Wirkungsgradsteigerung und CO2- Minderungstechnologien

DPG, Bad Honnef, 29.04.2005

SIEMENS

PGW, Lothar Balling

Siemens-Unternehmensstruktur Arbeitsgebiete und Bereiche

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Aufsichtsrat

Vorstand

Power
- **Power Generation (PG)**
- Power Transmission and Distribution (PTD)

Automation and Control
- Automation and Drives (A&D)
- Industrial Solutions and Services (I&S)
- Siemens Dematic (SD)
- Siemens Building Technologies (SBT)

Information and Communications
- Information and Communication Networks (ICN)
- Information and Communication Mobile (ICM)
- Siemens Business Services (SBS)

Transportation
- Transportation Systems (TS)
- Siemens VDO Automotive (SV)

Medical
- Medical Solutions (Med)

Lighting
- Osram

Finance and Real Estate
- Siemens Financial Services (SFS)
- Siemens Real Estate (SRE)

Regionale Einheiten: Zweigniederlassungen, Regionalgesellschaften, Repräsentanzen, Vertretungen

Power Generation - Organization

SIEMENS

Bereichsvorstand

Klaus Voges (Vorsitzender), Ralf Guntermann, Norbert König, Randy Zwirn

Fossil Power Generation Americas (A)
- ■ Michael Costa
- □ Harry Zike

Europe, Africa, Asia-Pacific (W)
- ■ Christian Urbanke
- □ Jörg Bürkle

Operating Plant Services (O)
- ■ Craig Weeks
- □ Michael Becker

Gas Turbines and Econopacs (G)
- ■ Klaus Riedle
- □ Günter Weis

Steam Turbines and Electrical Generators (S)
- □ Lutz Kahlbau/ Karl-Heinz Behrens

Instrumentation & Controls (L)
- ■ Erich Georg
- □ Thomas Böckel

Industrial Applications (I)
- ■ Frank Stieler
- □ Hannes Apitzsch

Stationary Fuel Cells (SFC)
- ■ Thomas Flower
- □ Adam Kupec

JV
Framatome ANP
seit 1.1.2001
(Siemens-Anteil 34 %)

JV
Voith Siemens Hydro
seit 1.4.2000
(Siemens-Anteil 35 %)

■ Gesamtleitung
□ Kfm. Leitung

Regionale Einheiten weltweit

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1. Market
2. Steam Power Plants
3. Combined Cycle Power Plants
4. Other CO2- reduction measures
5. General considerations

Power Plant Market Shares and Development

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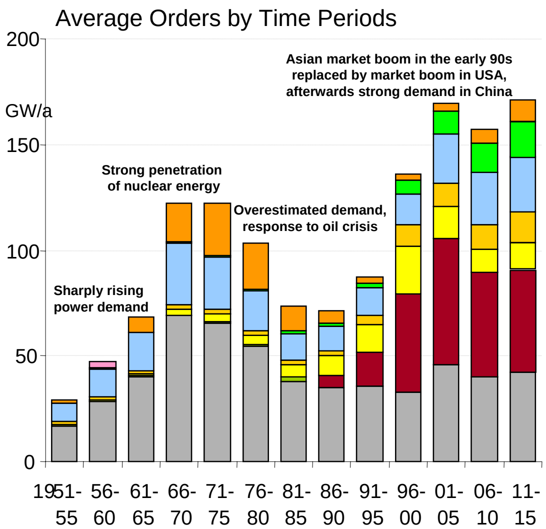
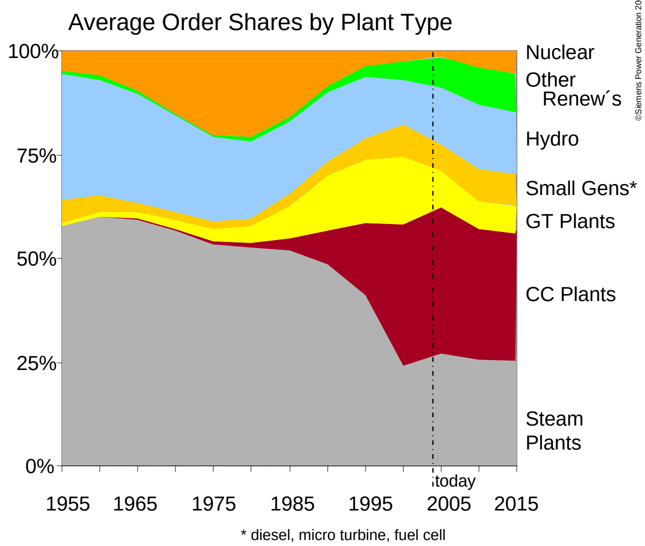
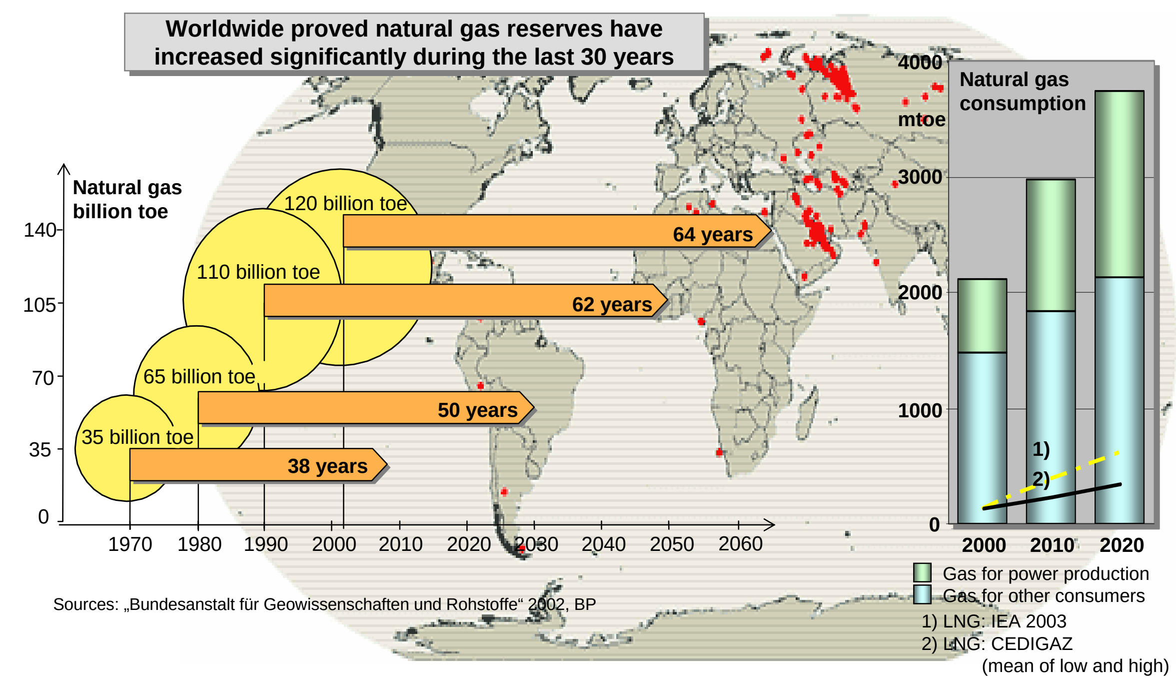
→ **Market for fossil-fueled plants will continue to prevail**
→ **Total market is having a wavelike and upward trend**





World Consumption of Natural Gas, Starting Penetration of LNG

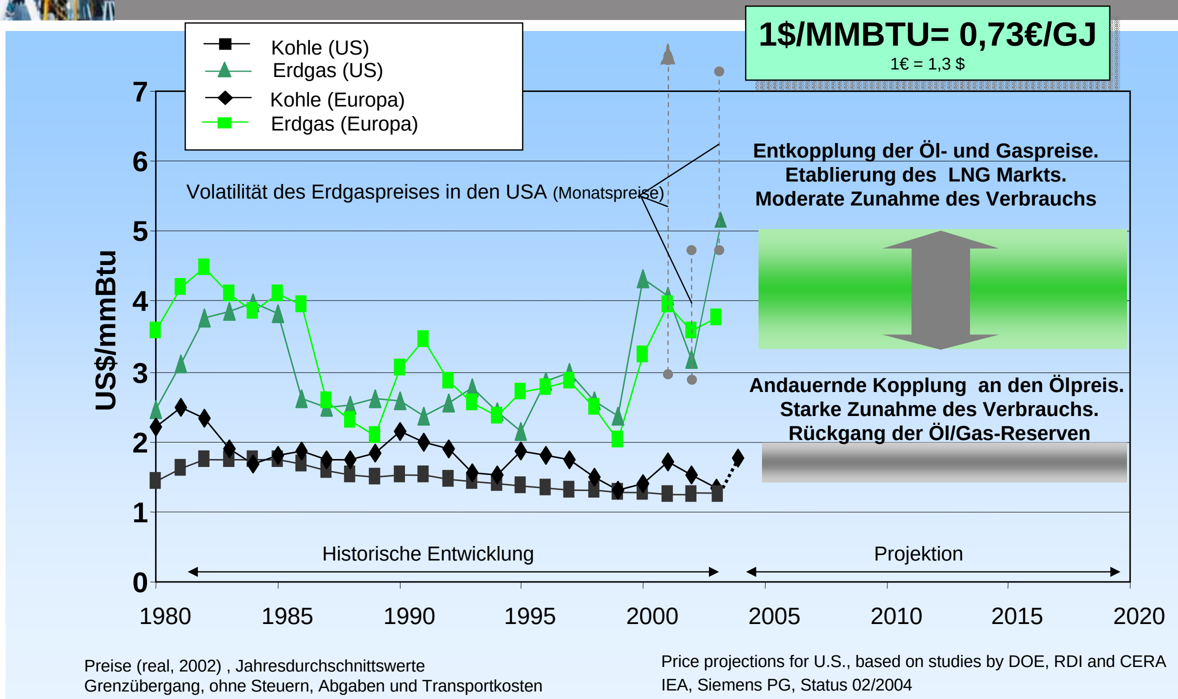
SIEMENS



Sources: „Bundesanstalt für Geowissenschaften und Rohstoffe" 2002, BP

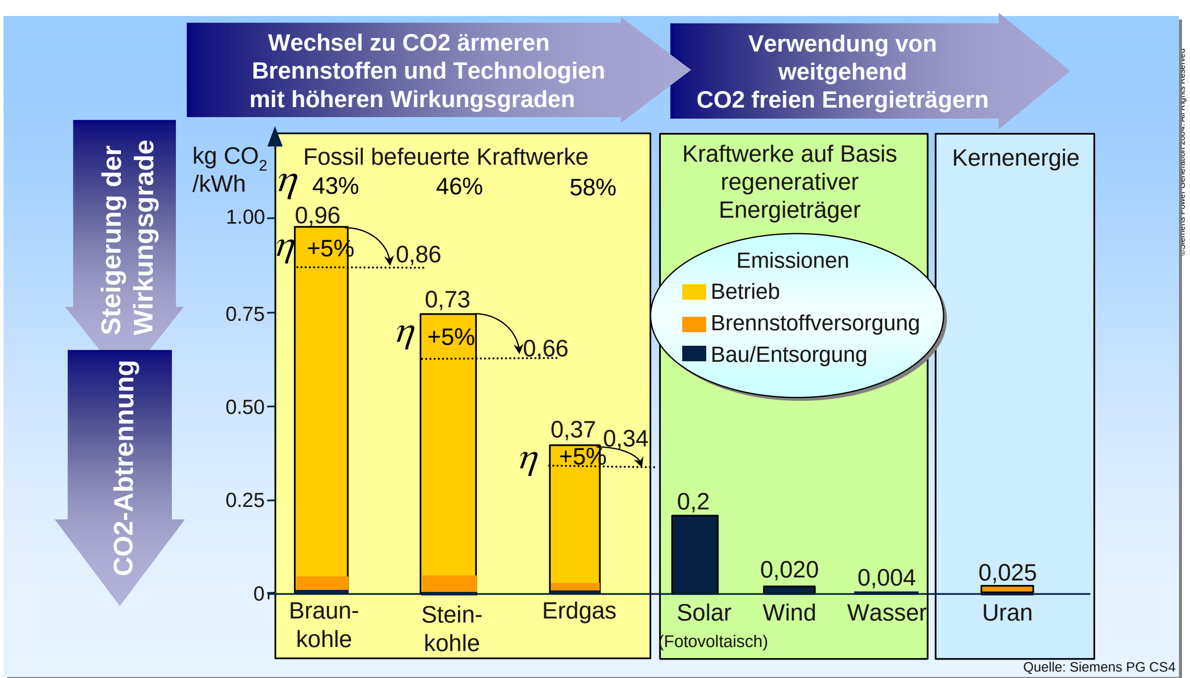
Historic and Projcted Coal and Gas Prices

SIEMENS



Möglichkeiten zur Einsparungen von CO2-Emissionen aus verschiedenen Kraftwerkstypen

SIEMENS



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1.Market

2.Steam Power Plants

3.Combined Cycle Power Plants

4.Other CO2- reduction measures

5.General considerations

Development of Efficiency / Fuel Consumption and Emissions in Coal-fired Power Plants

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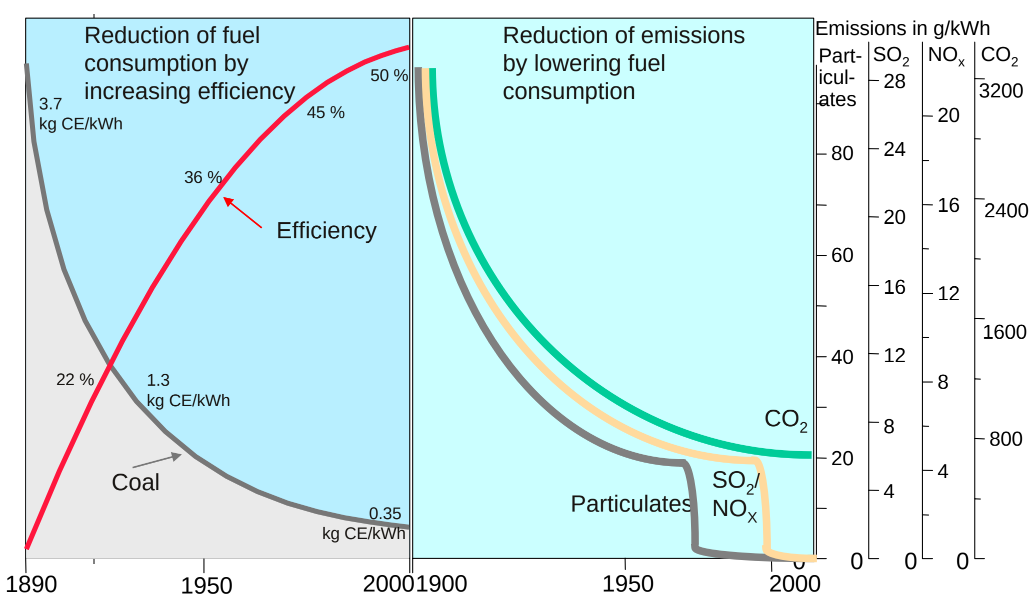
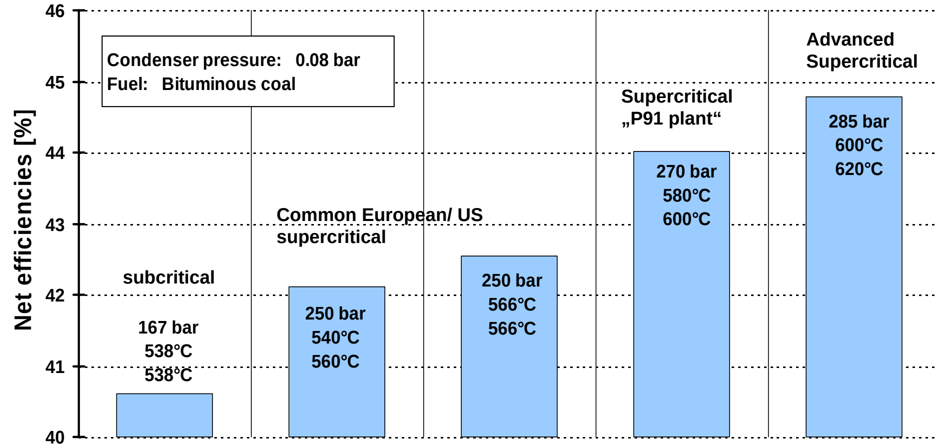


Typical steam parameters and corresponding net efficiencies of a 700 MW steam power plant

SIEMENS



1%-Point in efficiency:

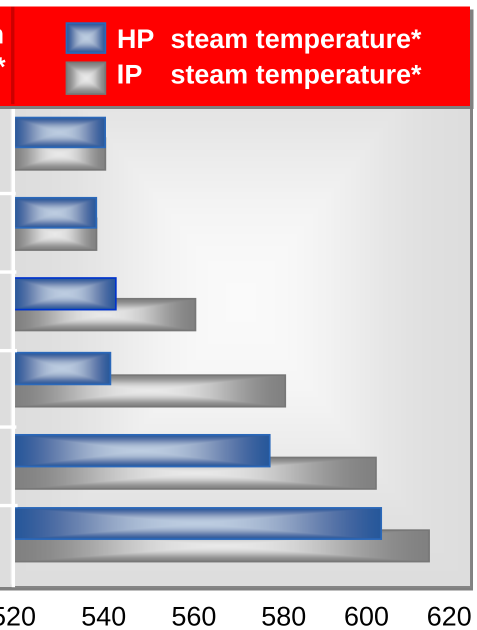
- reduces emissions by
  2.4 Mio t CO_2*, 2000 t NO_x*, 2000 t SO_2*, 500 t Particulates*
- reduces fuel costs by 2.4%

*based on:
- 1 x 700 MW
- 30 years operation
- 7000 full load hours/ a
- 50 mg/m³ @STP particulates
- 200 mg/m³ @STP NO_x and SO_2

Siemens' Steam Turbines - Long-Term Experience with Supercritical Steam Parameters

SIEMENS

Power plant Year of order	Output	HP steam pressure*
Emden 4, Germany 1969	420 MW	236 bar
Pleasants PS 1/2, USA 1972/1973	2x618 MW	242 bar
Schwarze Pumpe, Germany 1992	2x813 MW	252 bar
Boxberg Q/R, Germany 1994	2x915 MW	258 bar
Niederaußem, Germany 1995	1025 MW	265 bar
Isogo, Japan 1997	600 MW	251 bar



* @ turbine inlet

Steps of Development

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Konzeptstudie Referenzkraftwerk Nordrhein-Westfalen

VGB PowerTech

E_{max} - Kraftwerksinitiative

Concept study
Reference Power Plant North Rhine-Westphalia

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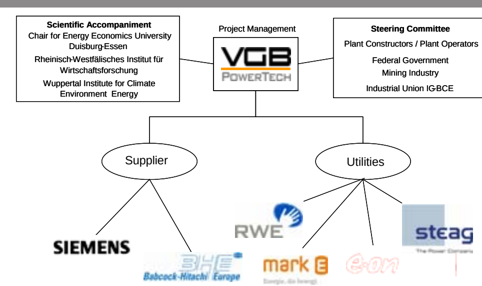
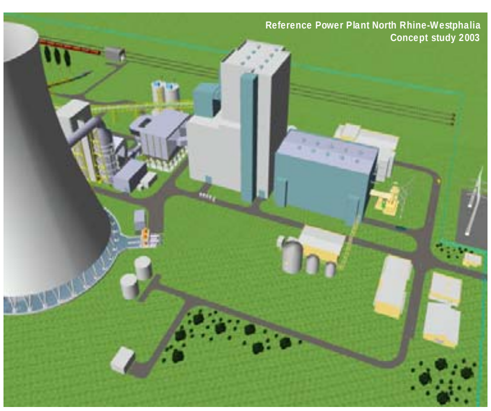
Objective:

Balancing efficiency, environmental friendliness and economics in the current European market





Reference Power Plant North Rhine-Westphalia*

- **600 MW gross** (R.O.); 50 Hz
- **285 bar/ 600°C/ 620°C** (@turbine inlet)
- **45.9% net** acc. DIN (@ 45 mbar)
- Turbine with single re-heat (SST5-6000 USC with L-2x16m²)
- Water / hydrogen cooled Generator
- Flue gas exhaust via cooling tower

* The study was supported by funds provided by the German Federal State of North Rhine-Westphalia (European Regional Development Fund – ERDF)

Materials for high-temperature Steam Power Plants components

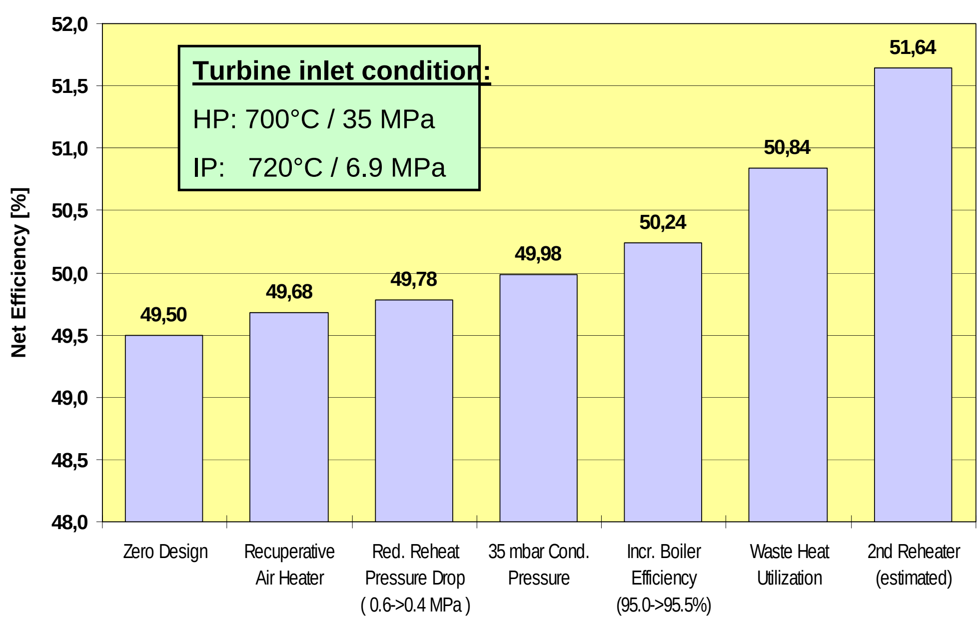
SIEMENS

HP pressure [bar] HP temperature [°C] IP temperature [°C]	250 540 560	250 566 566	270 580 600	300 600 620	300 - 350 650 - 720 650 - 720
Water wall panels	13 CrMo 44			HCM 2S 7 CrMoVTiB1010	HCM 12 T91, A617
Final SH / RH outlet sections	X20 CrMoV 121 T91, T92		Austenitic materials		Ni-base alloy
Main pipes, boiler headers	P91			NF616 / E911 P92	Ni-base alloy
Turbine parts, valve bodies	1-2 % Cr		9-12 % Cr		Ni-base alloy

today ◄ | ► Future

AD700 - Possible Achievable Net Efficiencies for Inland Site (4kPa condenser)

SIEMENS



AD700 – Components Exposed to High Temperature & Pressure

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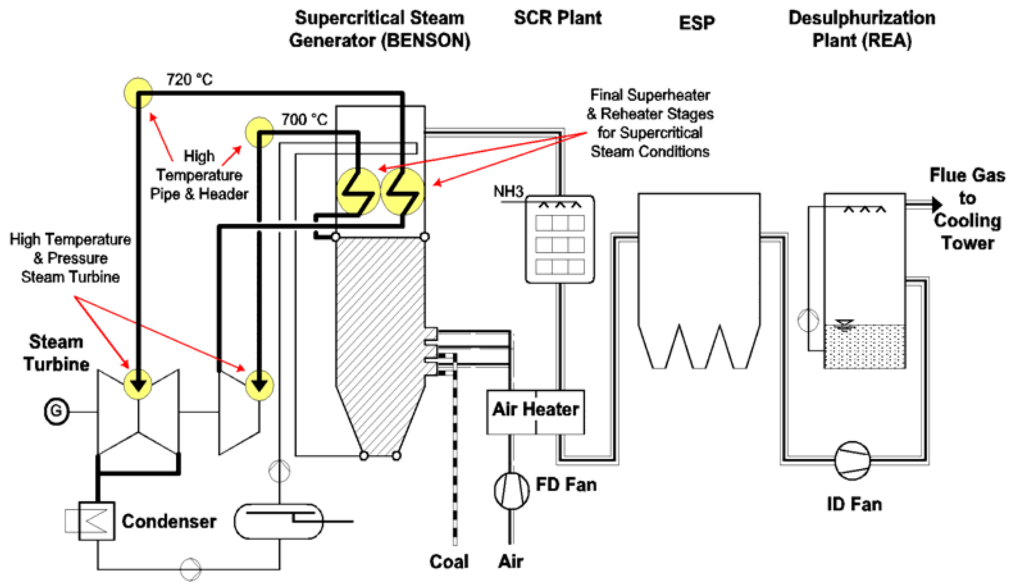

AD700 General Information

SIEMENS

Focus: Research and demonstration of a coal-fired power plant with ultra-supercritical steam parameters of 350bar / 700°C / 720°C to achieve a plant net efficiency > 50% (H_u basis) by using Ni-based tube and pipe alloys

Funding: European Community

Time Schedule: 17 years (project start: Jan 01, 1998)

Budget (1998-2005): ~ 32 Mio EUR

Contract Partner: ~40 European companies (suppliers and utilities)

Division of Work: Coordinated collaboration in the working areas „Process", „Boiler" and „Turbine"

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The Market Conditions Have Changed Dramatically in the Power Industry Over the Last 10 Years

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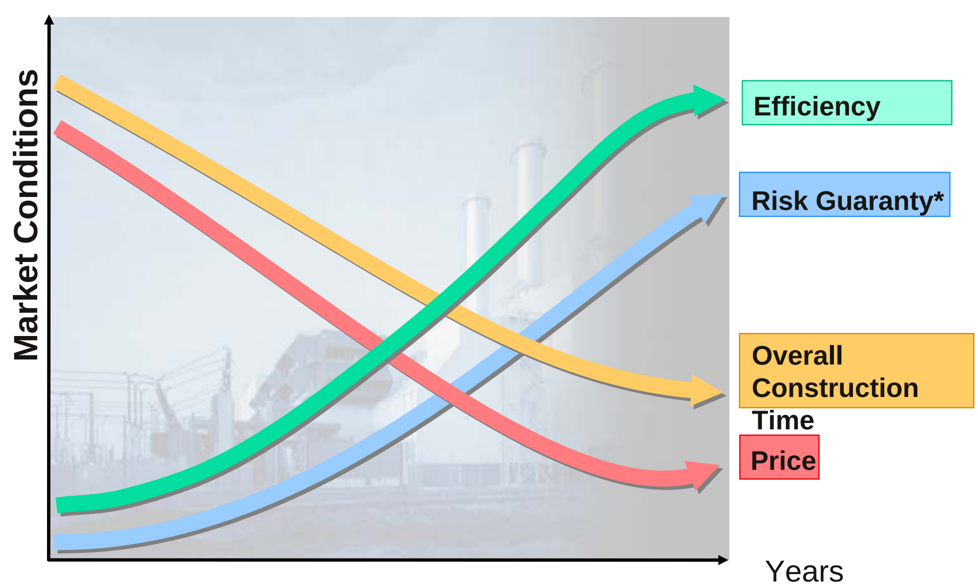

* technical warranties, delivery time

Development Steps of Combined Cycle Power Plants

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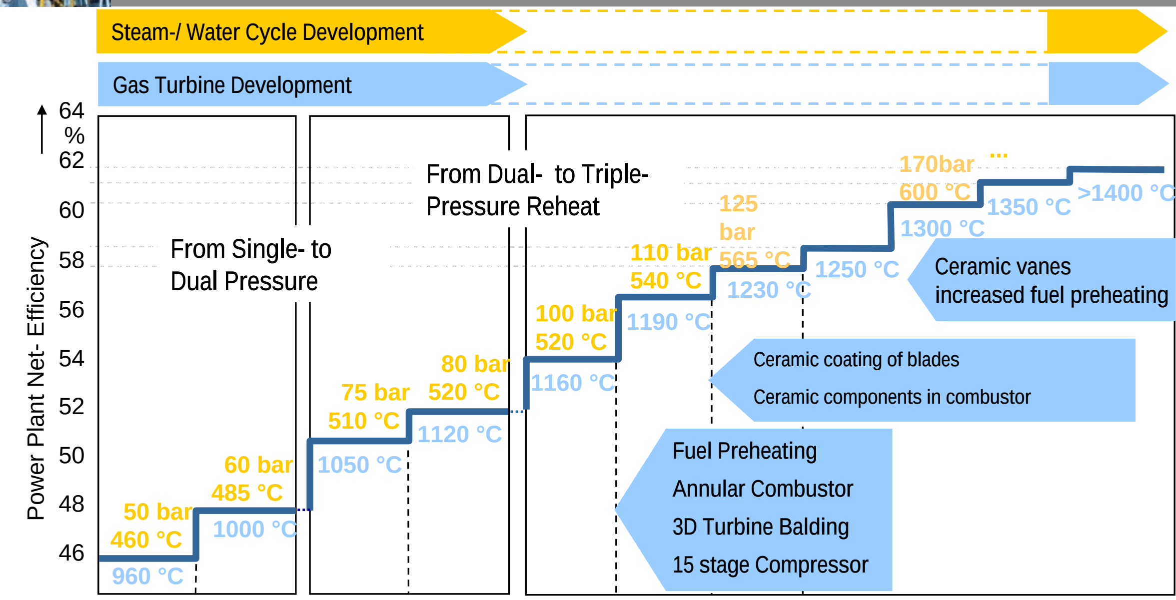
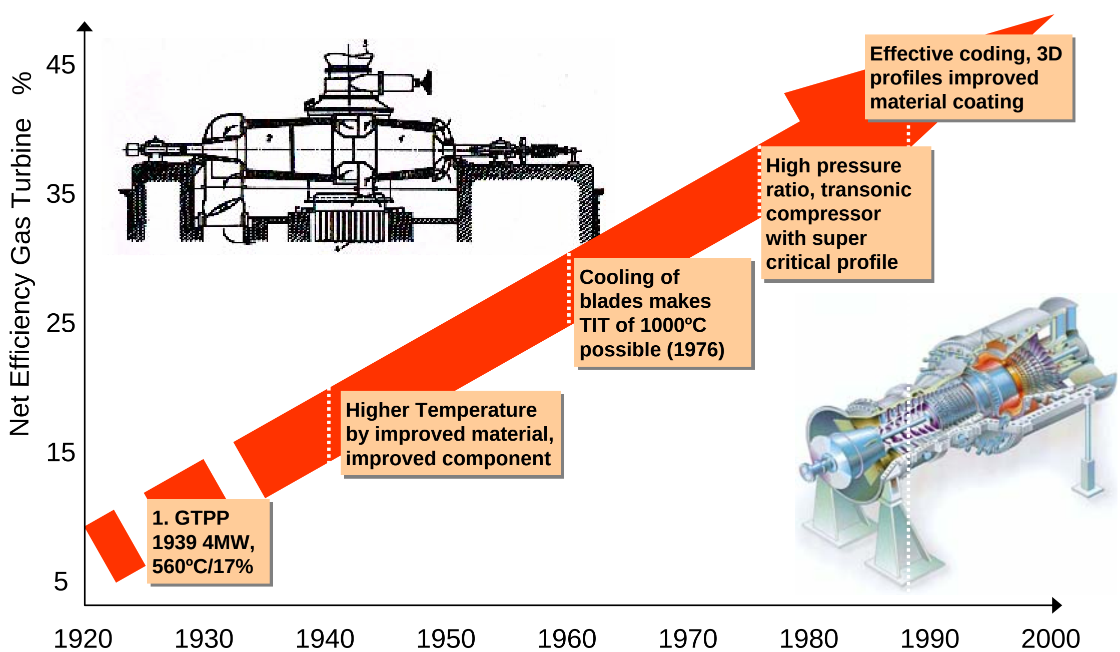


Fuel: Natural gas

Iso Conditions: 15 °C, 1013 mbar, 60 % humidity, 50mbar condenser pressure

Development of Gas Turbine Efficiency

SIEMENS



Firing Temperature

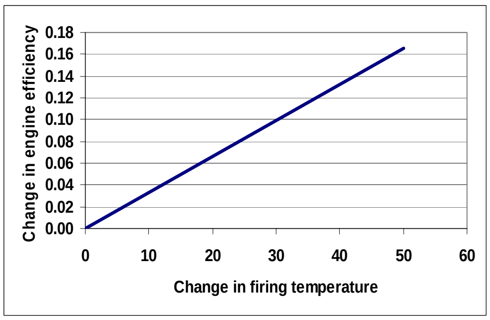
SIEMENS

Higher burner outlet temperatures through better alloys, coatings, cooling technologies and burners

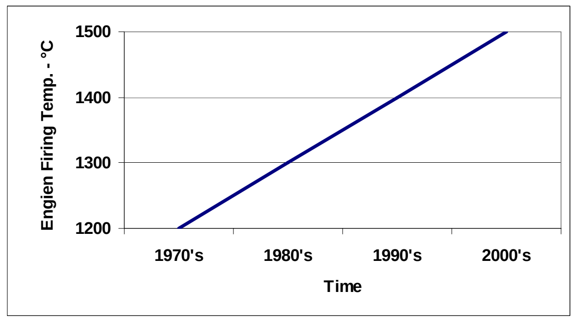
Results: higher firing temperature = higher output & efficiency

Hurdle: maintain life of hot gas path parts

Higher Firing temperature = Higher engine efficiency



Advanced technology makes higher firing temperature possible



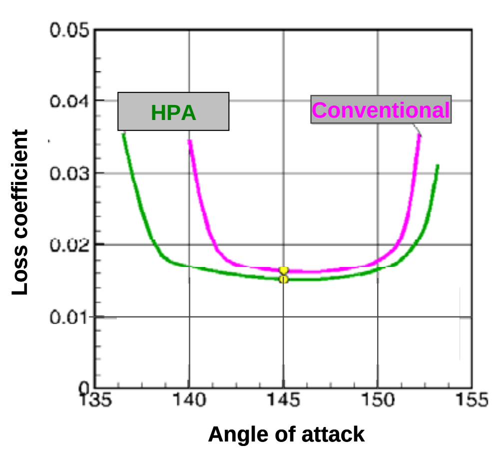
Aerodynamic Efficiency

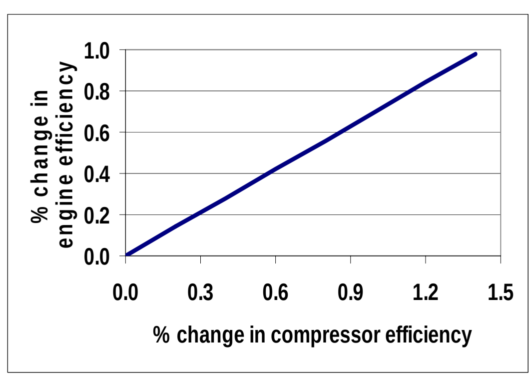
SIEMENS

Improve compressor aerodynamic efficiencies through enhanced analytical tools and testing

High Performance Airfoil (HPA)
profile specifically designed for industrial compressor application

Results: higher power output and efficiency



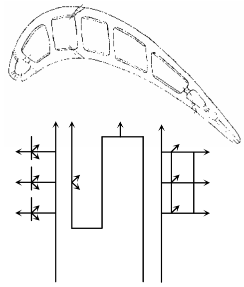


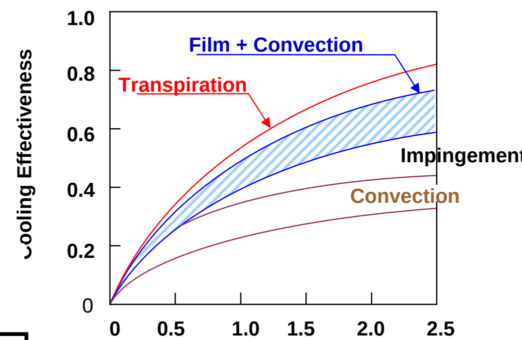
Air Cooling

SIEMENS

Advanced cooling technology makes higher burner outlet temperatures possible while maintaining parts service life

Blade Cooling Circuitry

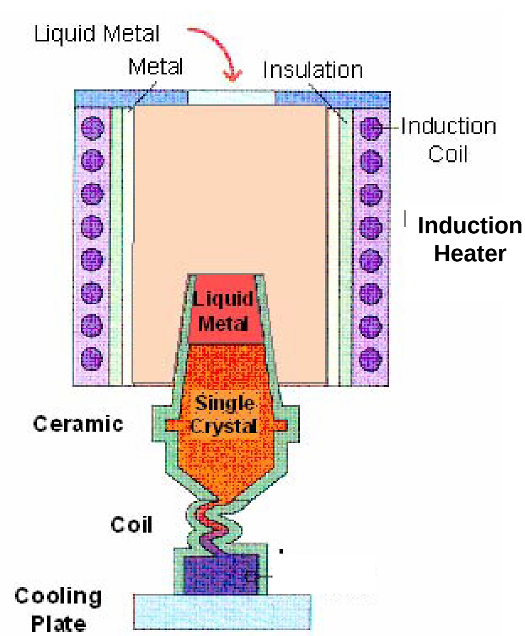




- **Leading edge impingement & shower head**
- **Heat transfer augmentation**
  - **Turbulators,**
  - **Pin Fin Array**
  - **Placement of tip cooling**
  - **Impingement**
  - **Rotational effects**

High Tech Material and Manufacturing Processes for Long Life Time of Turbine Blading

SIEMENS



First row
Single-Crystal Moving Blade

Use of Ceramics in Siemens Gas Turbines to reduce cooling air and increased performance

SIEMENS

Ceramics save cooling air for higher performance

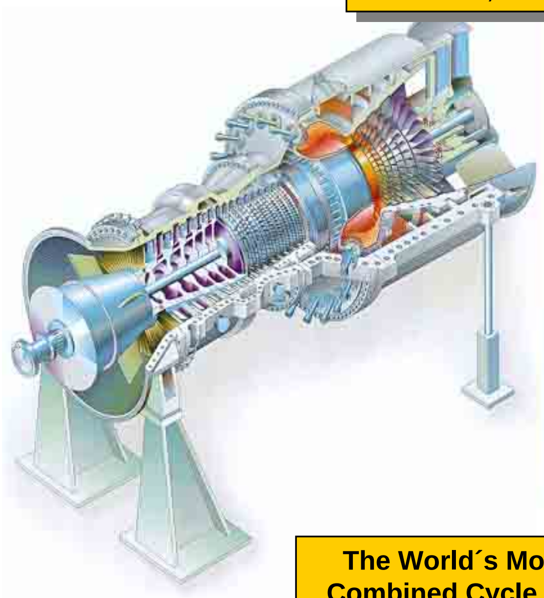
- **Combustor wall with ceramic tiles**
- **Thermal barrier coatings on vanes, blades and heat shields**

➡ **The extensive use of advanced ceramic parts and materials is a major reason for the world class performance of Siemens gas turbines**

GUD 1.V94.3A Mainz Wiesbaden/Germany

SIEMENS

398 MW, 58.4 %*



The World´s Most Efficient Combined Cycle Power Plant

* ISO- cond./certified

- **Donau Kurier**

28.04.2005

Neues Kraftwerk in Irsching

Ingolstadt (DK) Der Energieriese E.ON plant offenbar eine Großinvestition am Standort Irsching bei Ingolstadt. Nach Informationen unserer Zeitung will der Konzern dort bis spätestens 2009 ein großes Gaskraftwerk mit 800 Megawatt Leistung errichten. Branchenkreise sprechen von einem Investitionsvolumen von mehreren 100 Mio. Euro und etwa 35 Jobs für den Anlagenbetrieb.

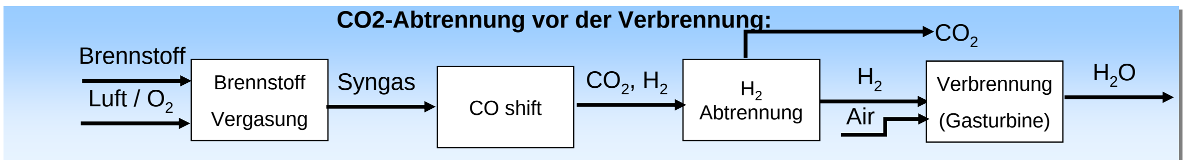
Zusätzlich will der Siemens-Konzern in Irsching seine neueste Gasturbinengeneration testen und dazu bis 2007 eine 350-Megawatt-Anlage installieren. Insgesamt werden damit weit über 500 Millionen Euro am Standort investiert. Die Planungen sind offenbar so weit gediehen, dass darüber bereits Kommunen und die Regierung von Oberbayern informiert worden sind. Allerdings erklärte ein Sprecher der E.ON Energie AG auf Anfrage, die endgültigen Investitionsentscheidungen und die Zustimmung der Unternehmensgremien stünden noch aus. Im 1969 in Betrieb gegangenen Kraftwerk ist derzeit nur noch Block 3 zur Reserve am Netz.

SEITE 7

1. Market
2. Steam Power Plants
3. Combined Cycle Power Plants
4. **Other CO2- reduction measures**
5. General considerations

Power plant concepts with CO2 capture can be classified in 3 types:

1. **Separation of the carbon before combustion (*pre-combustion*), i.e. decarbonisation of the fuel fed to a gas turbine at elevated pressure; applicable only for GT/combined cycle concepts.**



Power plant concepts with CO2 capture can be classified in 3 types:

2. **Separation of the carbon after combustion (*post-combustion*), i.e. CO_2 removal from the flue gas coming from a boiler or a gas turbine at atmospheric conditions; fuel independent application for GT/combined cycle as well as for conventional steam power plants.**

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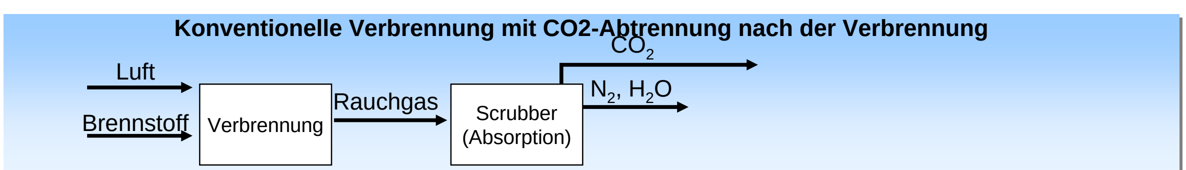
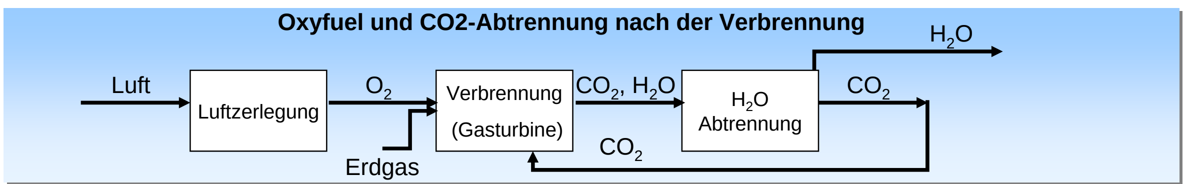
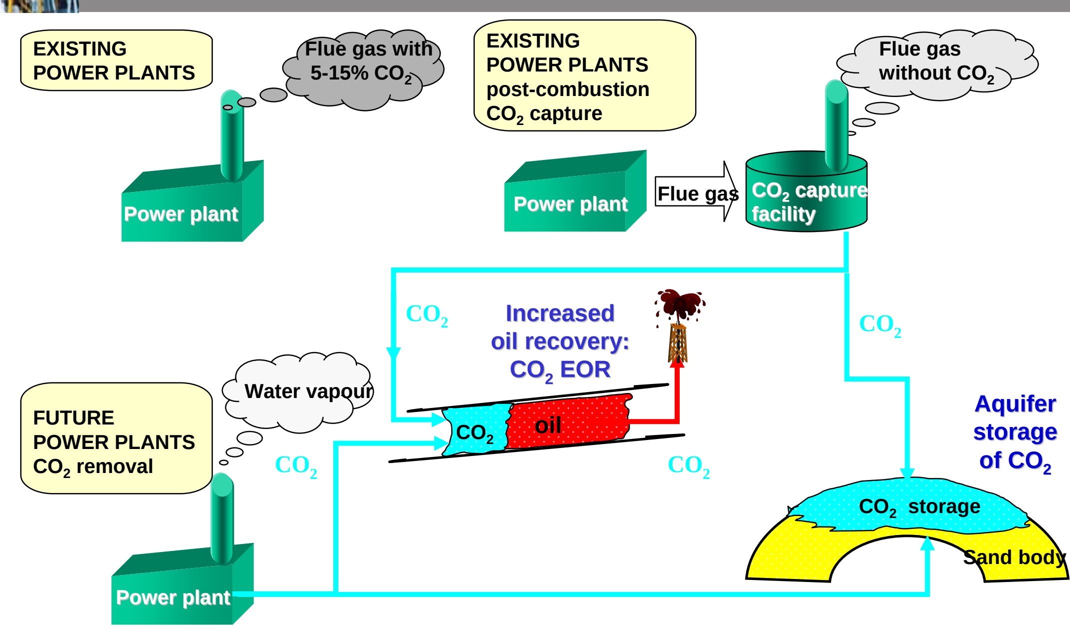


Power plant concepts with CO2 capture can be classified in 3 types:

3. ***Oxyfuel*** **processes represent post-combustion strategies but are separately classified because the CO_2 can be isolated by "simply" condensing the flue gas steam content which is only practicable when nitrogen disappears and air is replaced by *oxygen-blown combustion*.**





Source: EU Meeting on CO_2 Capture and Storage, Brussels, 10 December, 2003

Ongoing CO2 free Power Plant Development with major Siemens Participation

SIEMENS

IGCC (Coal) - Operational feeedback and target costs; 2008

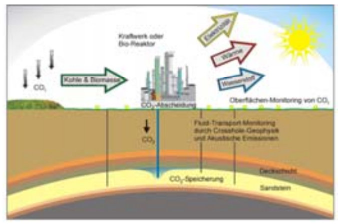
SPP- post combustion CO2 sequestration; 2007

COORIVA
Feasibility Study of IGCC with CO2 capture

CASTOR
Post Combustion CO2 Sequestration

IGCC (NG/ Coal) – Burner development for 4000F; 2008

ENCAP
Hydrogen combustion, IGCC and advanced pre- combustion concepts,
Oxycoal and membrane



CES cycle
Oxyfuel based cycle consisting of stationary rocket engine and advanced turbine

Sargas Concept
pressurised post combustion concept

OXYCOAL AC
Integrated BMWA project of RWTH Aachen to develop a membrane based oxyfuel concept

ADECOS
BMWA project of TU Dresden and THH Hamburg to develop an advanced oxyfuel concept

SPP – with O2 generation via refrigeration tech.; 2008

SPP – with O2 generation via membrane tech.; 2007

Development Plan ZEIGCC

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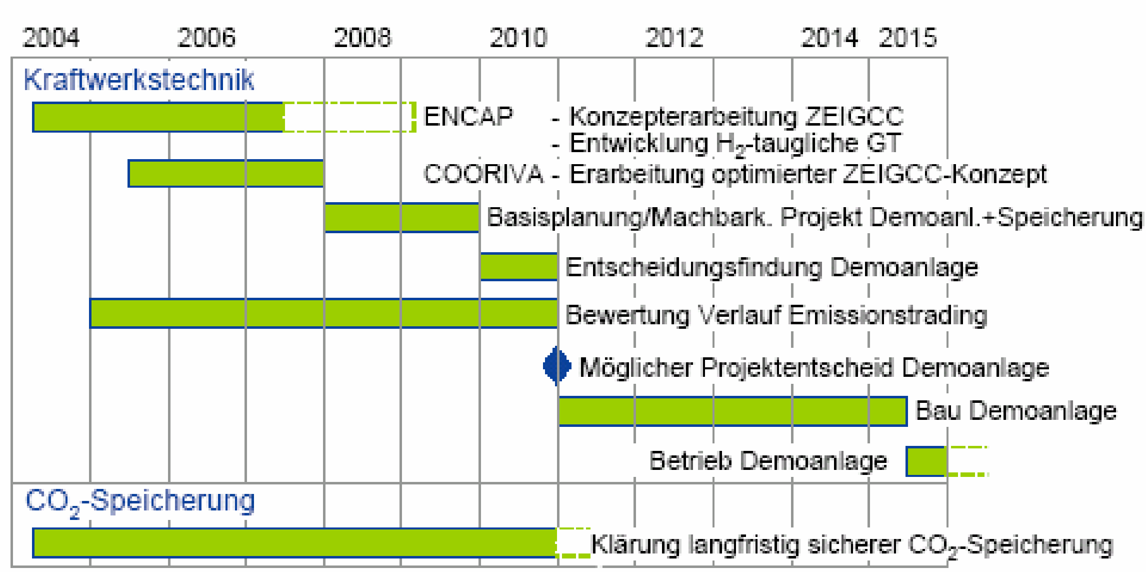

Efficiency Losses and CO_2 Avoidance Costs For Different Concepts

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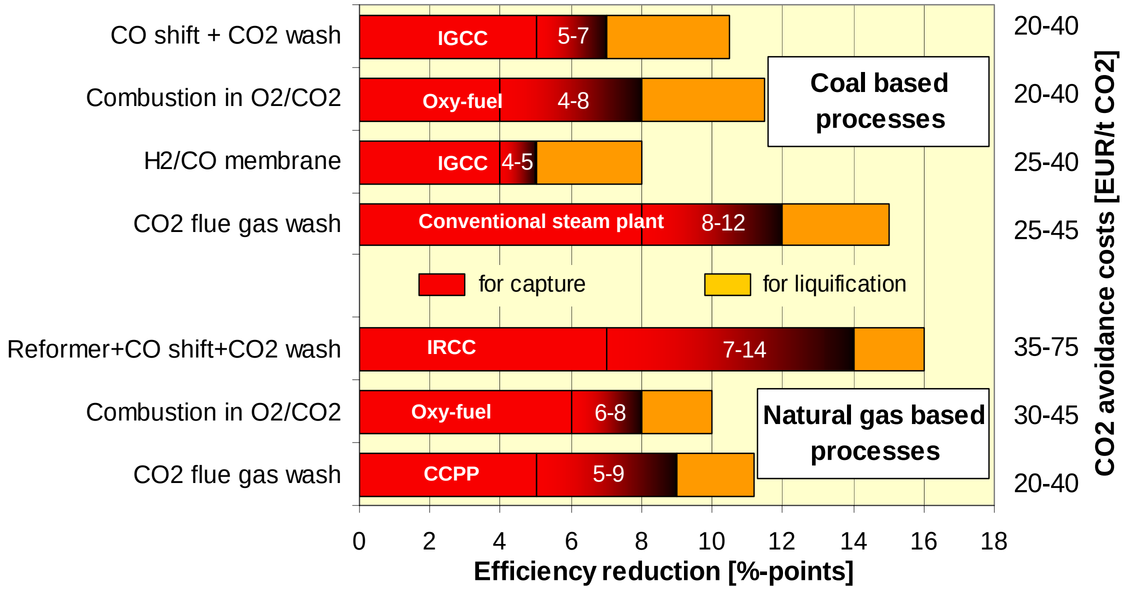

Source: Göttlicher, G., State of the Art of CO_2-Capture Technologies for Power Plants. POWER-GEN Europe 2003, 06-08 May 2003, Düsseldorf/Germany

CO_2 Prices can be understood as increased Fuel Prices

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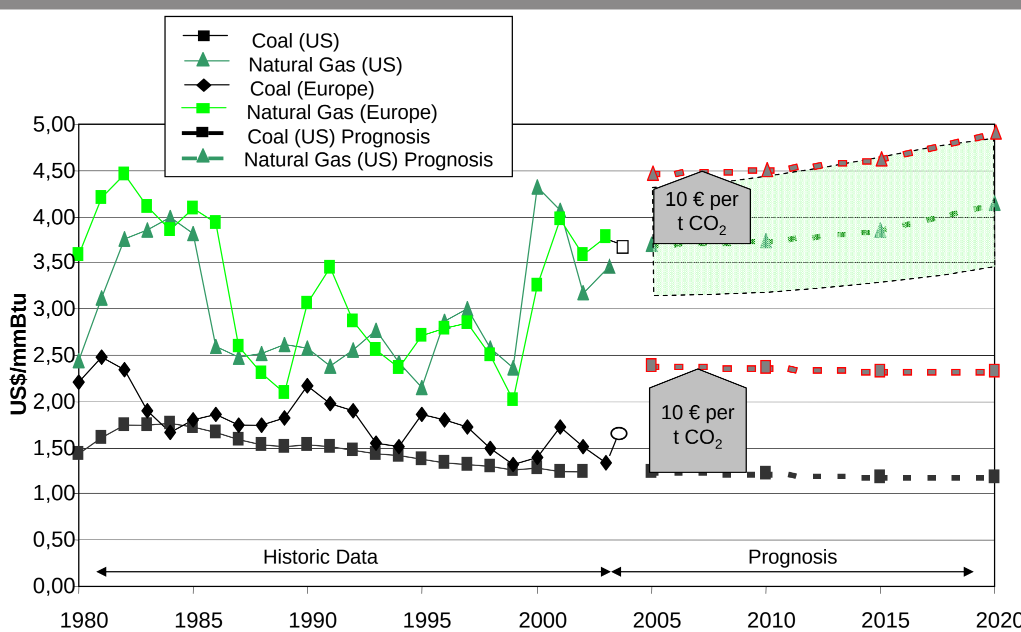

EU: prices free of border, not including taxes and transport costs to plant site

Price prognosis for U.S., based on studies by DOE, RDI and CERA
Status 04/2004

Conceivable Time Frame for Implementation of CO_2-Free Power Plant Concepts

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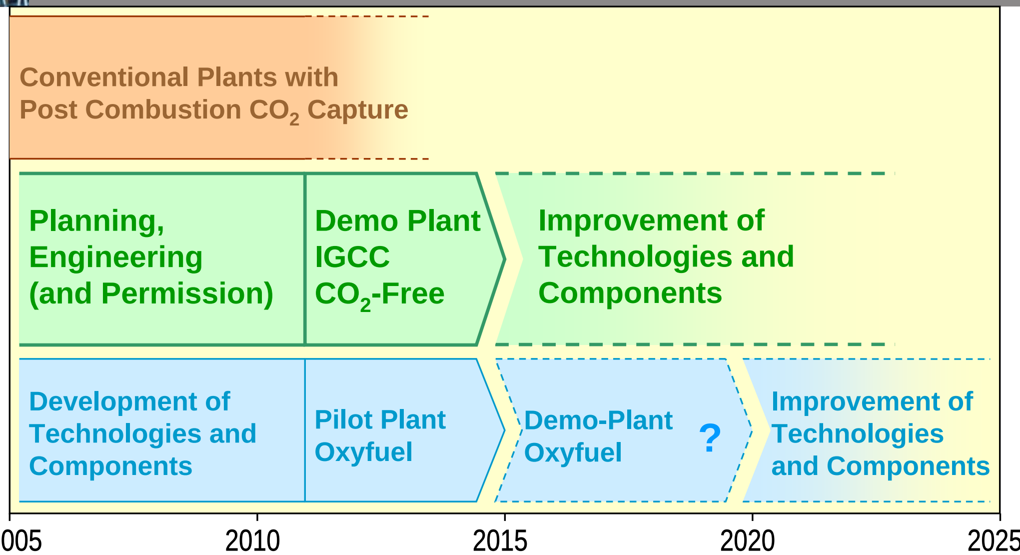

Demo-Plants Are the Precondition for a New Technology to Enter the Market

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1. Market
2. Steam Power Plants
3. Combined Cycle Power Plants
4. Other CO2- reduction measures
5. **General considerations**

Base Load Units are being reduced in liberalized markets, flexibility is a success factor

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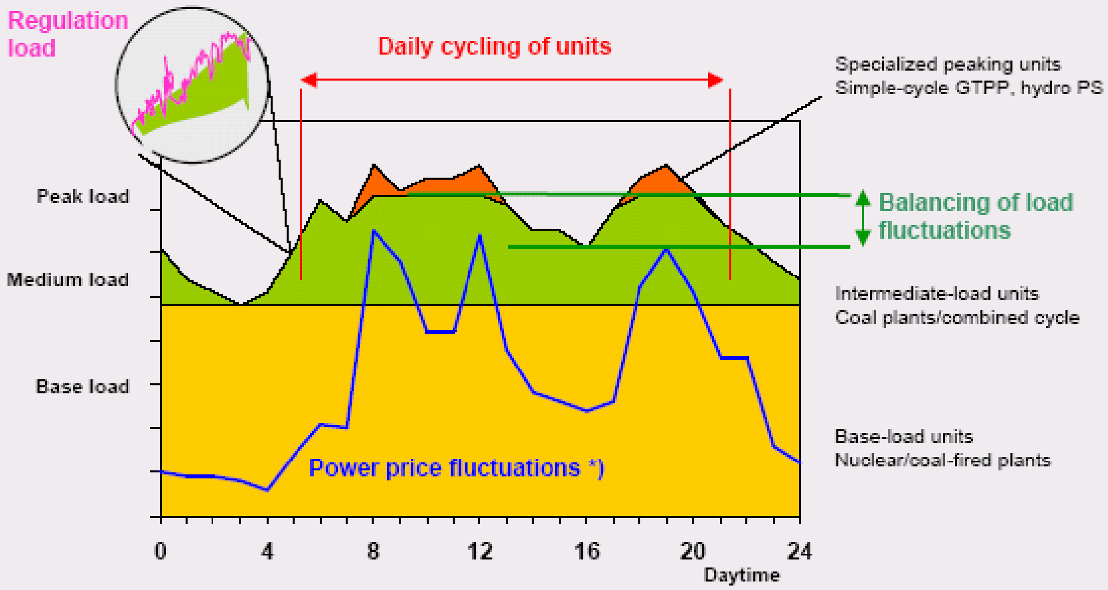

*) While for base-load power typically 2.5 ct/kWh are paid, peak load and regulation load are refunded with up to 11 ct/kWh

Short Pay Back time is another major factor for the decision on CCPPs and STPPs

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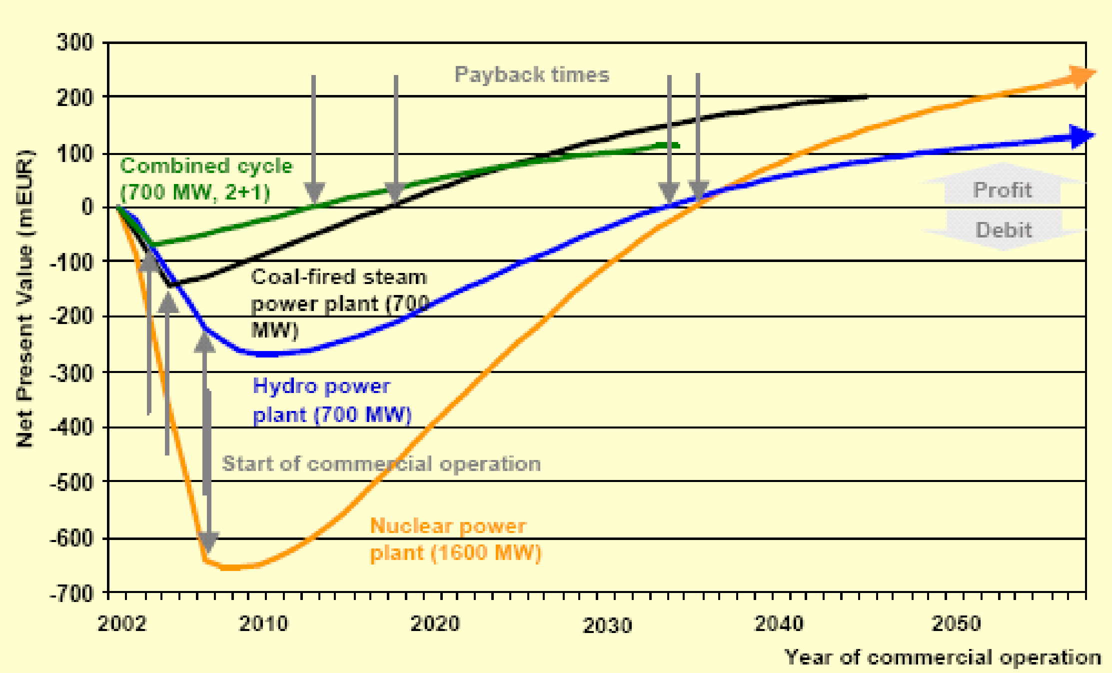

Global potential of CO_2 emission reduction via increased efficiencies and fuel switch

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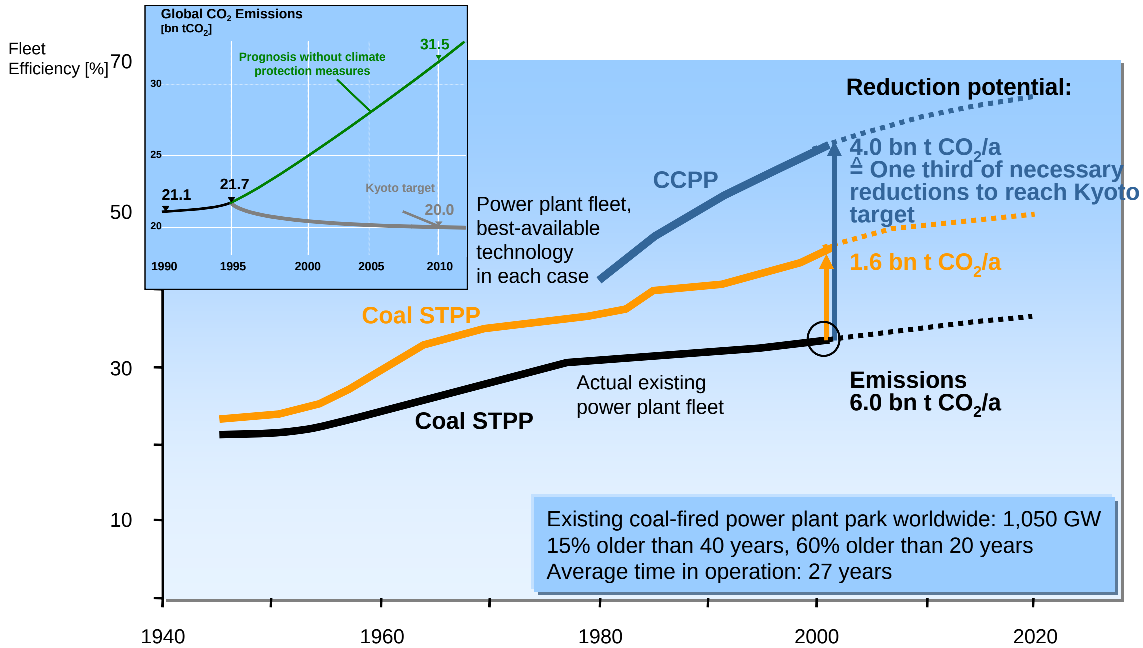

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Universität Stuttgart
Institut für Energiewirtschaft und Rationelle Energieanwendung IER

Role of new energy technologies in GHG mitigation and sustainable development

Prof. Alfred Voss
Institute of Energy Economics and the Rational Use of Energy
University of Stuttgart, Germany

Universität Stuttgart
Institut für Energiewirtschaft und Rationelle Energieanwendung IER

GHG reduction and sustainable development scenarios to assess the role of energy technologies: A case for Germany

- Reference case (REF)
  - no CO_2 emissions reduction targets
  - phasing out of nuclear
- CO_2-control scenarios (21% in 2010; 50% in 2030; 80% in 2050)

ICCF/FORATOM Climate Change Forum, Brussels, Nov 26, 2003

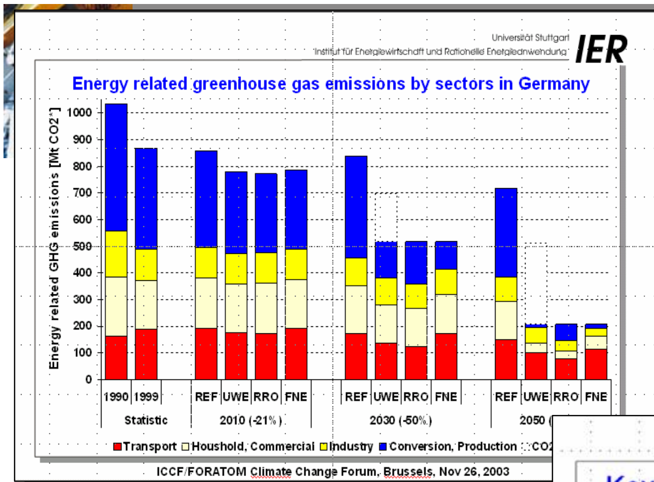
Universität Stuttgart
Institut für Energiewirtschaft und Rationelle Energieanwendung IER

✓Clean coal technologies (UWE)
- efficient fossil power plants
- CO_2 sequestrations

✓Renewable energy technologies case (RRO)
- increasing renewable contribution to electricity and primary energy supply to 50% by 2050.

✓Full scope technologies case (FNE)
- cost effective CO_2 reduction
- no nuclear phase out

ICCF/FORATOM Climate Change Forum, Brussels, Nov 26, 2003



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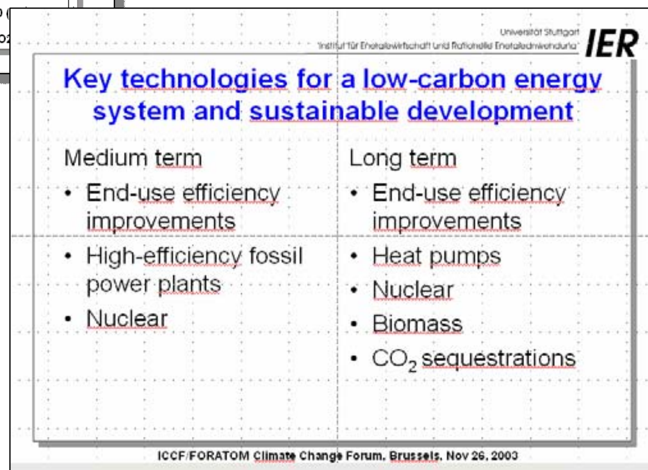

Roadmap Towards Future Power Generation Portfolio

SIEMENS

Today's Power Solutions + **Advanced Components and Technology for High Efficiency** + **Ongoing Research & Development for Low CO_2 Emission Solutions** = **Future Power Solutions**

Advanced Components and Technology for High Efficiency:
- High Efficient Turbomachinery
- Materials
- Fuel Processing
- Fuel Flexibility

Ongoing Research & Development for Low CO_2 Emission Solutions:
- CO_2 Capture and Storage
- Hydrogen Combustion
- Combustion with Pure Oxygen
- Advanced Thermal Cycles

Only Combined Innovation in Power Plant Components & CO_2 Capture Equipment Can Lead to Acceptable Solutions