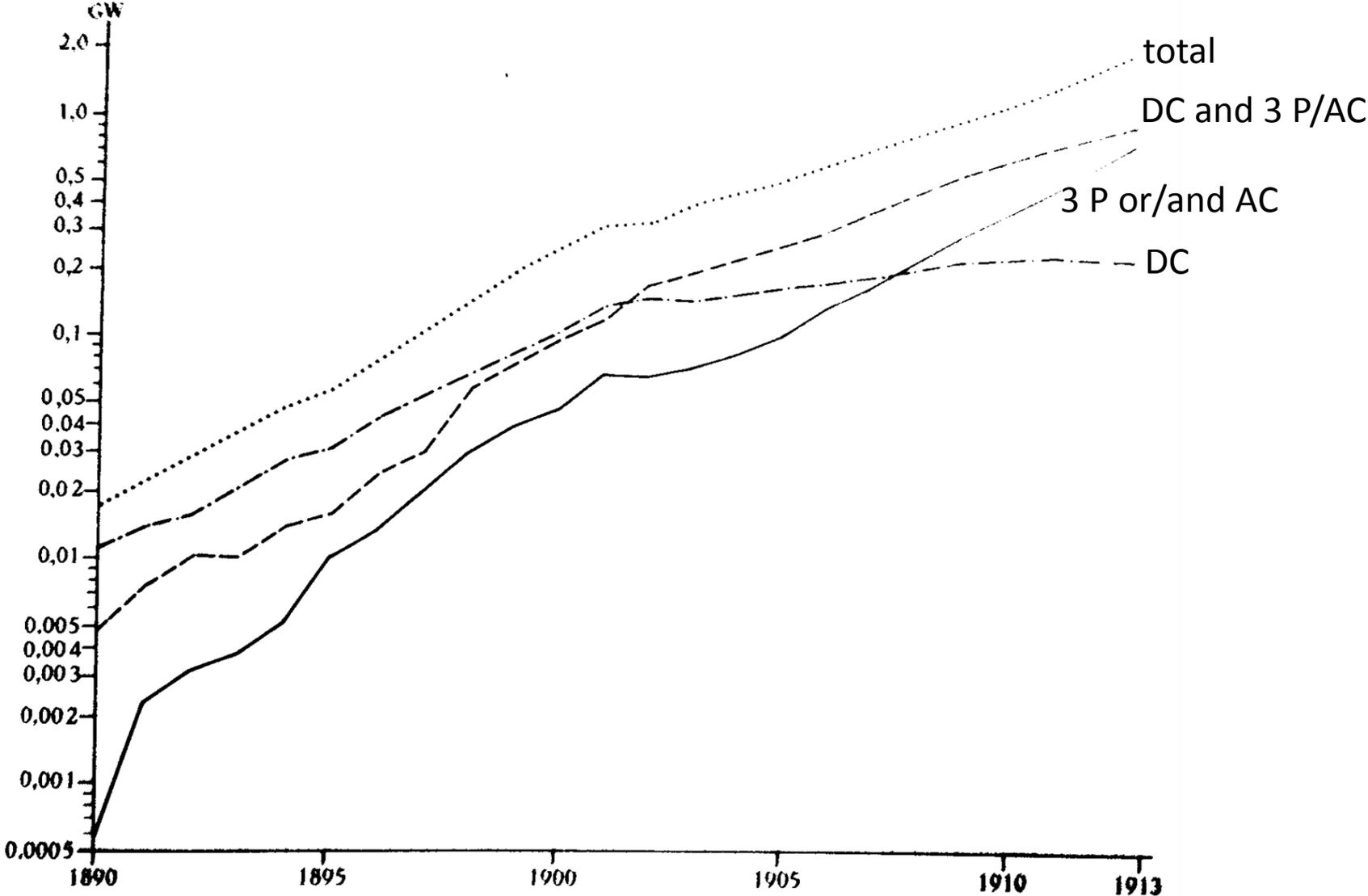


Power stations

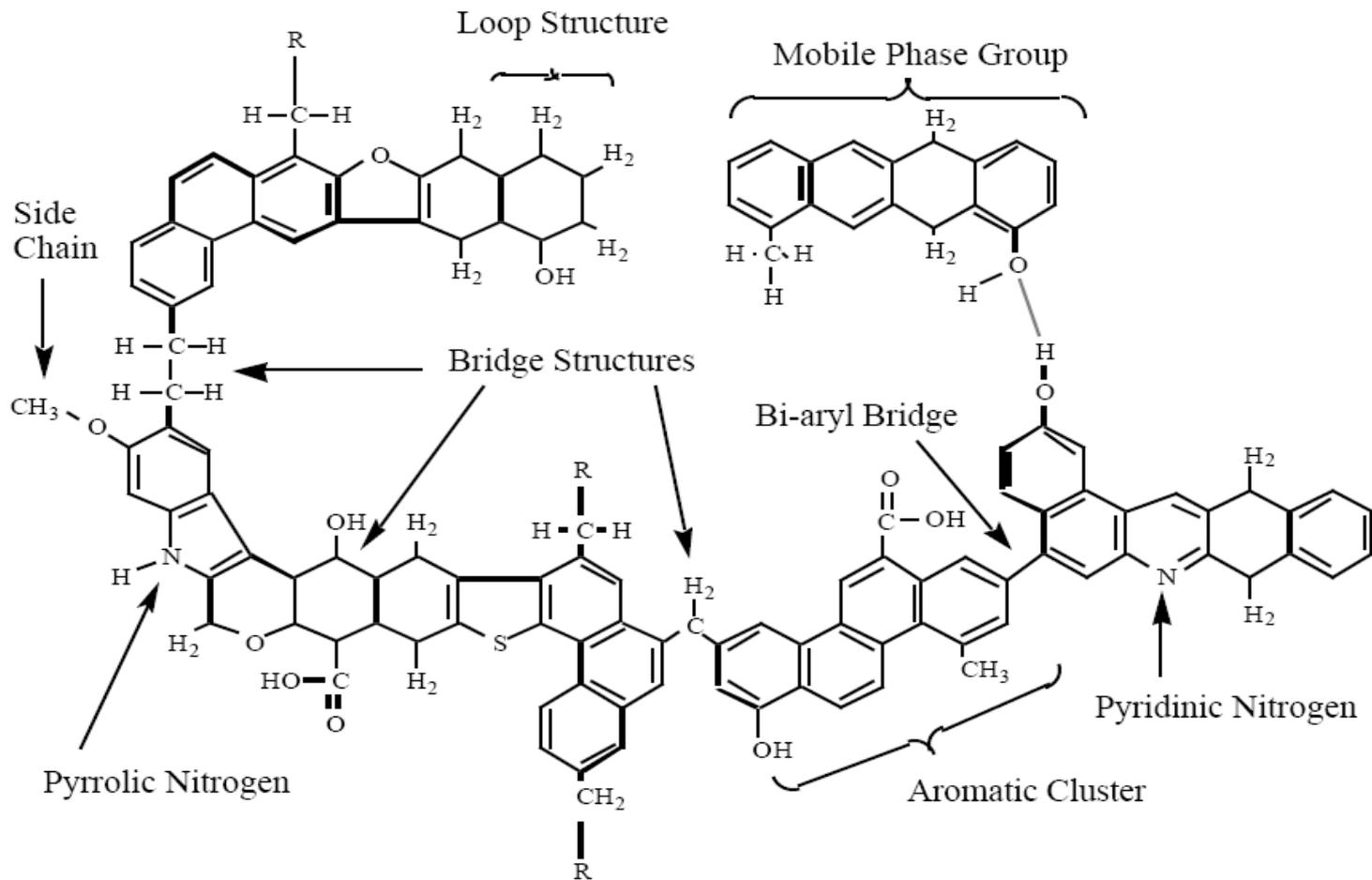
Available drives:

- Steam engine
- Hydro
- Gas engine

# Power Production in German Empire

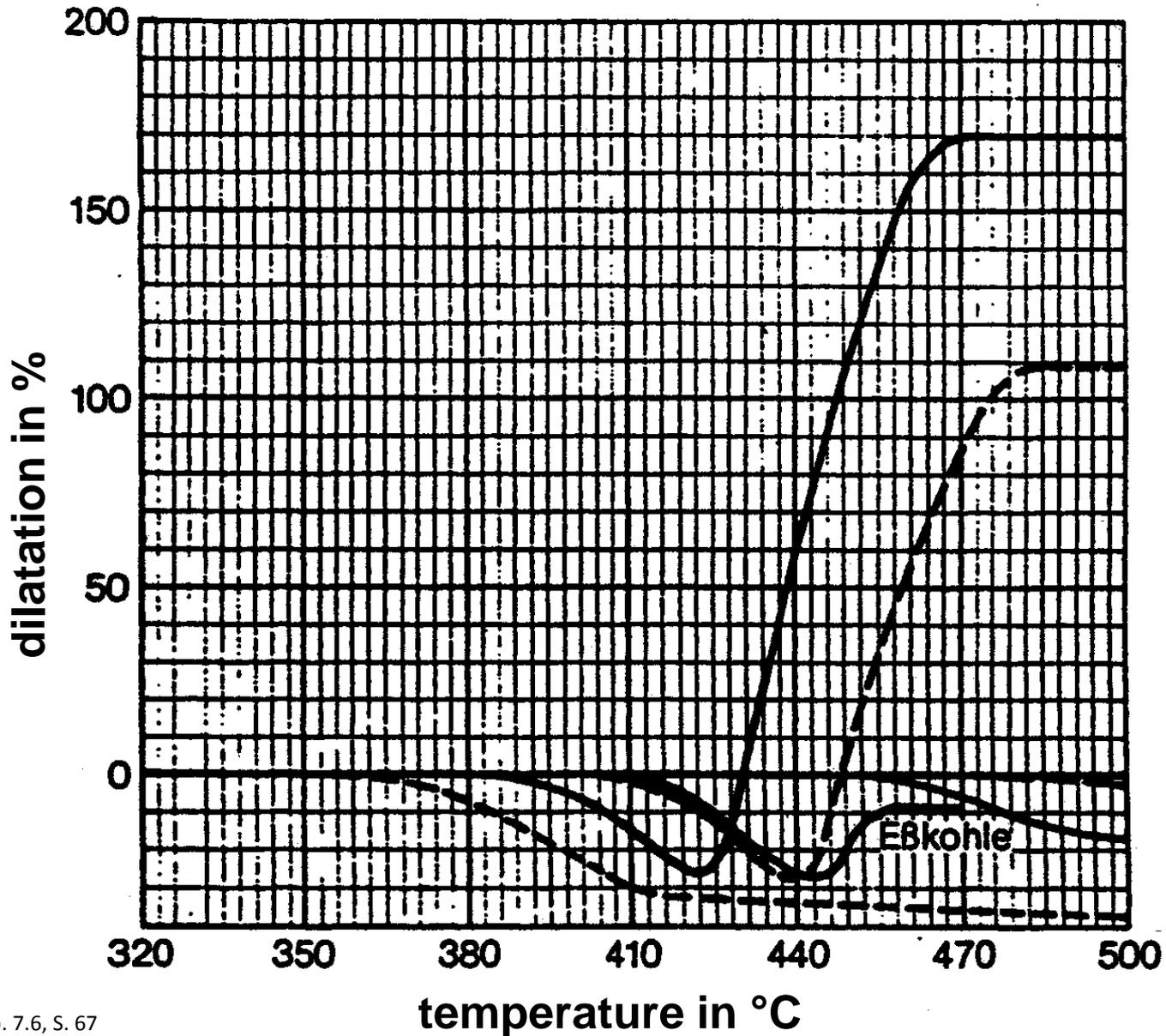


# Coal: a Basic Chemical – or a Chemical Base

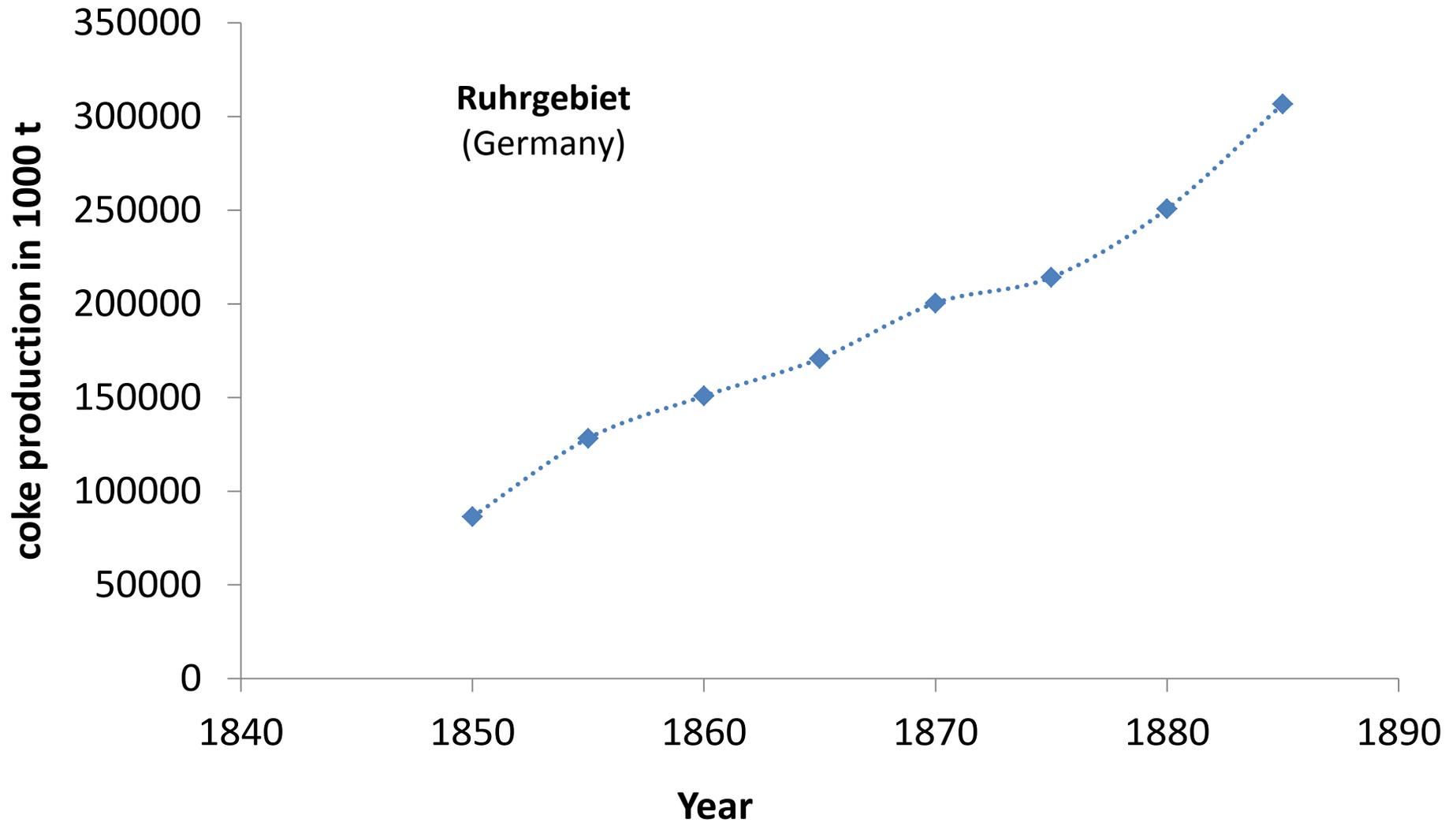


**A characteristic “coal molecule”**

# Dilatation of Ruhrkohlen



# Coke production in the Ruhr District



# Coal as a Basic Chemical – or as a Chemical Base

In 1664 it is reported:

The English John Clayton „...distilled coal in a retort and obtained a phlegma, a black oil and an uncondensable spirit which was inflammable.“



**The basic process to use coal chemically is the pyrolysis**



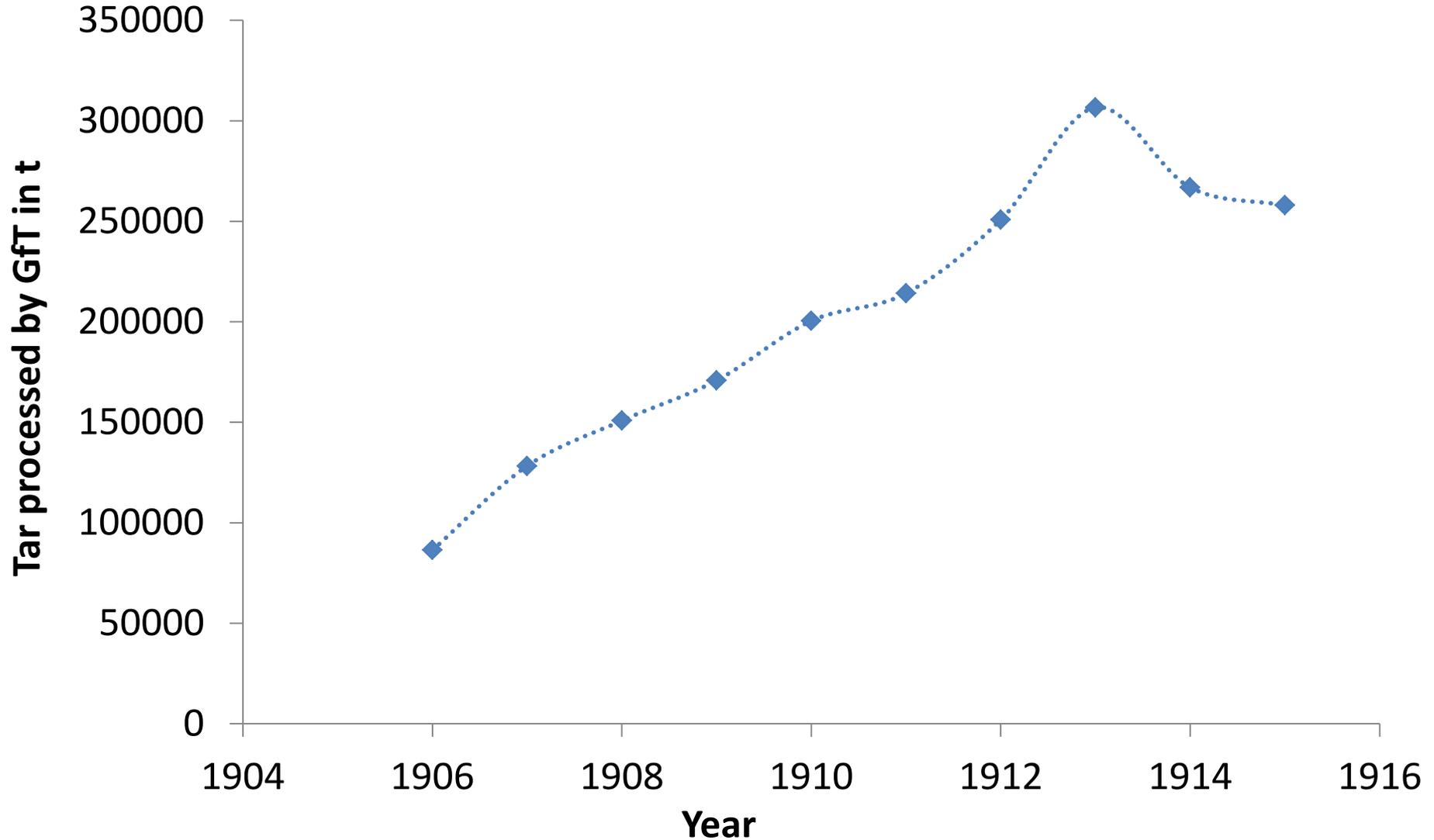
# Factory for treatment of woody material with tar



# Tar: A source of high valuable chemicals, dyes

Year	Substance	T <sub>boil</sub> in °C	T <sub>melt</sub> in °C	X <sub>i,tar</sub> in ma.-%	Identified by...
1820	<b>Naphthalene</b>	218	80	10	A. Garden, J. Kidd
1832	<b>Anthracene</b>	340	218	1.8	J.B. Dumas, M.A. Laurent
1834	<b>Phenol</b>	182	41	0.4	F.F. Runge
1834	<b>Aniline</b>	184	-6	0.02	F.F. Runge
1837	<b>Chrysene</b>	441	256	2.0	M.A. Laurent
1837	<b>Pyrene</b>	393	150	2.0	M. A. Laurent
1843	<b>Chinoline</b>	237	-14	0.3	A.W. Hofmann
1845	<b>Benzene</b>	80	5.5	0.4	A.W. Hofmann
1846	<b>a-Picoline</b>	129	-67	0.02	Th. Anderson
1848	<b>Toluene</b>	111	-95	0.3	C.B. Mansfield

# Tar processing in a specialised plant (later Rütger)



# Gas: The third valuable product of coal pyrolysis

- 1792 William Murdoch sold gas filled in pig bladders
- Since 1799 Lampadius experimented with gas production from coal for lighting  
1811 a street in Freiberg, Saxonia was lighted
- From 1812 on Samuel Clegg operated a gas manufacturing plant

# Honor for a scientist



Source: Wiki



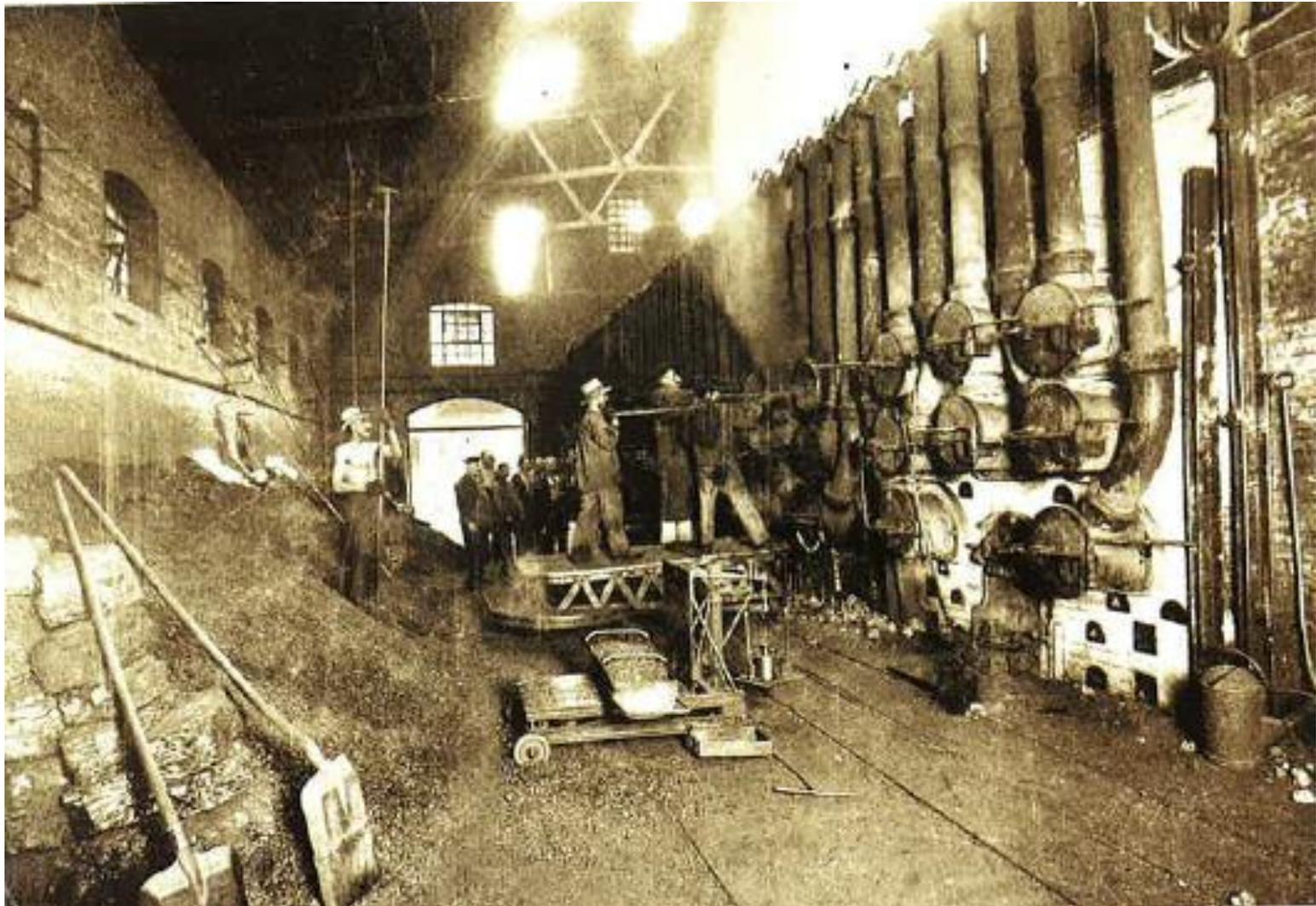
**Wilhelm August Eberhard Lampadius**  
08.08.1772 – 13.04.1842



**Carl Auer von Welsbach**  
01.09.1858 – 04.08.1929

1891 Invention of the  
Incandescent mantle  
for the Gas light

# A town gas manufacturing plant



# The challenges: Energy sector

- Electric energy: from enhancer to competitor
- increased use of coal for the dynamo drives - replaced local steam engines
- in 1884: steam turbine invented by British Charles Parsons
- Hydro power, still around 1900 considerable part for electricity, allowed to use it elsewhere, independent of rivers and mountains
- For peak demand Diesel engines



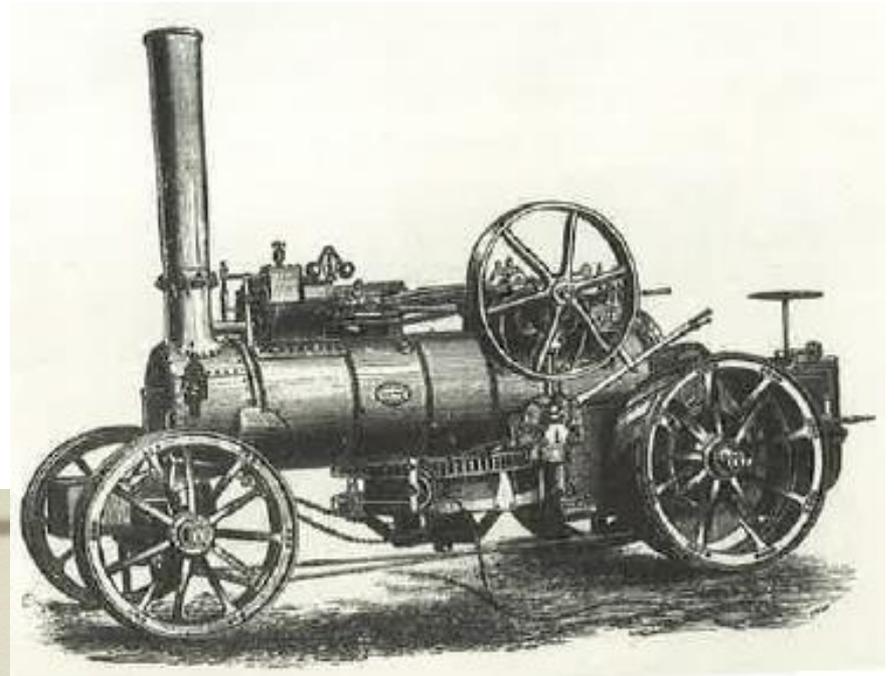
**Edwin L. Drake**

29.03.1819 – 08.11.1880

27.08.1859: Entdeckung  
der ersten US-Ölquelle in  
Titusville (in 21 m Tiefe)

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- In the period 1910 – 1930 switch from mobile steam engines to oil/gasoline fuelled tractors



Source: Propyläen Technik Geschichte: seit 1914



Lanz Traktor

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- Within 10 years (1940 – 1950) transition locomotives fuel from coal to Diesel in USA, in Europe to electric drive (somewhat later and more slowly)
  
- In later stages: oil and gas and nuclear fission „fuel“ the power stations
  
- Recently: wind and solar energy; biomass

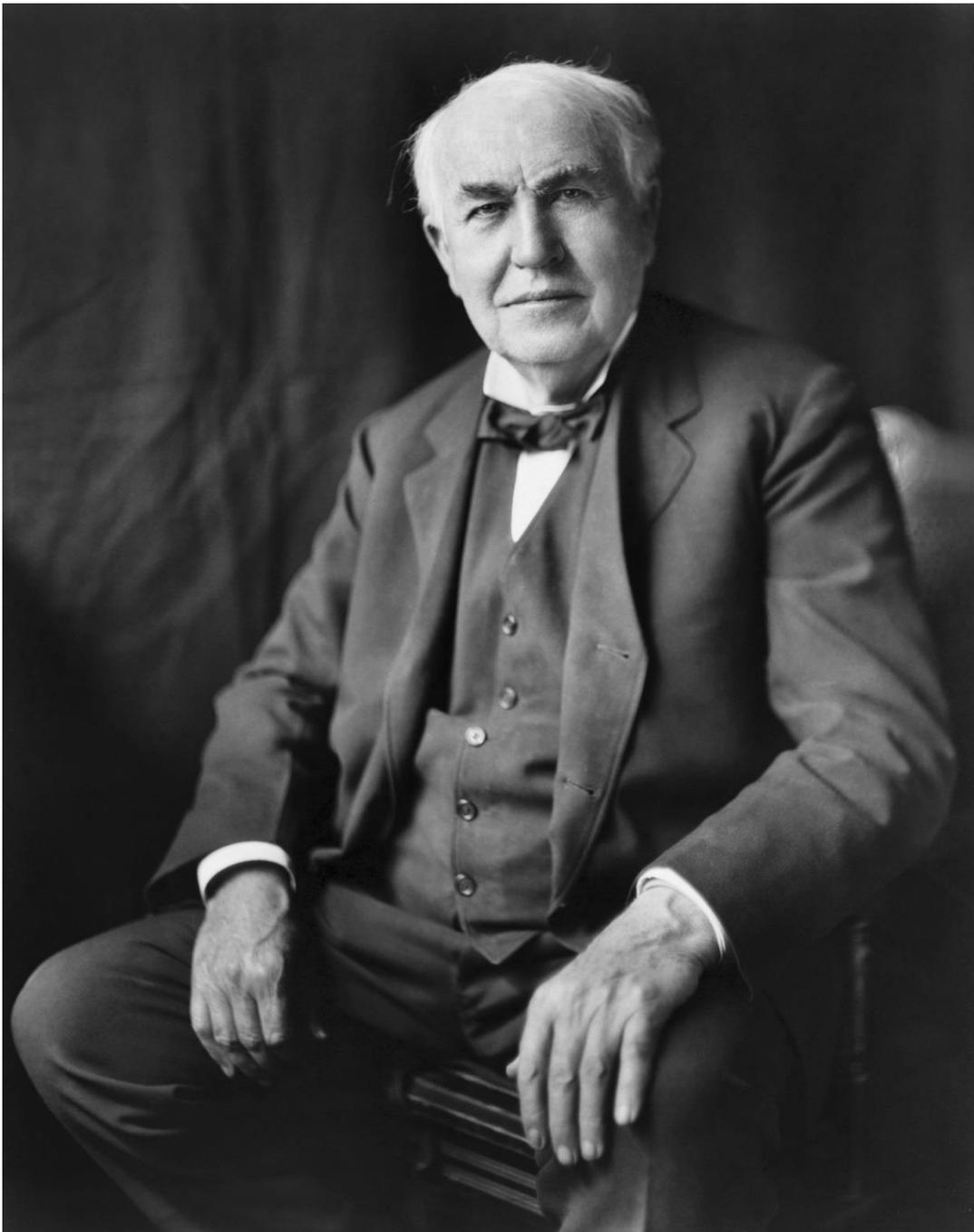


**A strong and manifold competition**

# The challenges: Gas sector

Electric lighting

Thomas Alvar Edison 1879: Improved electric bulb  
(carbon fiber)



**Thomas Alvar Edison**  
11.2.1847 – 18.10.1931

1879 Improved electric bulb  
(carbon fiber)

# The challenges: Gas sector

Electric lighting

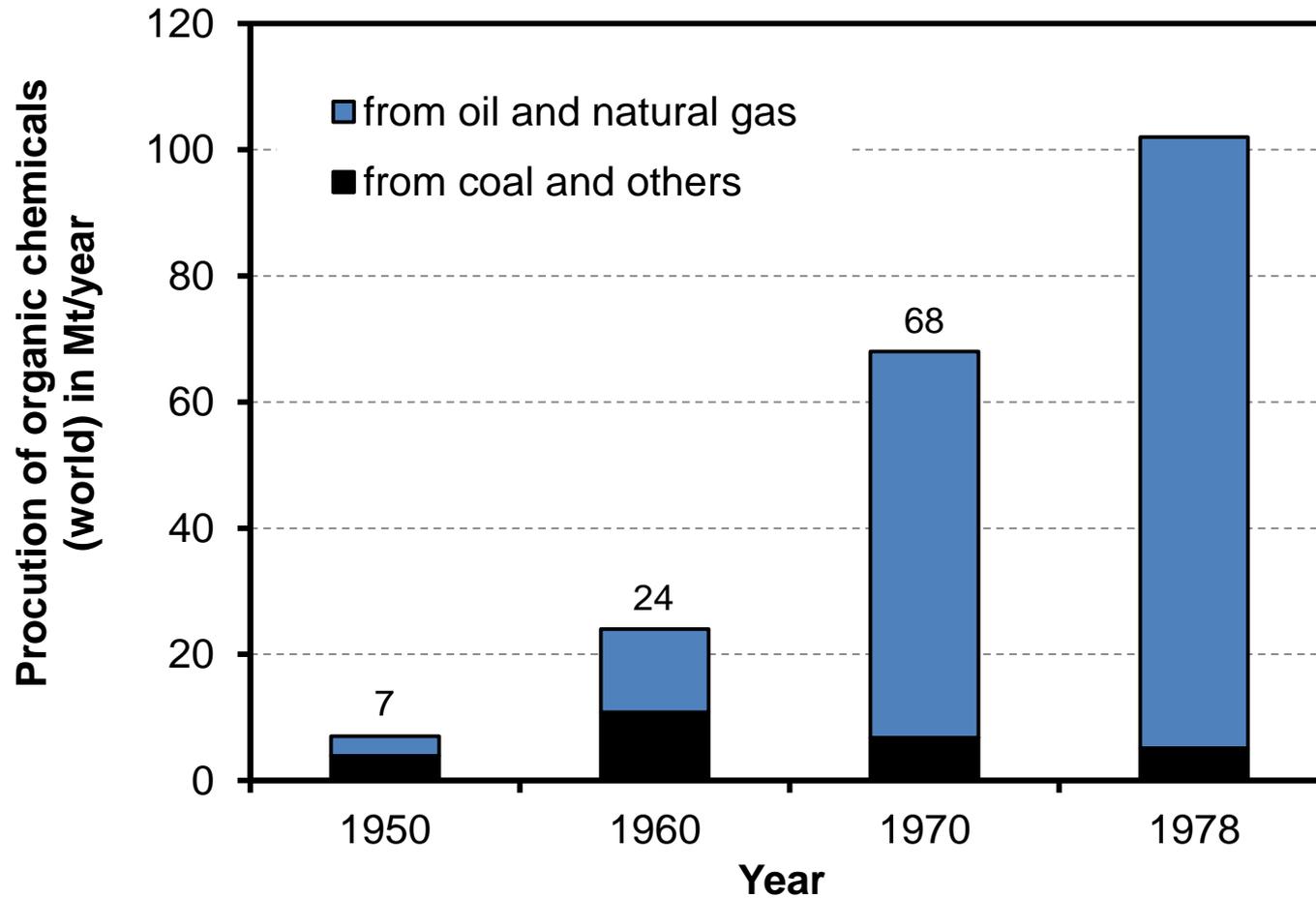
Thomas Alvar Edison 1879: Improved electric bulb  
(carbon fiber)

Domestic oil and/or natural gas heating  
CHP

Electric cooking

Naphtha and natural gas become the preferred feed for the chemical industry

# Coal in the chemical industry



# State-related features of the competing fuels

	oil	natural gas	coal
availability (time)	low - medium	medium	high
energy density	high	low	high
range of application: fuels	high	medium	low
range of application: chemistry	medium	medium - high	low
storability	high	medium	high
impurities	medium	low	high
specific CO <sub>2</sub> emissions	medium - high	comparatively low	high

# The challenges: Environment



# The challenges: Environment

In 1273 English nobility was successful in complaining that the smoke gave reason for deceases and other undesirable matters for men, animals and plants

A royal decree was issued forbidding the private use of hard coal for

However, due to scarcity of wood use of coal became accepted

In 16. century development of mild pyrolysis, equivalent to char coal production  
Removal of undesirable volatiles, especially sulfur

# The challenges: Environment



Source: Greater London Authority, December 2002

- Great smog 1952, London: 12,000 people died
- A dense fog covered London between the 5 and 8 December 1952
- Cause: industrial pollution and domestic coal burning

# The challenges: Environment

A8 TUESDAY, SEPTEMBER 30, 2014

ALBERTA

EDMONTON JOURNAL [edmontonjournal.com](http://edmontonjournal.com)

## Cheap coal a false economy, expert says

*Physicians urge  
move to cleaner,  
healthier options.*

SHEILA PRATT  
*Edmonton Journal*

Alberta would save millions in health-care costs by phasing out coal-burning power plants, says a leading U.S. expert on the health effects of air pollution from coal.

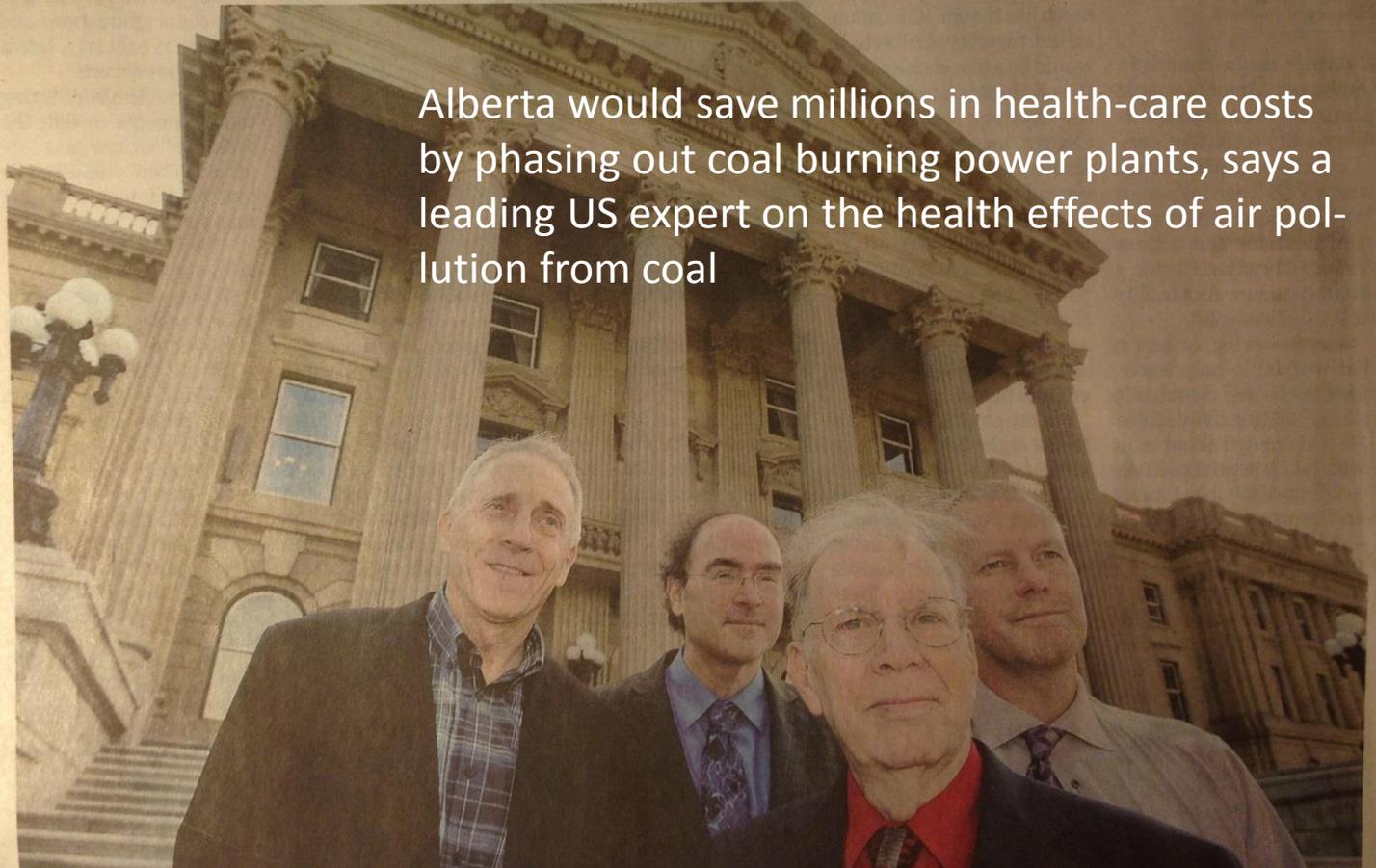
Dr. Alan Lockwood says the U.S. saves \$2 trillion in health-care costs each year by reducing pollution from coal plants under the Clean Air Act and closing older plants.

Alberta has plentiful cheap coal just west of Edmonton that fuels several electricity plants, Lockwood said in an interview Monday.

"But it's a false economy — burning what looks like a cheap source of energy," said Lockwood, author of *The Silent Epidemic: Coal and the Hidden Threat to Health*.

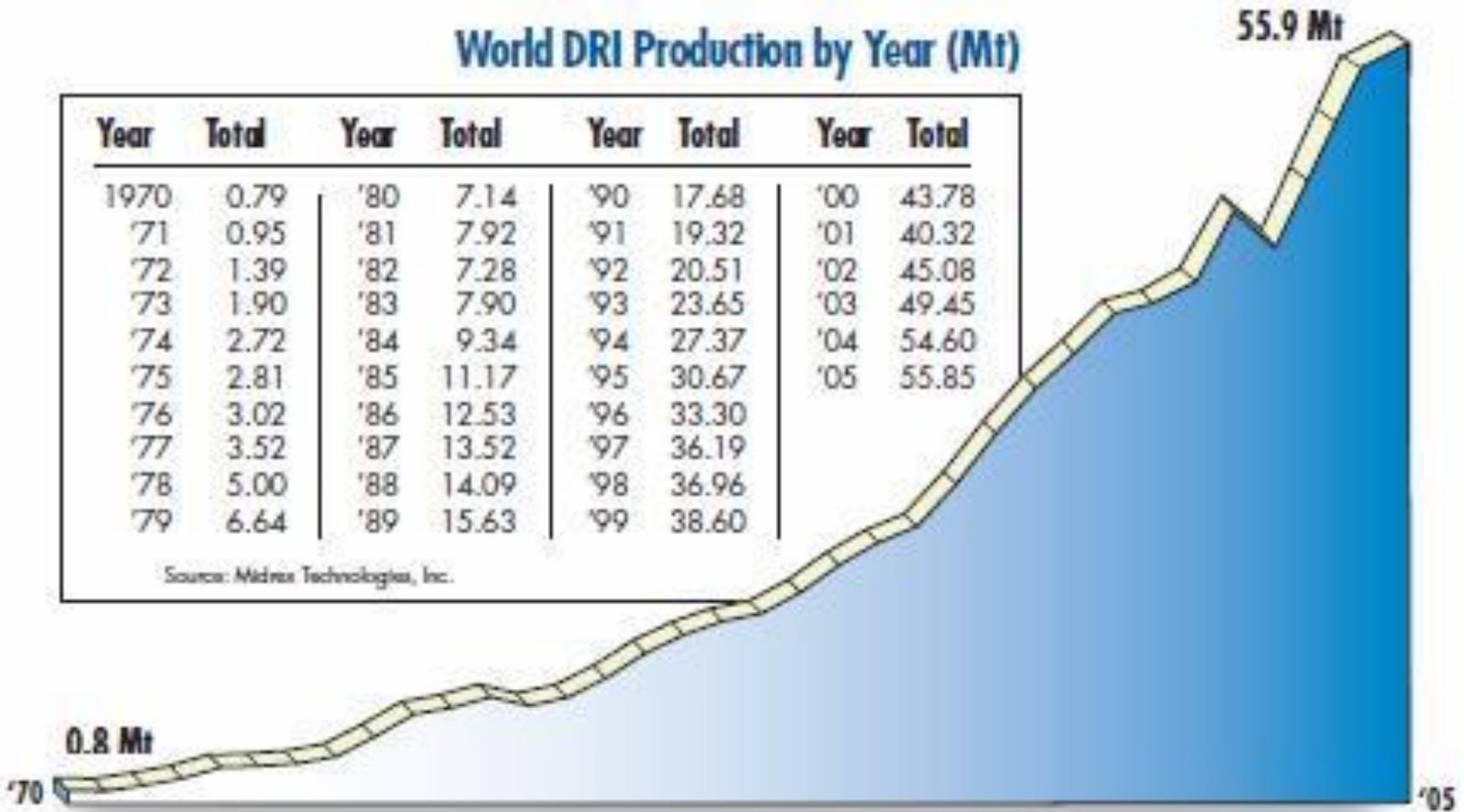
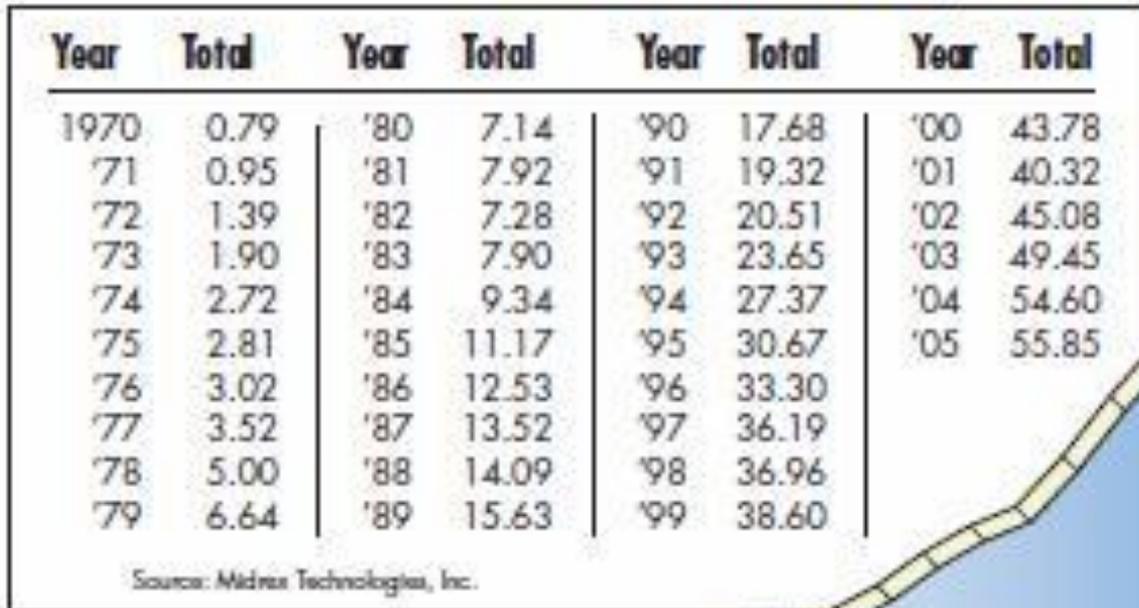
"The health-care costs that

Alberta would save millions in health-care costs by phasing out coal burning power plants, says a leading US expert on the health effects of air pollution from coal

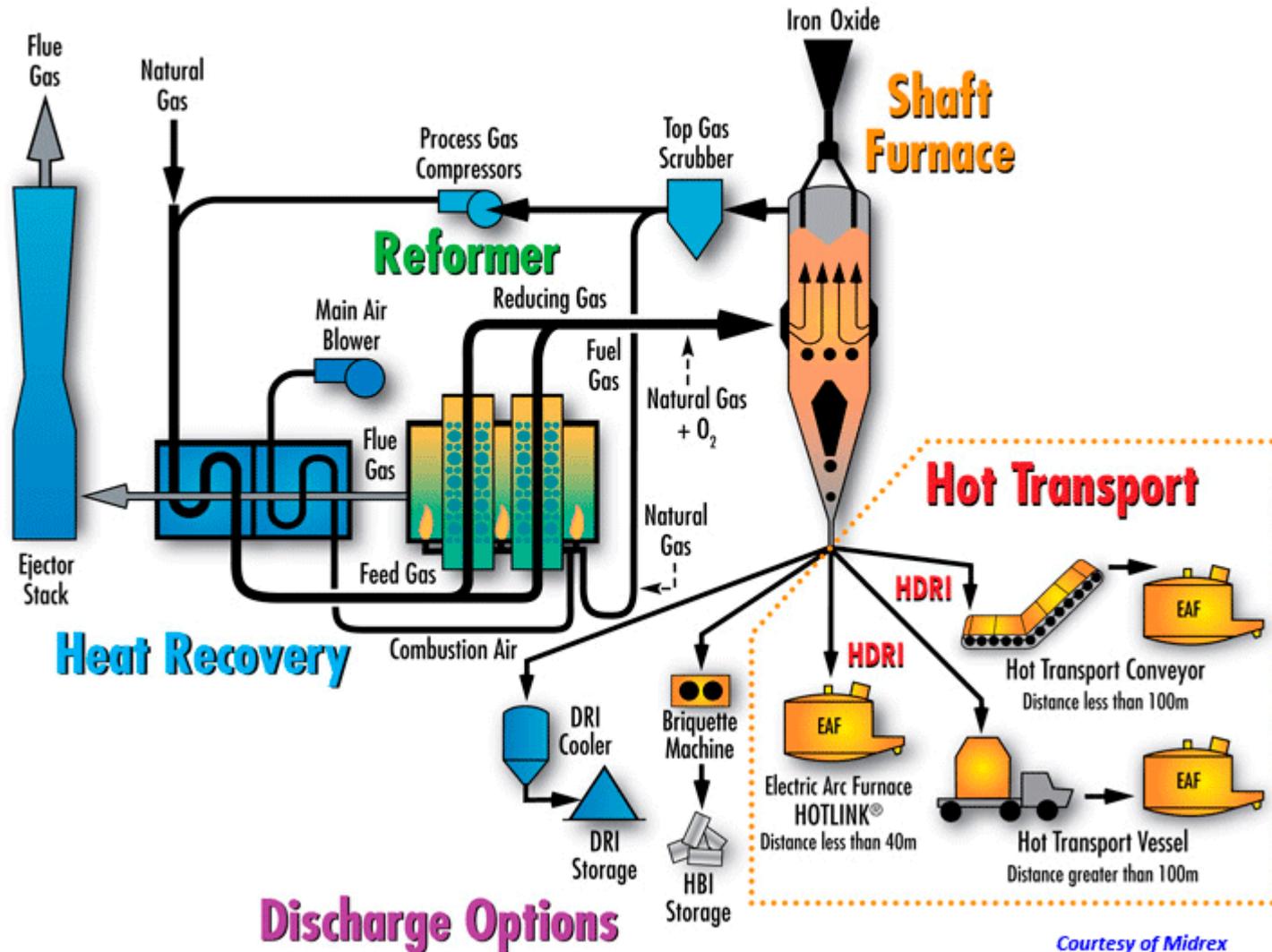


# The challenges: Metallurgical coke

World DRI Production by Year (Mt)

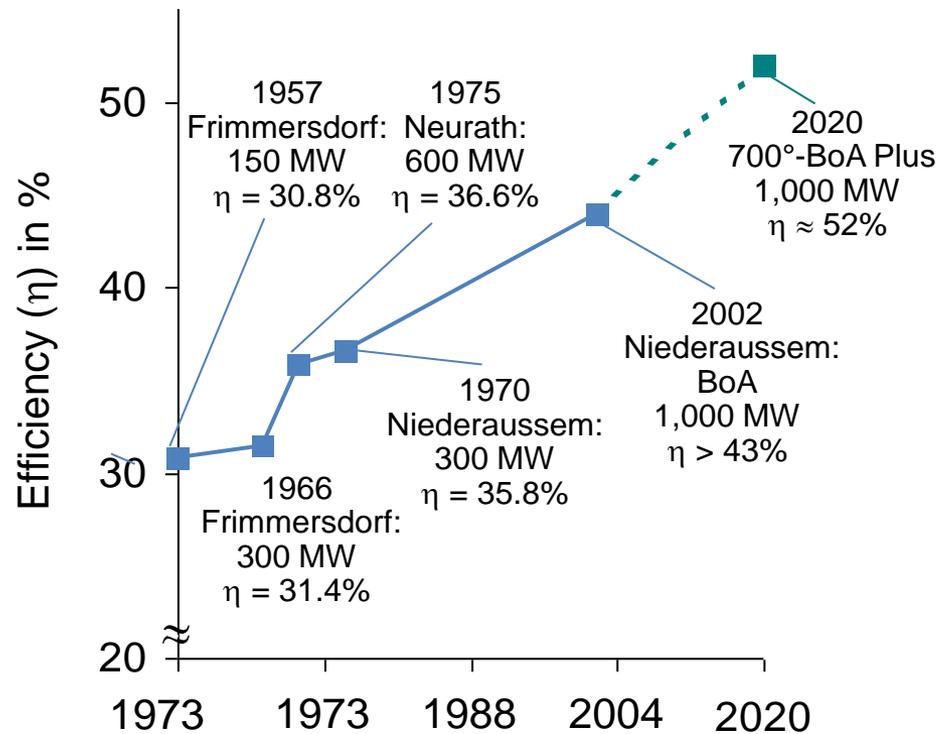


# The MIDREX<sup>®</sup> Process



# The transition

Continuously improving power station efficiency







## **Friedrich Bergius**

Geboren: 11.10.1884

Gestorben: 31.03.1949

Patent „Kohleverflüssigung“ 1913

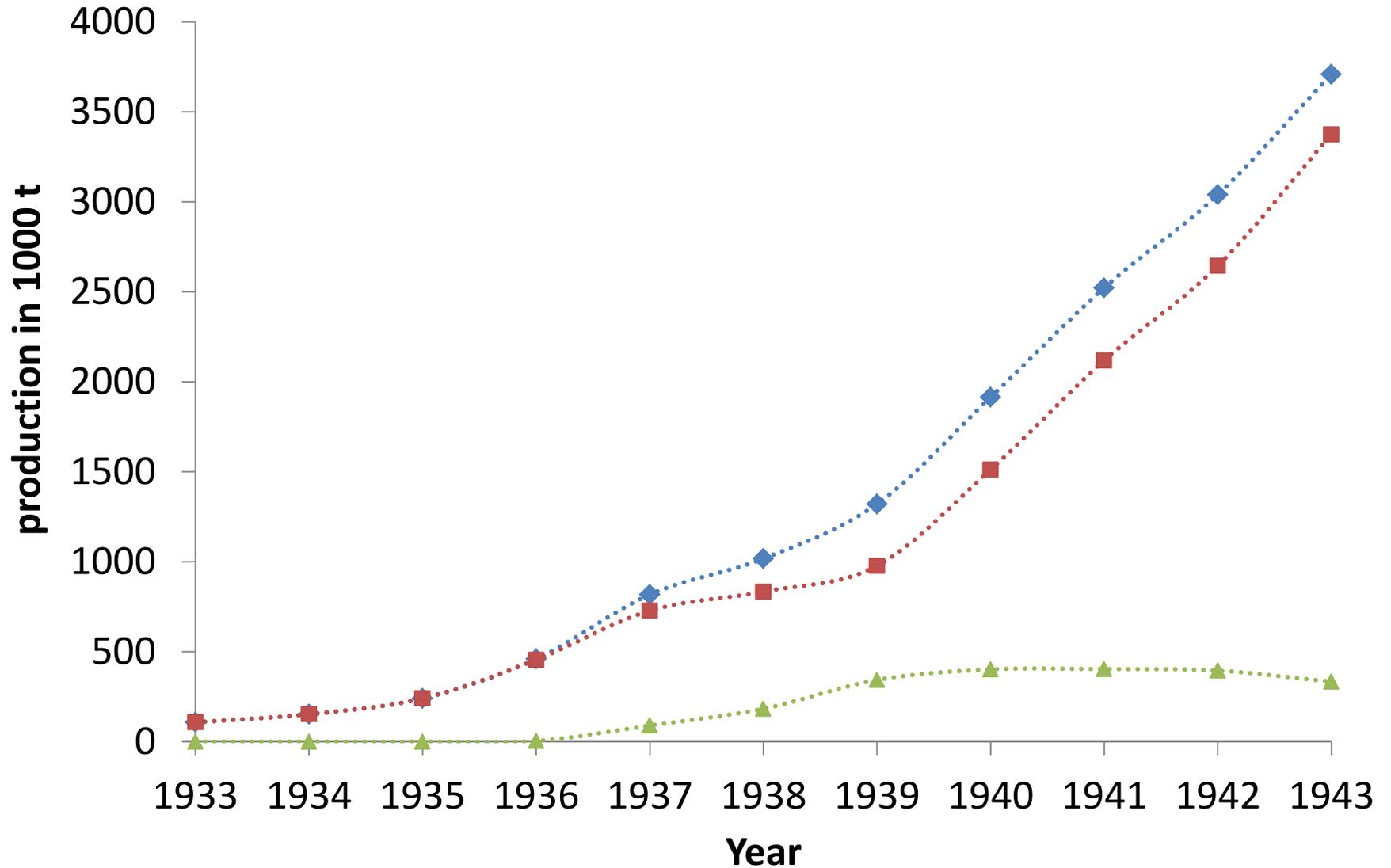


**Franz Joseph Emil Fischer**

19.03.1877 – 01.12.1947

FT-Synthese 1925 (Mülheim a. d. R.)

# Synfuel Production



# The transition

Continuously improving power station efficiency

Development of new products:

Activated coke based on subb. coal

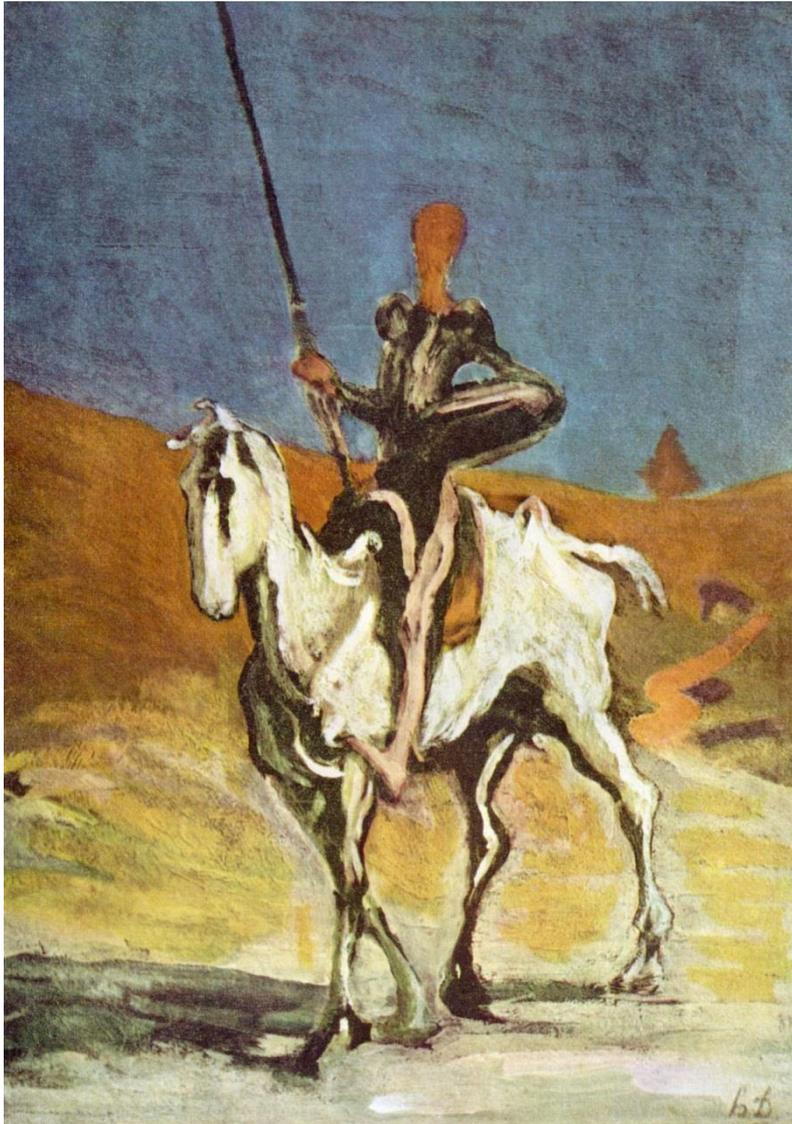
Adsorbent based on lignite

Form coke

Developments with nil or minor success

- Coal dust motor (Rudolf Pawlowski) around 1930 – 1940; demonstration for about 100 kW in Brno
- Coal fired gas turbine around 1990, preliminary studies
- Coal liquefaction: direct (Bergius) or indirect (Fischer)
  - IGCC
  - “Greening” of coal (with biomass)

???



## Don Quijote

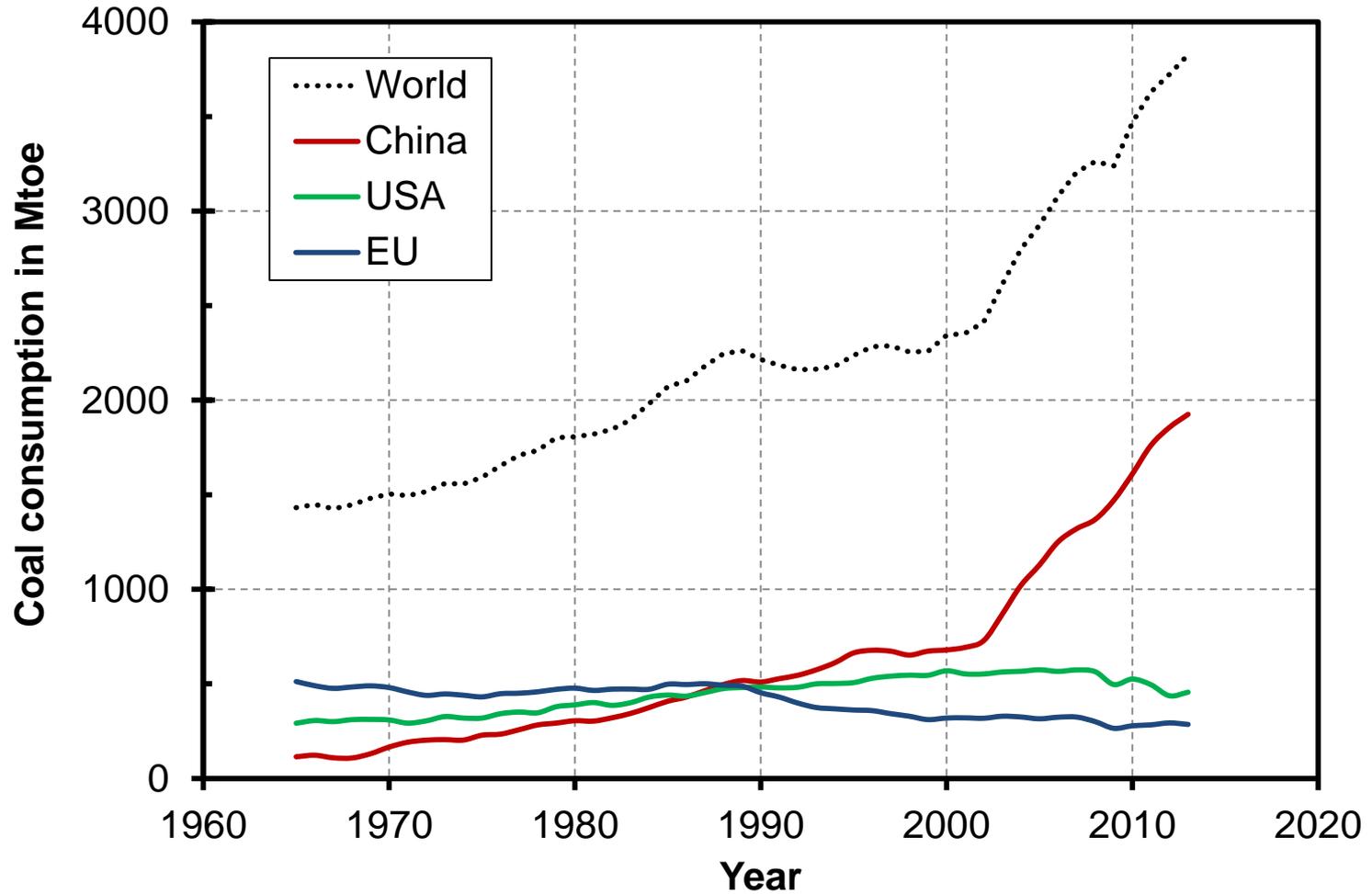
1605 (part 1 )/ 1615 (part 2)

immortal

# Future

Coal use has increased continuously for electric power and for coke

# World coal consumption



# Future

Coal use increased continuously for electric power and for coke

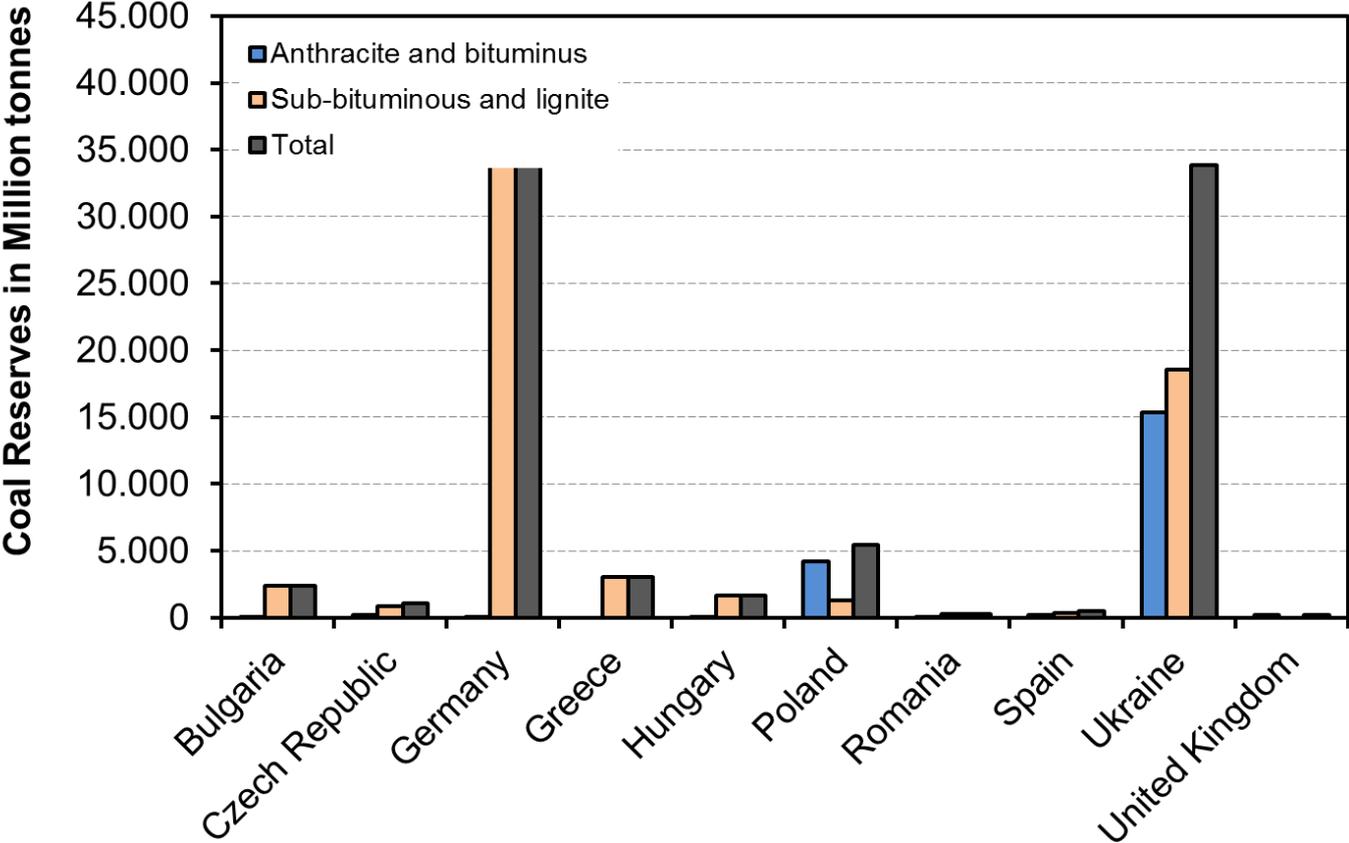
This is true on world scale but not nation-wise

Exemple: Germany (80 % renewables in 2050)

Denmark (0 % fossile in 2050)

Some European countries kept coal production/utilisation  
some not – independend from the reserves

# Coal: Proved Reserves at end 2013

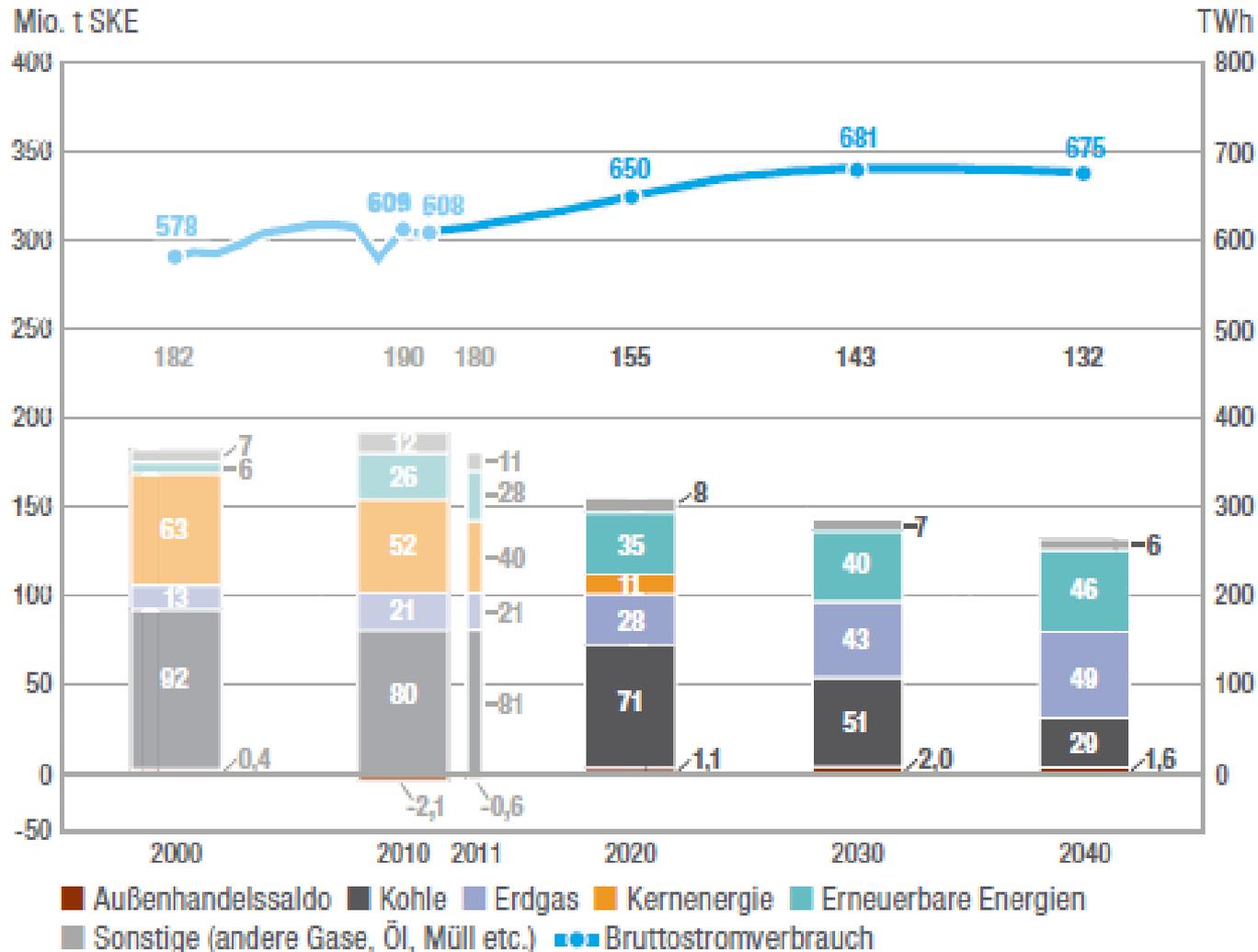


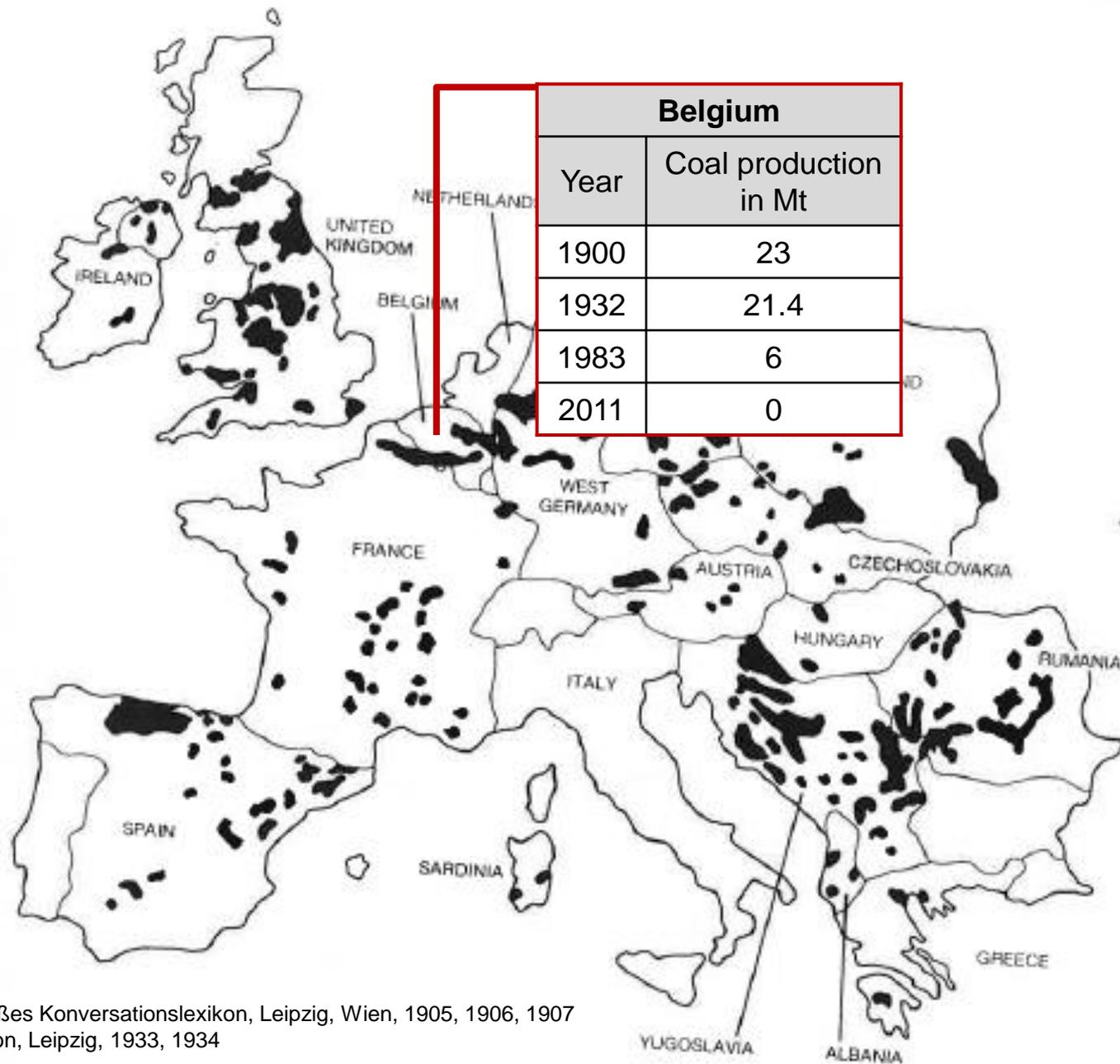
Source: BP Statistical Review of World Energy June 2014

# Future: EXXON's view on German power market

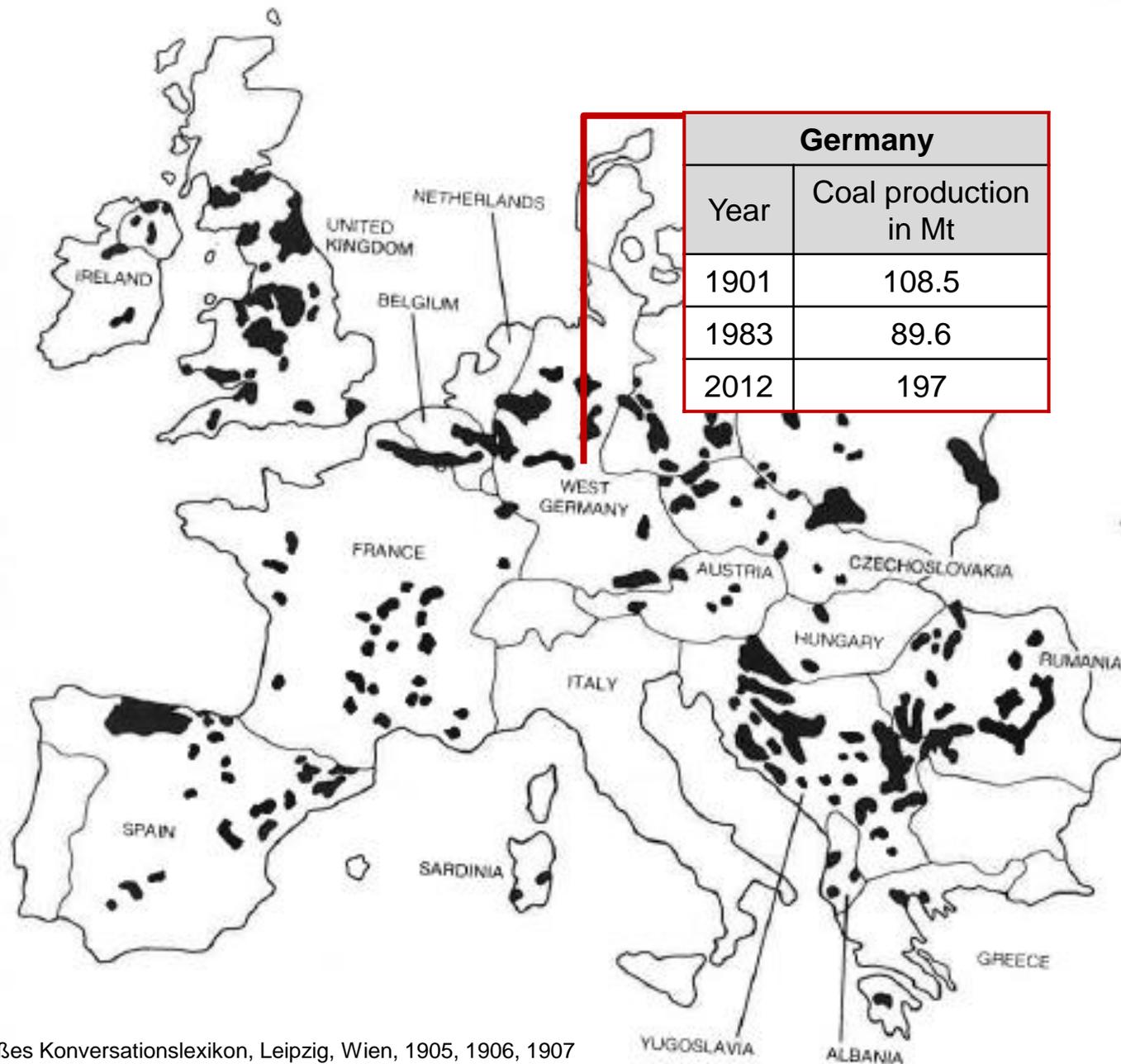
## Power production

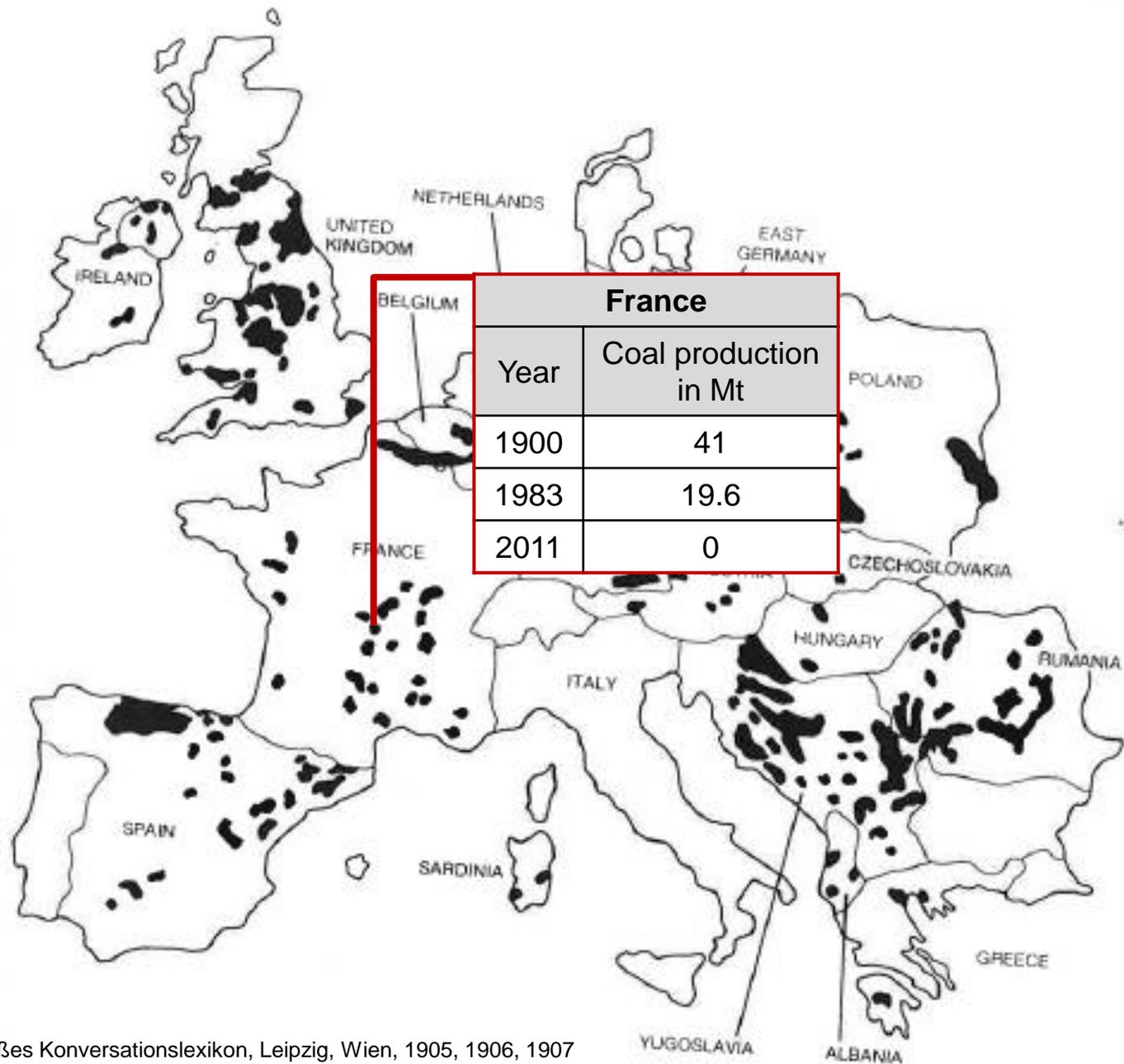
## Power consumption

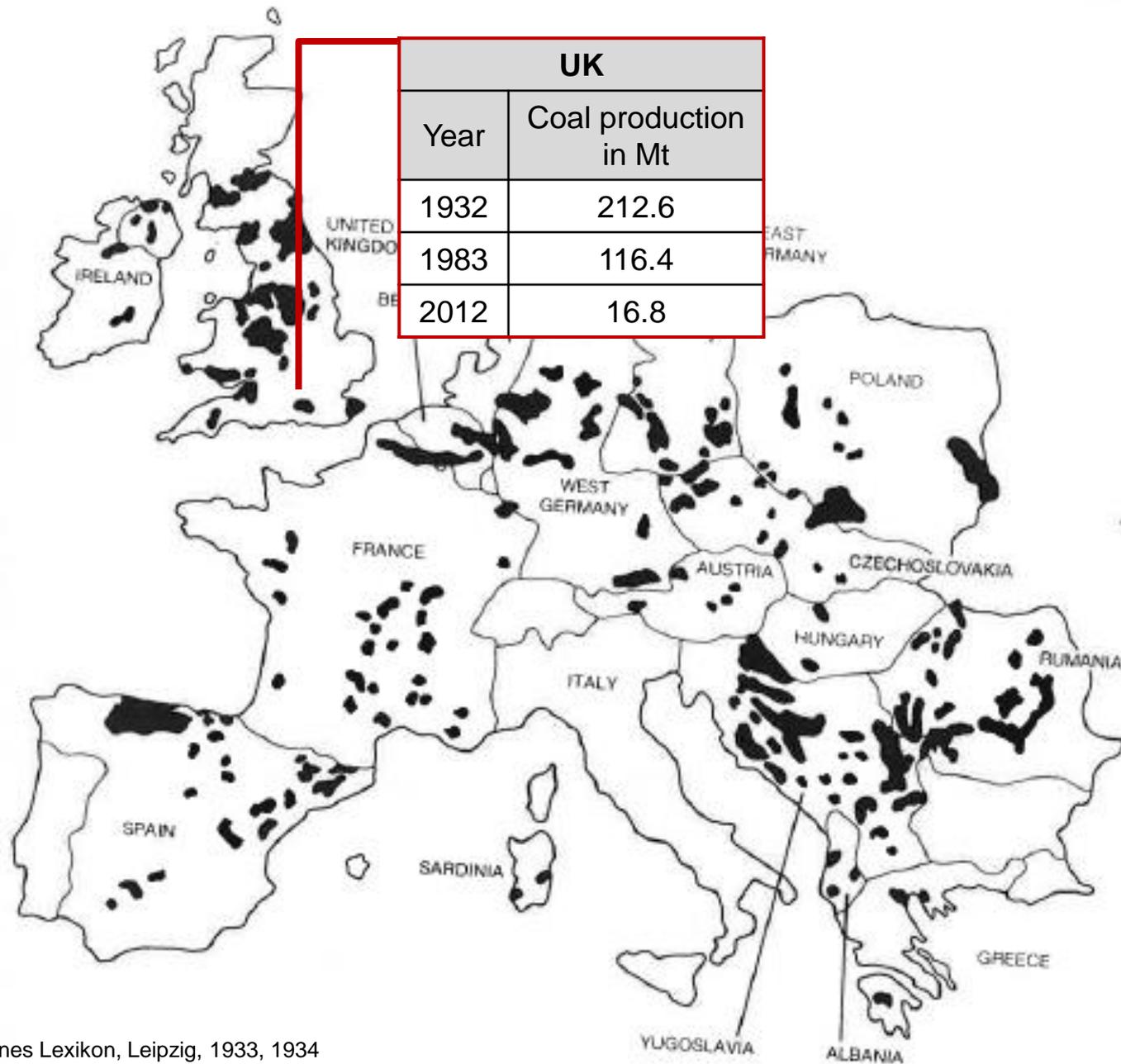




**Sources:** Meyers großes Konversationslexikon, Leipzig, Wien, 1905, 1906, 1907  
 Meyers kleines Lexikon, Leipzig, 1933, 1934  
 Euracoal  
 Eurostat 2013



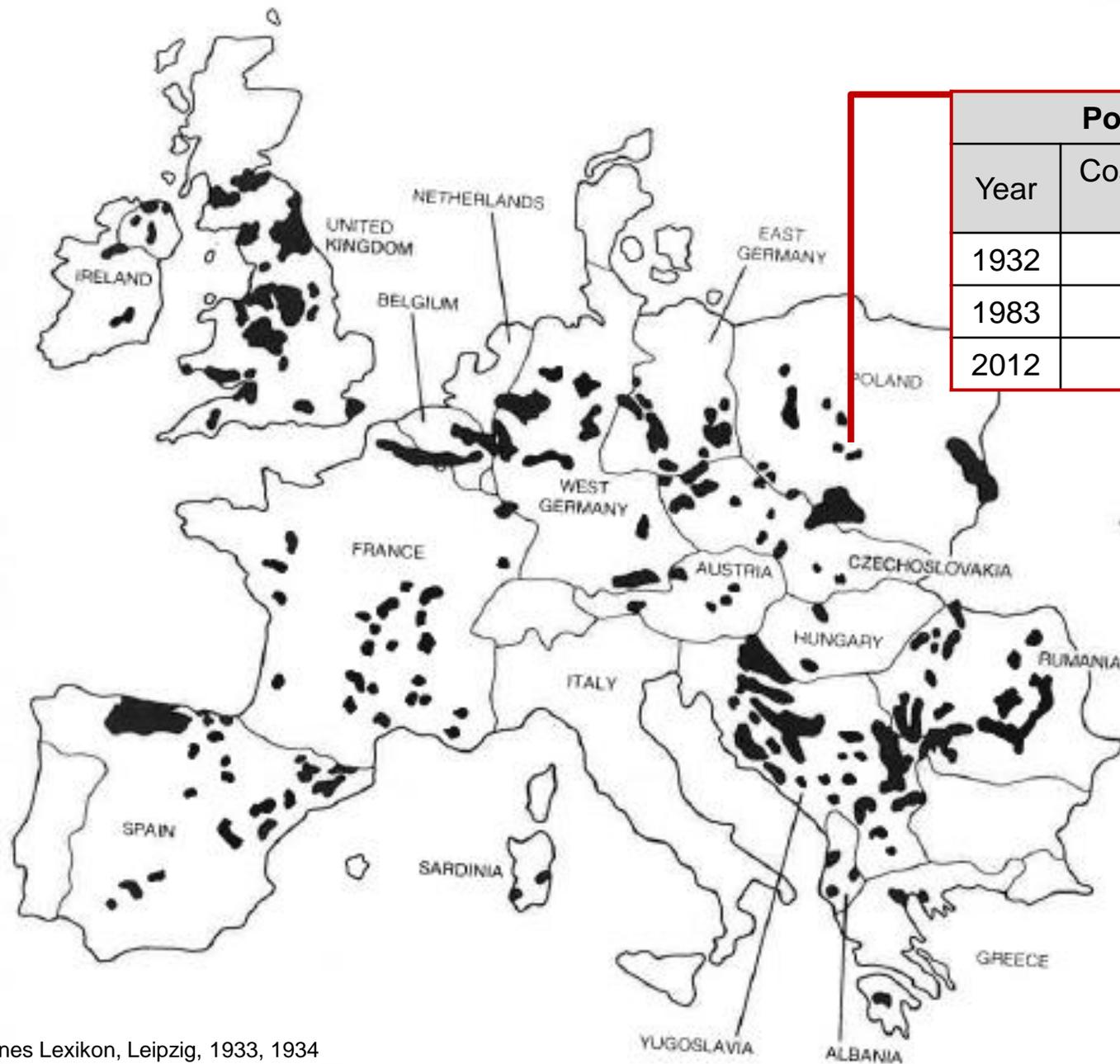




Sources: Meyers kleines Lexikon, Leipzig, 1933, 1934

Gatzka, W.: Coal, Economic aspects in Ullmanns Encyclopedia of Industrial Chemistry, Vol. A7, Weinheim 1986

BGR 2013

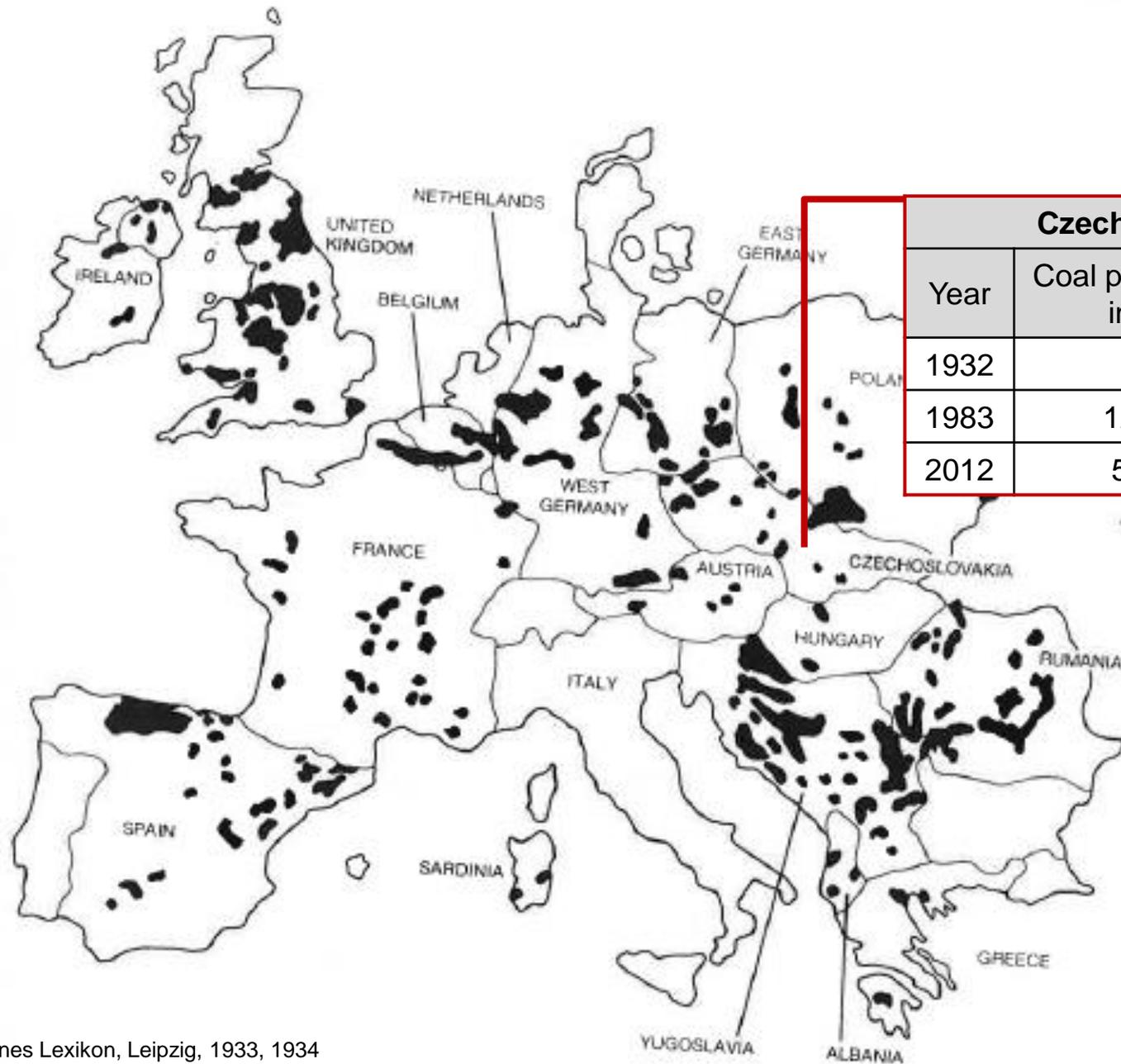


Poland	
Year	Coal production in Mt
1932	28.8
1983	233.5
2012	144

Sources: Meyers kleines Lexikon, Leipzig, 1933, 1934

Gatzka, W.: Coal, Economic aspects in Ullmanns Encyclopedia of Industrial Chemistry, Vol. A7, Weinheim 1986

IEA 2013



Czech.	
Year	Coal production in Mt
1932	11
1983	129.3
2012	54.5

Sources: Meyers kleines Lexikon, Leipzig, 1933, 1934

Gatzka, W.: Coal, Economic aspects in Ullmanns Encyclopedia of Industrial Chemistry, Vol. A7, Weinheim 1986

BGR 2013

# Future

What will facilitate the coal use in the remaining „coal countries“ was discussed during yesterday’s plenary

- Efficiency, efficiency, efficiency
- Flexibility with respect to a grid dominated by fluctuating production from wind and solar
- Management of gaseous pollutions
- Management of trace elements

*Ben Yamagata: „Rely on American ingenuity“*



**Thank you for your attention**

**and Manuel Götz and Siegfried Bajohr  
for their help**