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Future Markets and Technologies of Gas Turbines

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Drivers Towards Meeting The KYOTO Commitments

Reduce energy / electricity consumption through

- More efficient consumer equipment
- Reduced use of equipment

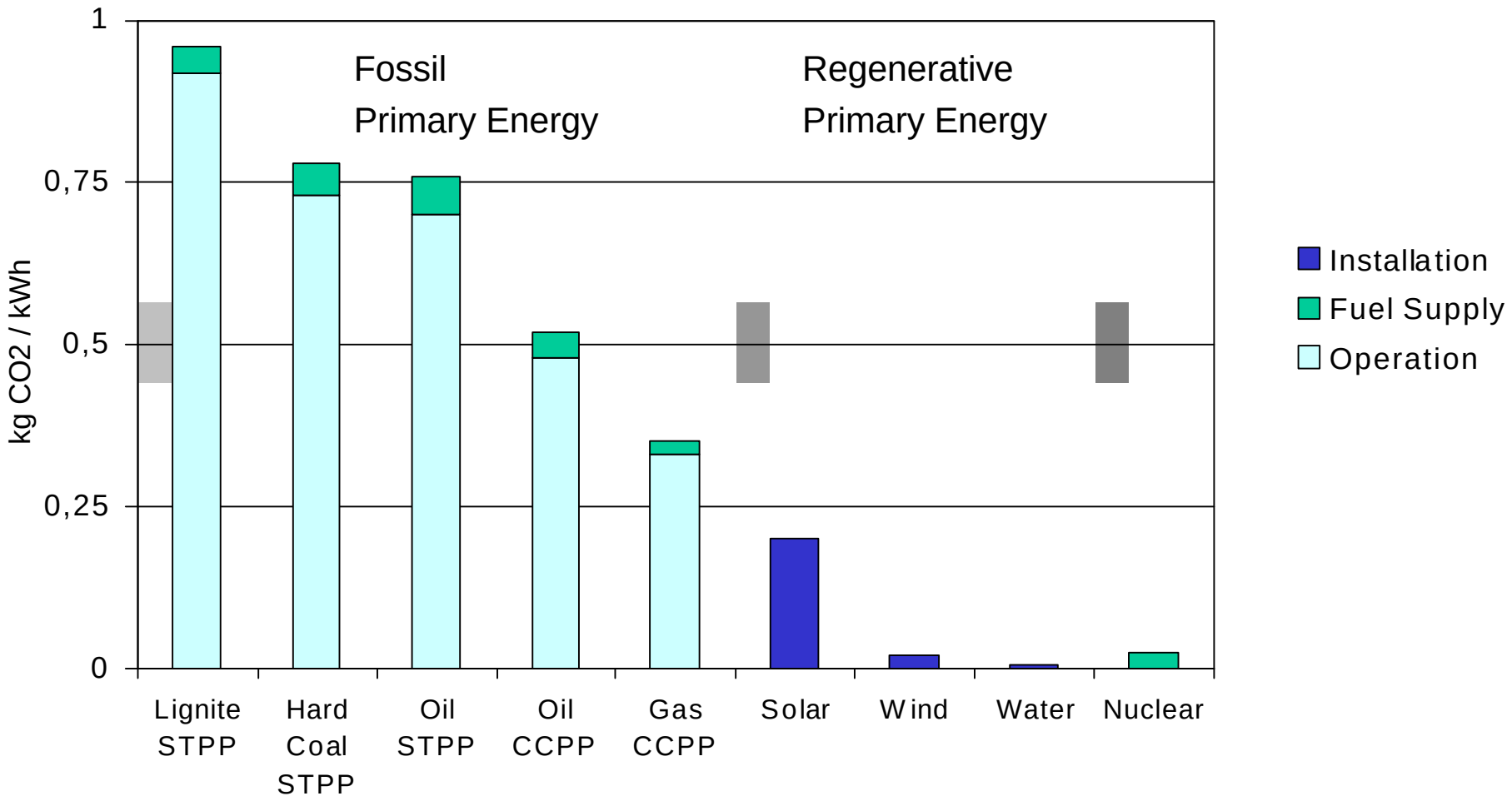
Sequester CO_2

Generate electricity from **regenerative** primary energy sources / **switch** to lower **C-content** primary fuels

Improve internal efficiency of power plant equipment through modernization or new built

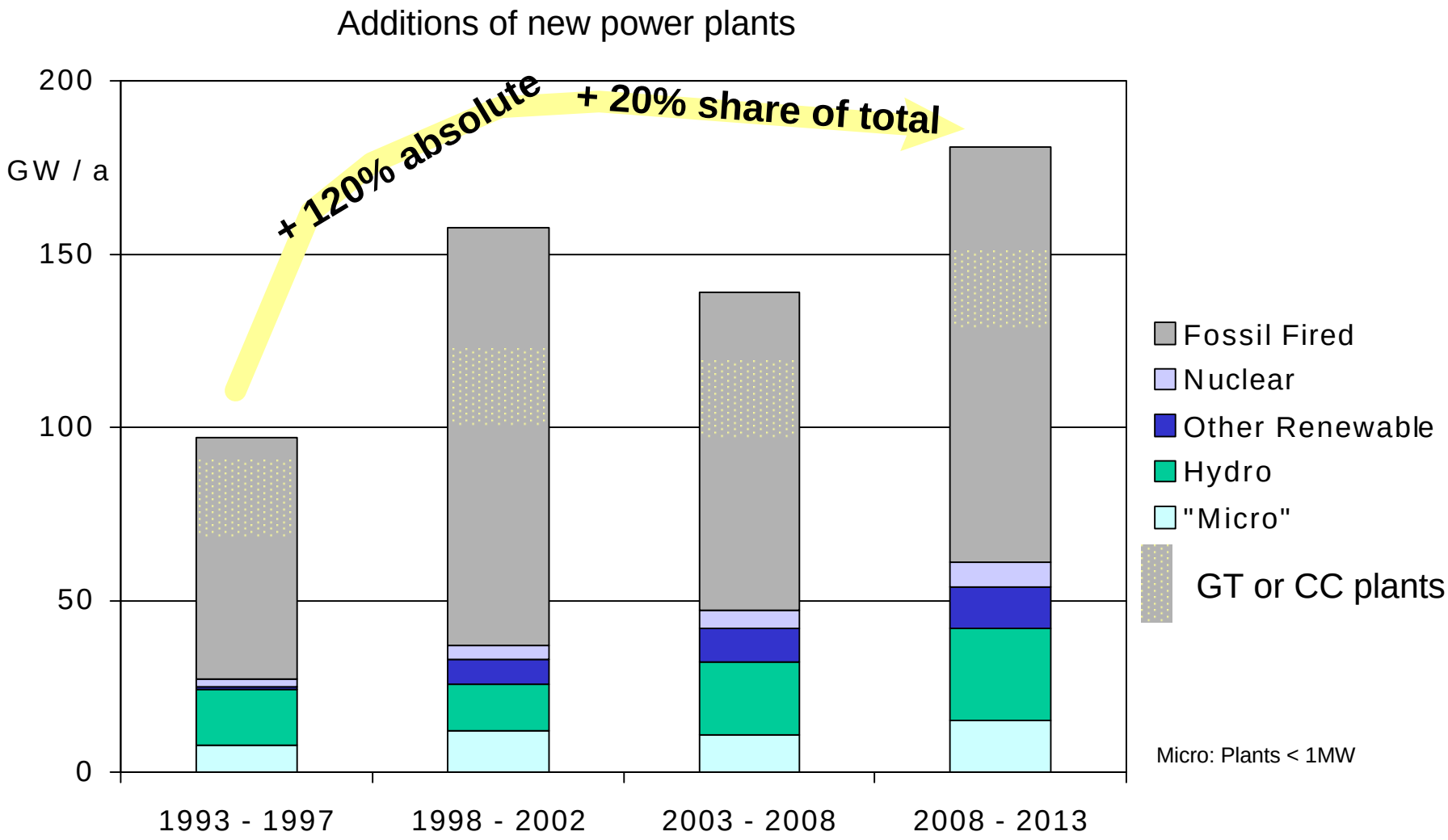
Migrate power plant population towards lower CO_2 emitting **technologies**

Gas Turbines… Have Significant Advantages Over Other "Conventional" Electricity Generation Concepts



Source: Siemens; today´s typical plant efficiencies

The Share Of Gas Turbines In Electricity Generation Continues To Grow



Source: Siemens

The Gas Turbine Market Growth Was Economically Driven – Environmental Aspects Will Take Over

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Economical Drivers

- Lowest invest costs
- Shortest project cycle times – permission to operation
- Lowest life cycle cost
-

Emission trading will quantify environmental advantages

Environmental Drivers

- Most efficient use of primary energy
- Maximize reach of fossil fuels
  - Minimize CO_2 emissions
- Lowest NOx emissions
- Practically no particulates etc.

Gas Turbines Have Significant CO_2 Reduction Potential -- Through Internal Improvements And Extended Application

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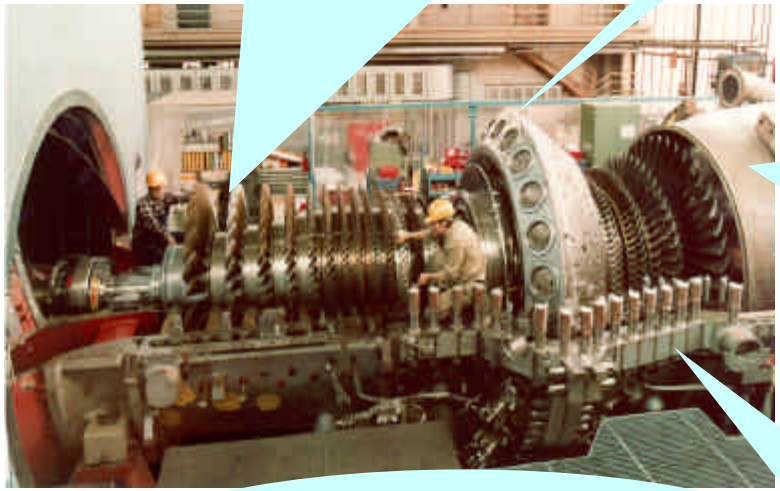
Compressor:
1% improved efficiency = - 8.300 t CO_2 / a
Discipline: Aerodynamics / CFD

Combustion:
+50K gas temperatures = - 40.000 t CO_2 / a
Disciplines: Aero-Acoustics; Gas-Kinetics



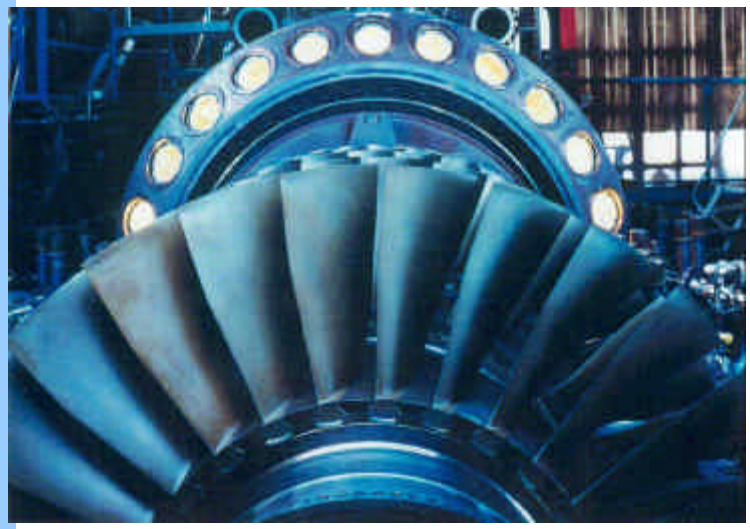
System "Gas Turbine":
1% improved efficiency = - 28.000 t CO_2 / a
e.g. through clearance control; leakage control
Disciplines: Materials; Heat Transfer; Cycle Modelling; CFD for Secondary Flows etc.

All Together:
Testing, Testing, Testing

Turbine:
1% improved efficiency = - 19.000 t CO_2 / a
Discipline: Aerodynamics
+50K gas temperatures = - 40.000 t CO_2 / a
Disciplines: Materials; Cooling; Heat Transfer

Source: Siemens; all numbers refer to a 1000MW CC plant; fuel methane

Gas Turbines Have Significant CO_2 Reduction Potential -- Through Internal Improvements And Extended Application



Replace
1 GW of old coal fired STPP
= - 3.500.000 t CO_2 / a

Re-Power
1 GW of old coal fired STPP
= - 3.000.000 t CO_2 / a

Co-Generation
1 GW of heat for industrial / heating application = - 700.000 t CO_2 / a

Coal Gasification
1 GW generated in IGCC instead of coal fired STPP = - 600.000 t CO_2 / a

No R&D required

but

Governments can create attractive boundary conditions

Huge potential but not yet commercialized

Source: Siemens; STPP = Steam Power Plant; IGCC = Integrated Gasification Combined Cycle
Replace: Δ efficiency = 20%pts; Re-Power: Δ efficiency = 10%pts + 30% power; replaces STPP
Co-Generation: Δ efficiency = 25%pts yearly average; IGCC: Δ efficiency = 10%pts

Concerted Effort In Major Engineering Disciplines Will Result In Significant CO_2 Reduction

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Typical 2003
1000MW Gas Fired
CC Power Plant:

Efficiency
58%
NOx Emissions
25ppm
CO_2 Emissions
2,800,000 t/a

Metallic Materials:
Metal Temperatures + 100°C ; validation through testing

Ceramic Materials:
Coatings: Surface Temperatures + 100°C
Structures: Large scale Matrix Composites

Cooling Technologies:
Near Wall cooling -> manufacturing & repair and validation through testing

Aerodynamics:
3D viscous codes and validation through testing

Combustion:
Combustion kinetics and acoustics and validation through testing
Application of Low BTU gases such as Coal Gas

Typical 2013
1000MW Gas Fired
CC Power Plant:

Efficiency
63%
NOx Emissions
25ppm
CO_2 Emissions
2,550,000 t/a

Source: Siemens; 8000hrs/a methane base load operation

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Conclusions

Gas Turbines can significantly and quickly contribute to meeting the KYOTO targets against global warming through

- **Continuous large scale R&D efforts resulting in efficiency increase**
    - **Extended application**
- **Co-Generation / Coal Plant replacements**
    - **H_2 rich fuels – e.g. coal / syn-gas**