COGEN Europe

Working towards the wider use of cogeneration in Europe for a sustainable energy future

CHP
Combined Heat and Power
Cooling Heat and Power
Cutting Harmful Pollutants
Creating Higher Profits

The European Association for the Promotion of Cogeneration

European Challenges for Gas Turbines for CHP

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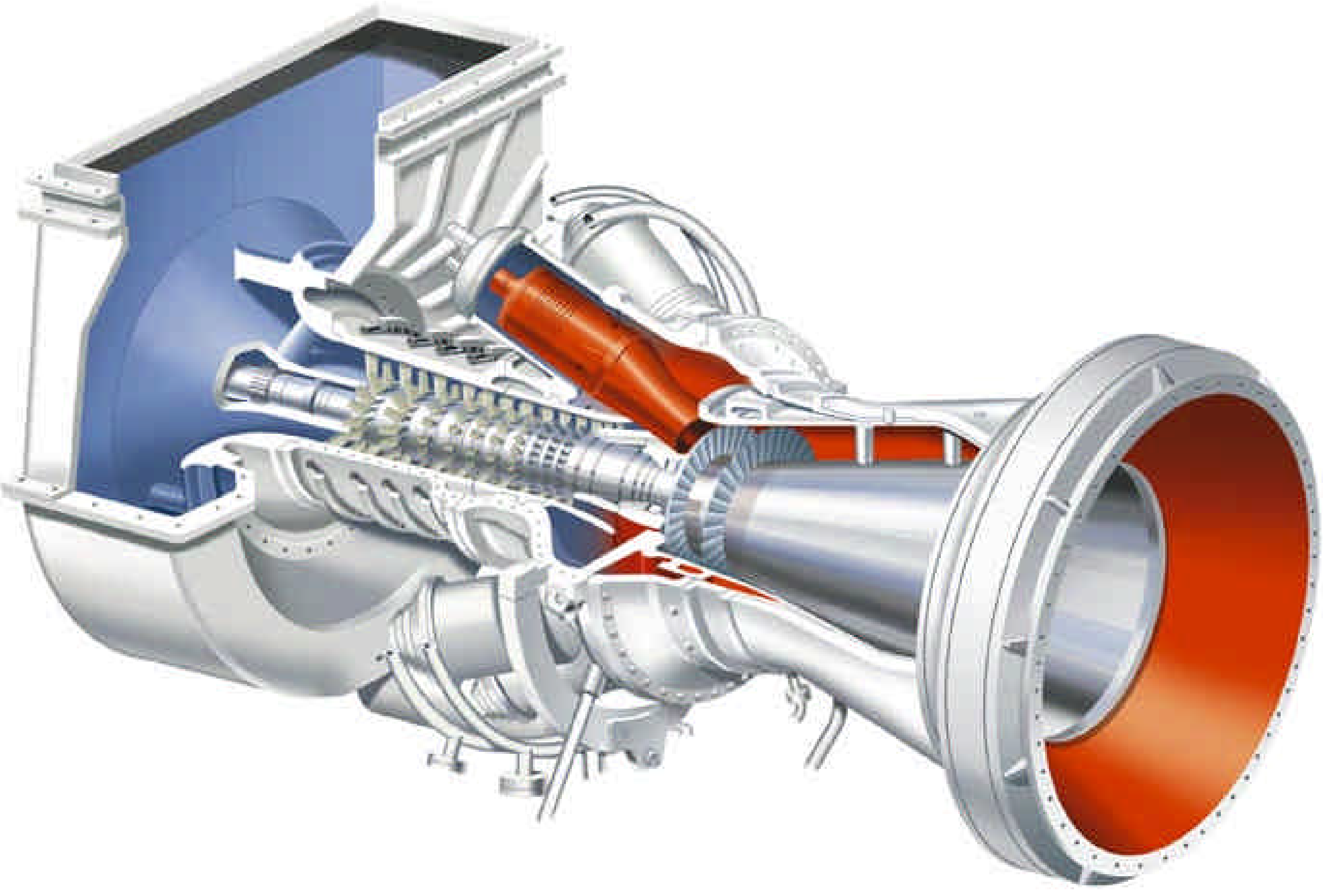
COGEN Europe

CAME – GT Conference

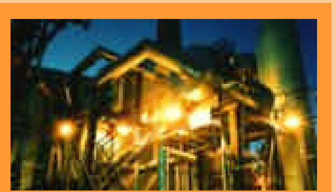
Brussels

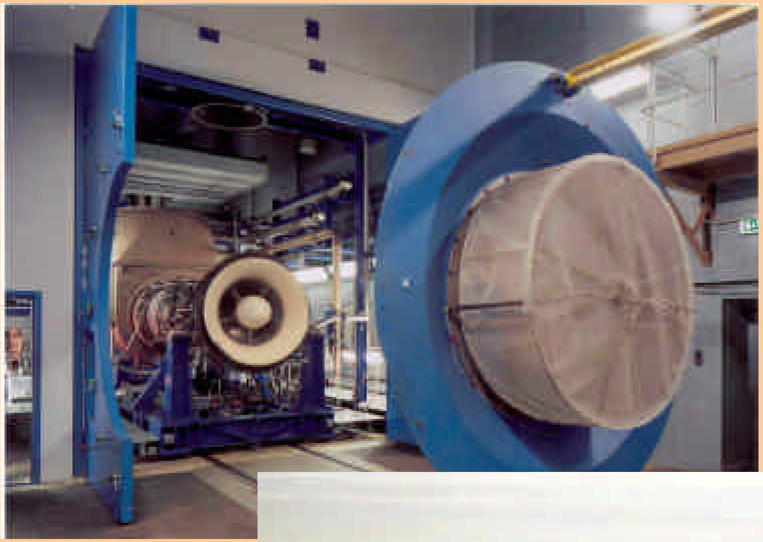
11 July 2003

Tempest Gas Turbine



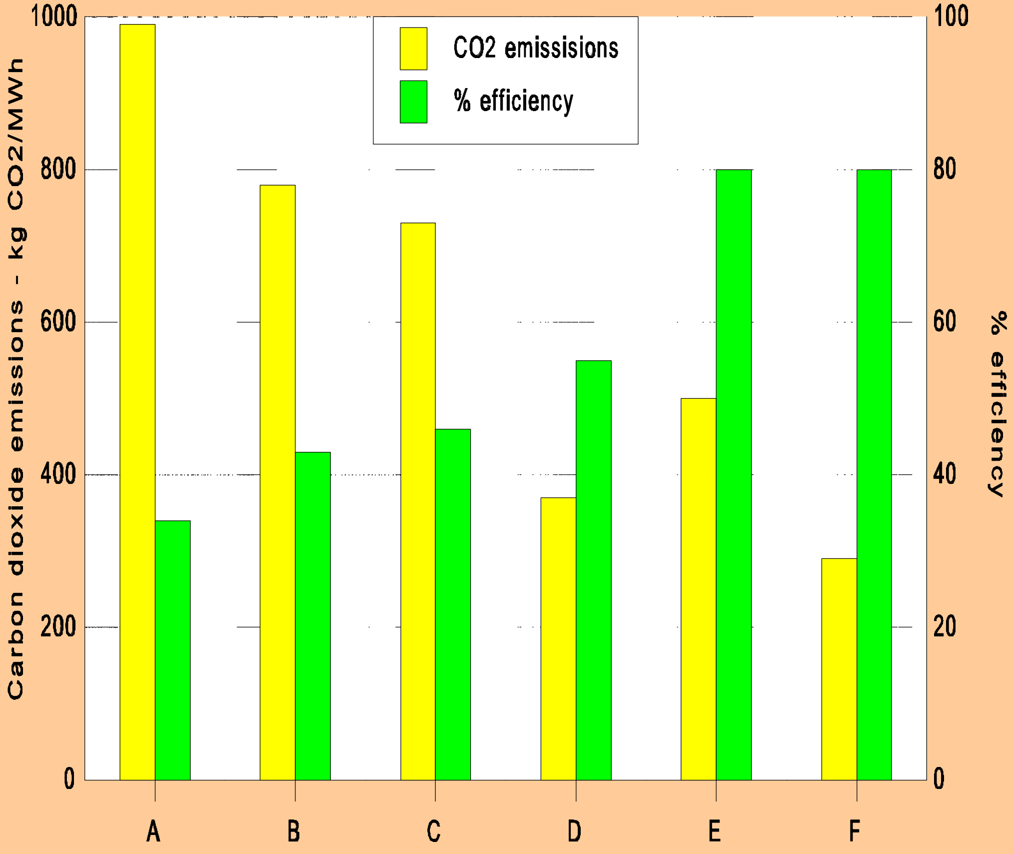
COGEN
europe





Clear Benefits of Cogeneration

Carbon dioxide emissions, efficiencies of power production



- A Coal-fired steam turbine
- B New clean coal-fired station
- C Coal gasification/steam turbine
- D New combined cycle (CCGT)
- E Coal cogeneration
- F Gas cogeneration
- The Marginal Electrical Efficiency
- of cogeneration is at least 70%
- Each MWh of cogeneration saves
- between 160 and 500 kg of CO_2

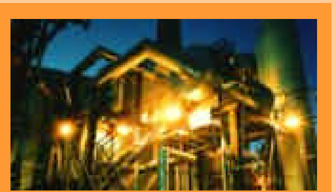
Key Facts and Trends

- Challenges of environment, energy saving and fuel supply security
- New technologies open new doors
  - Micro turbines; Stirling Engines; Fuel Cells
- Natural gas the fuel of choice
- Liberalisation
- Traditional business is being squeezed
    - liberalisation, regulation and competition
    - cogeneration target 18% and should be more
    - Renewable target 12% of which 8-10% is electricity
- Environment means status quo is not an option
- Need to readjust ….. and fast

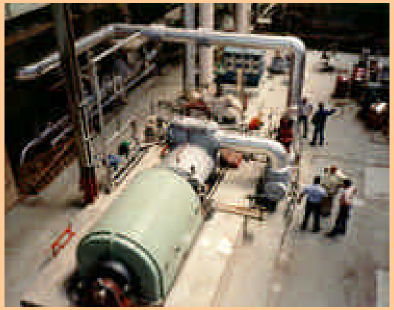
The Need for Cogeneration

- Kyoto single biggest challenge
- Brings Quality criteria to the energy sector
- In a Kyoto context 40-50% efficiency of energy conversion is unacceptable
- Cogeneration
  - Maximised to meet the needs of the energy user
  - Overall efficiency of fuel conversion of 80% and more
  - Nearest competitor is 15% point less efficient!
- Saves around 200 million tonnes CO_2
- Reduces energy dependence by 1200 PJ/a
- 18% target for cogeneration will deliver another 180 million tonnes and 1000 PJ/a energy savings

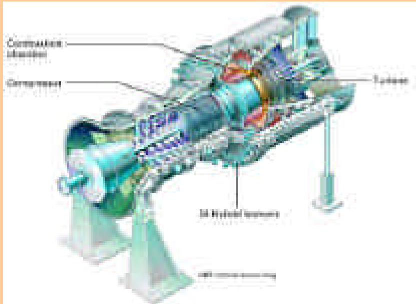
Available and Forthcoming Technologies



Steam Turbines

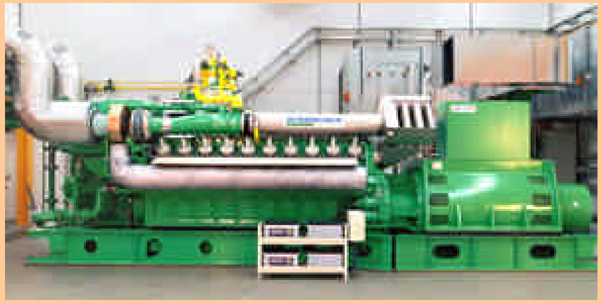


Gas Turbines



Combined Cycles

Engines (Diesel, Otto)



Microturbines

Fuel Cells

Stirling Engines

CHP Technologies

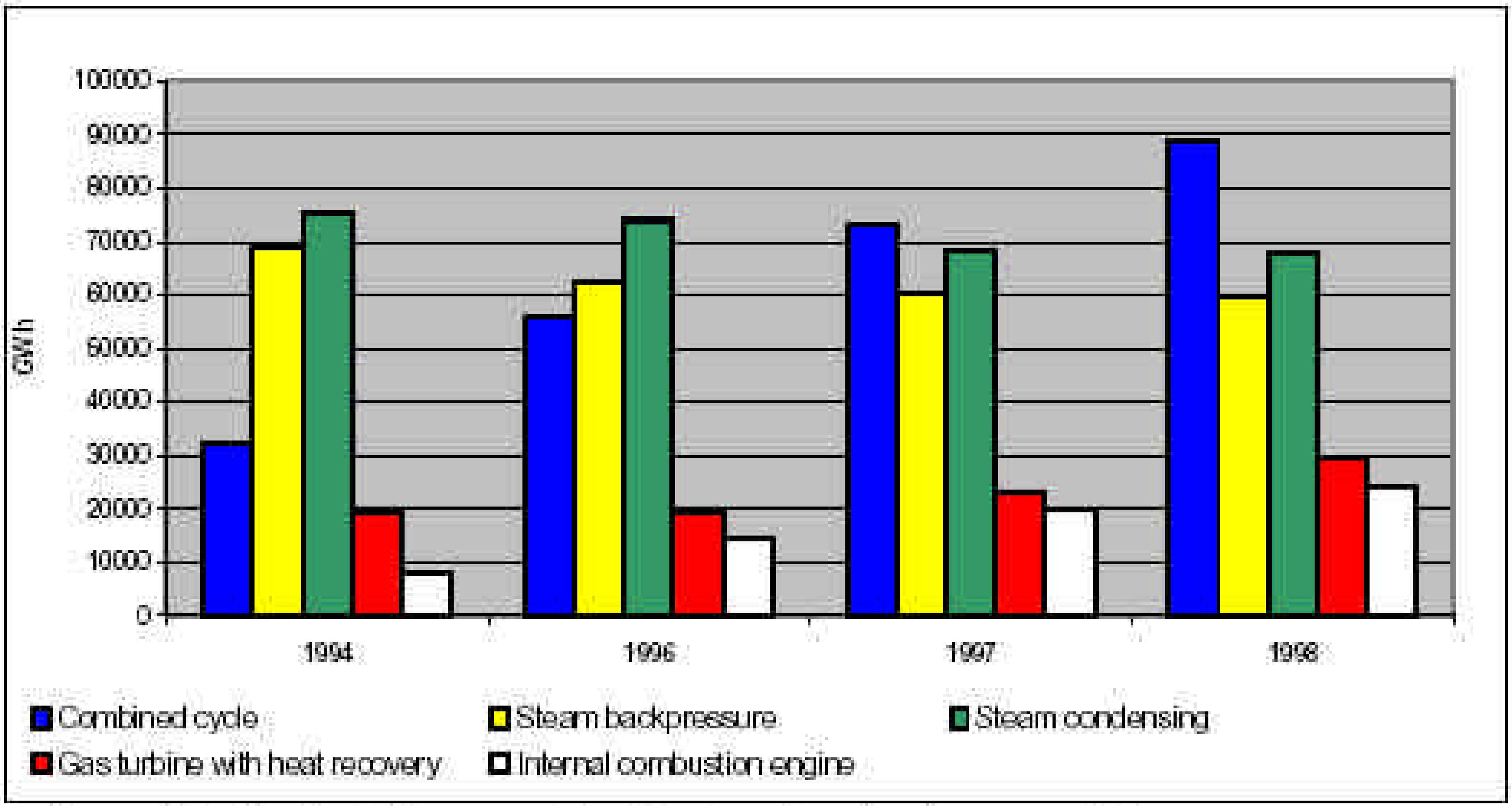


Figure 3. CHP electricity production by type of cycles, European Union.

Technology change

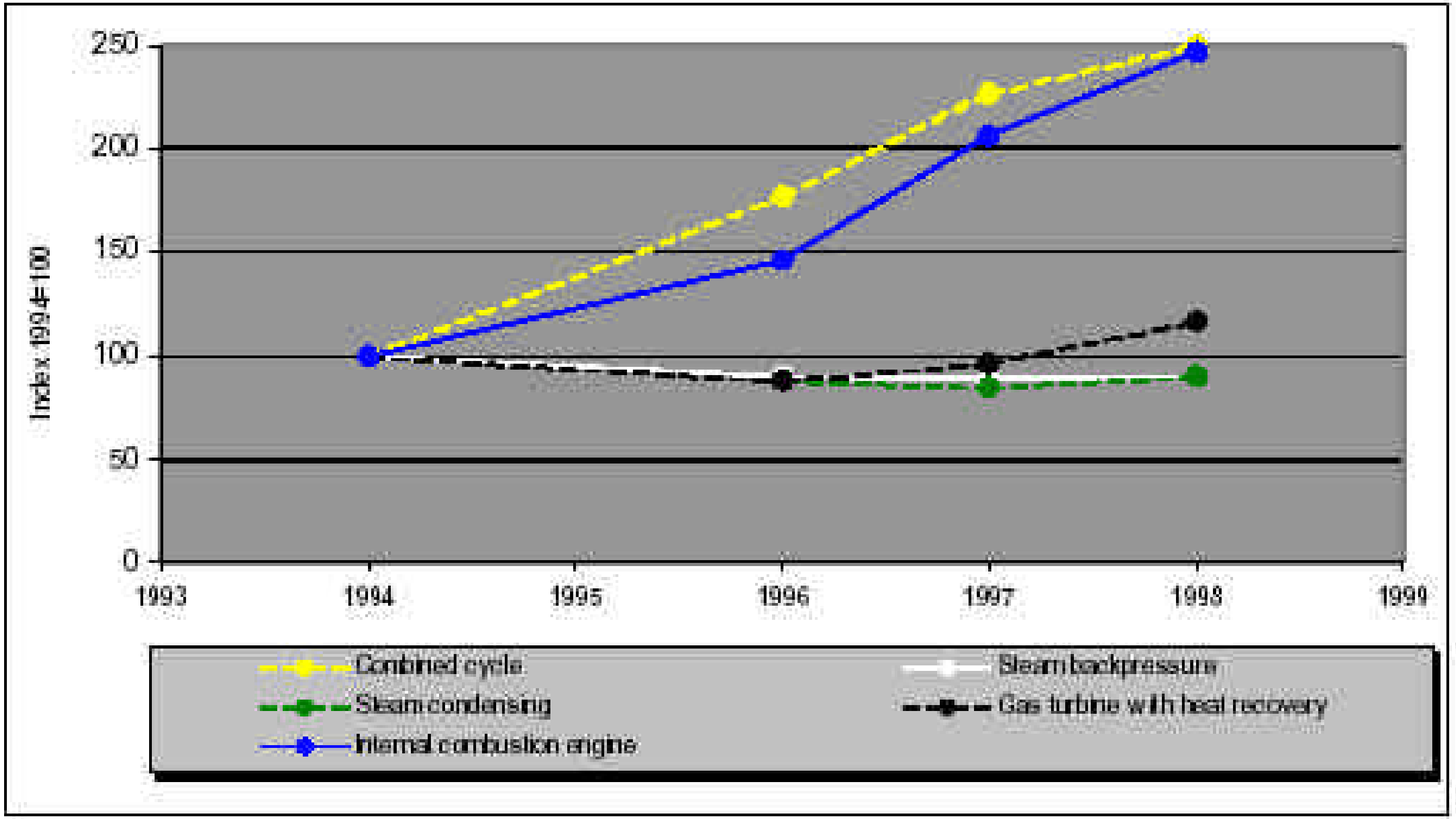
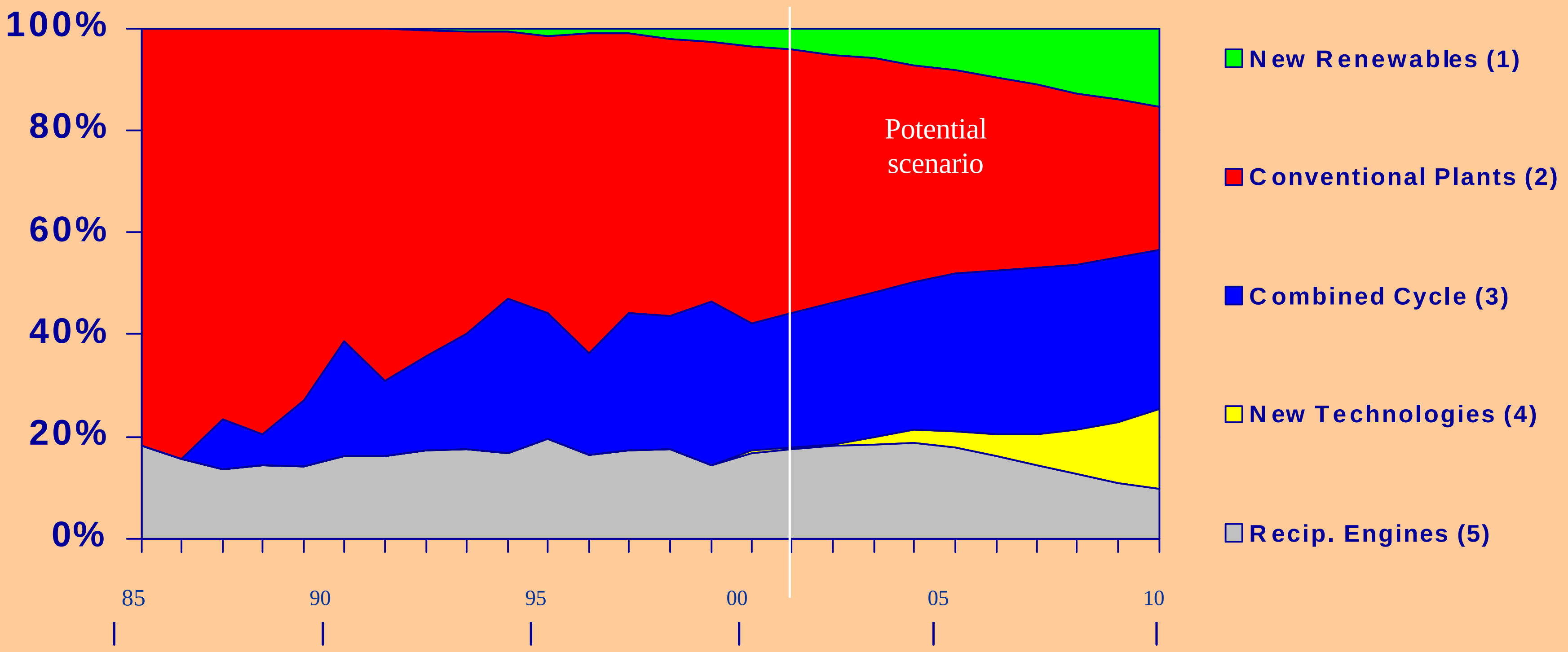


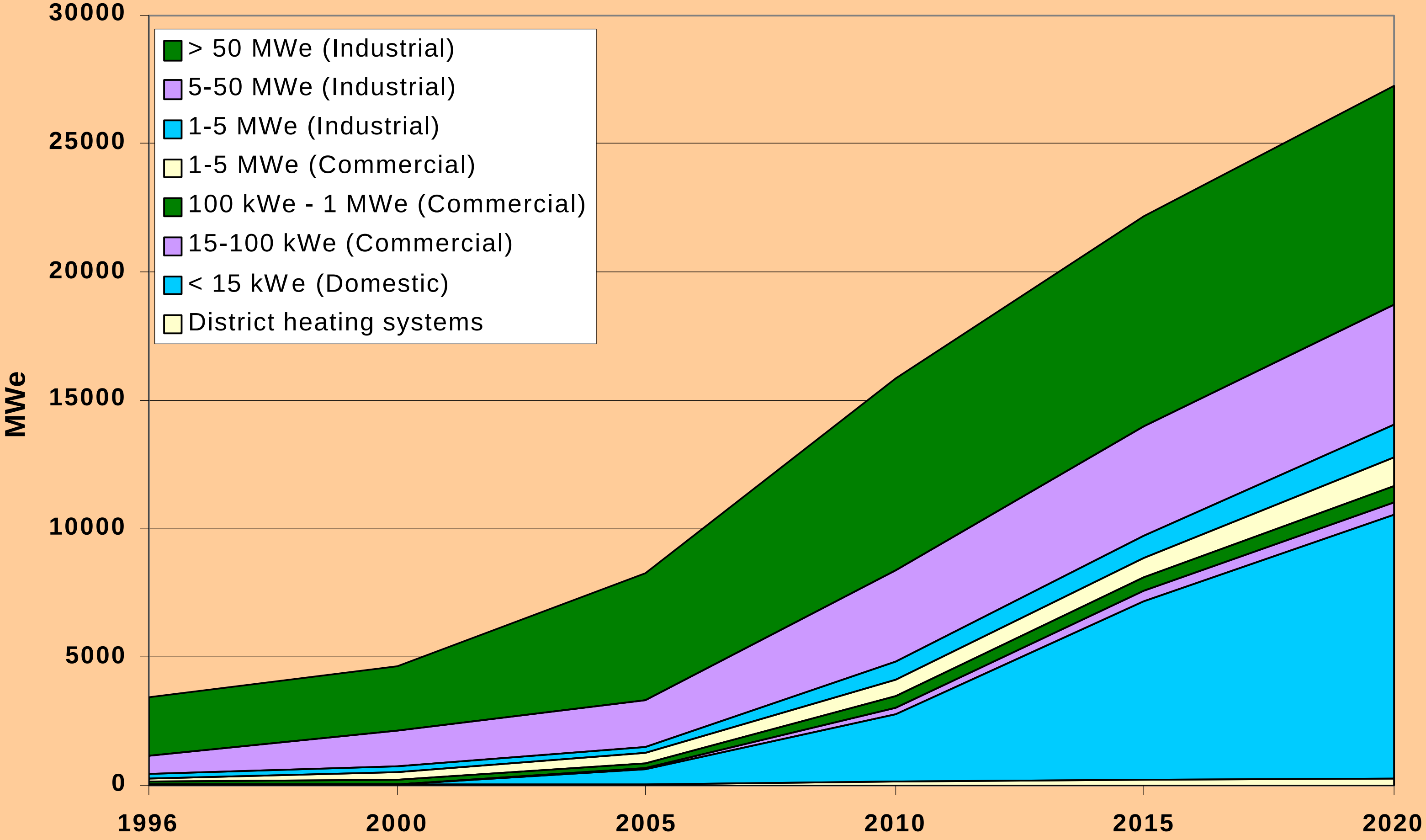
Figure 2. Relative changes of the CHP electrical capacities of different types of cycle in EU-15 (1994 = 100).

Technology portfolio

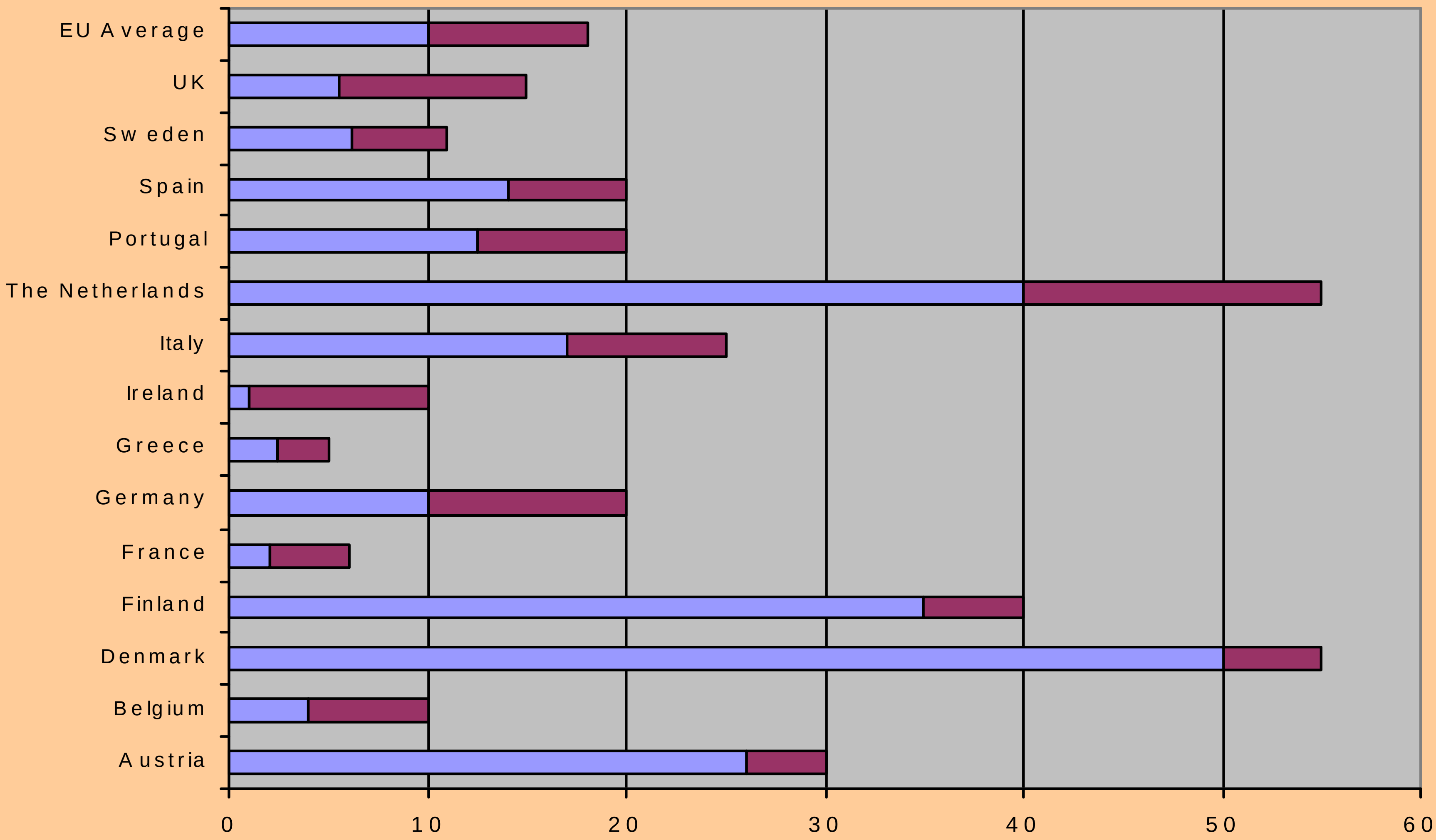


Notes: (1) Wind, Solar, Biomass and hydro
(2) Conventional ST, SC GT and Nuclear
(3) GT CC
(4) Small On-site CHP (mini/micro-turbines, fuel cells, Stirling engines, …), Cleaner Gensets for Power Reliability & Quality
(5) Diesel Engines (unit size > 0.5 MW)

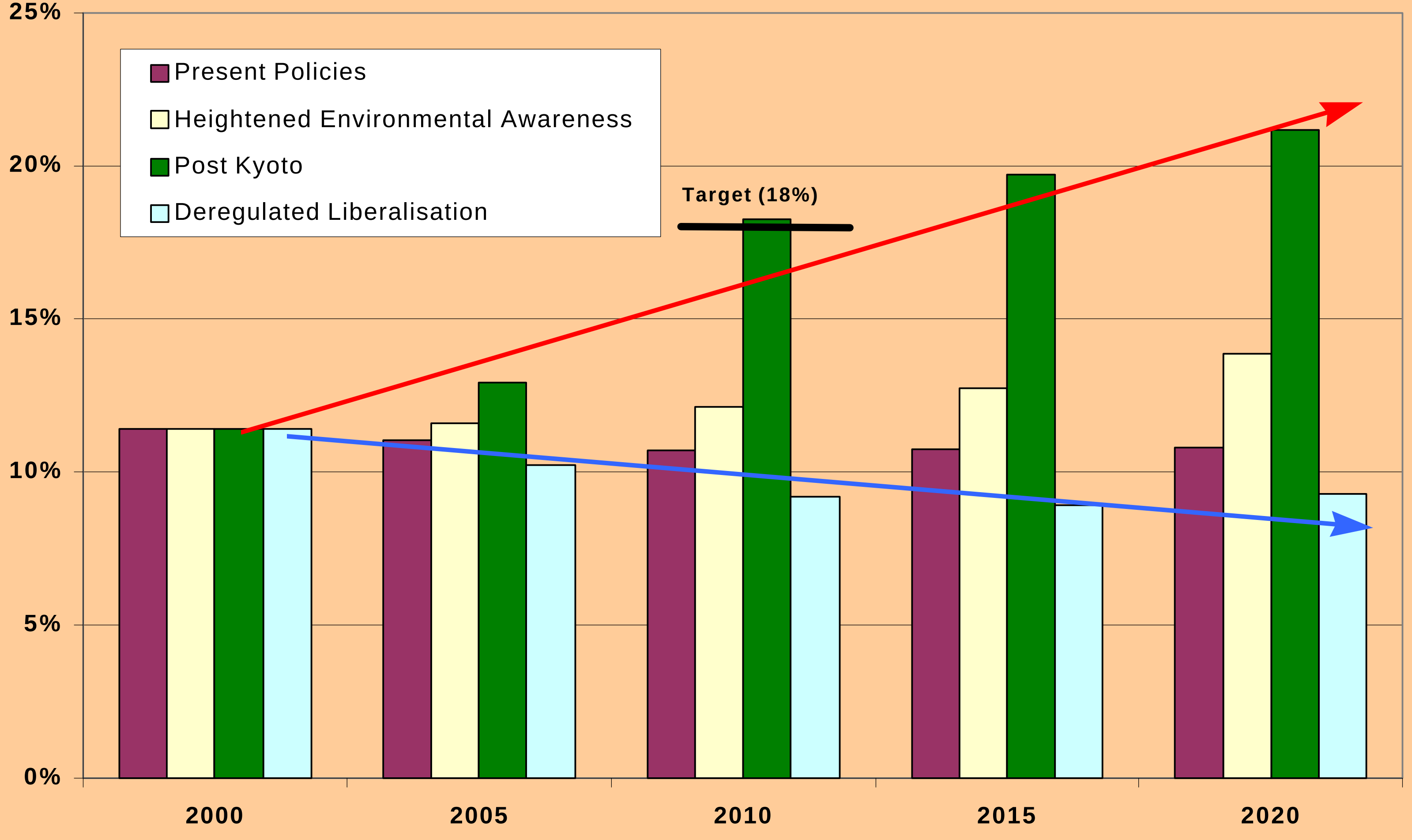
UK Cogeneration - Post Kyoto (MW_e)



CHP as a share of national power production - 1999 & 2010



Production share of electricity by CHP



Policy Drivers

- Liberalisation of the energy market
- Climate change and Kyoto Protocol Targets
- Security of Energy Supply

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CHP HELPS ALL THREE

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- High oil prices are a mixed blessing
- Lack of real Government action

State of the European Market

- The prices for electricity are below sustainable levels
- The gas market remains unliberalised with gas pricing dominated by oil price
- It is almost impossible to build any new generating capacity
- Capacity gaps will emerge from 2005 onwards
- Kyoto and IPPC and Emission Trading will cause a radical change to investment decisions

Thoughts on the Future

- The future electricity market will remain uncertain and investment in large fixed long term projects will present a greater risk than small blocks
- Low efficiency will handicap the central power station model
- Decentralisation brings three advantages
  - Smaller individual investments
  - High efficiency
  - Reduced need to invest in network extension or strengthening

IMPLICATIONS FOR GAS TURBINES

Forcing Issues

- Competition
  - Lower electricity prices
  - Higher gas prices
  - CCGTs
- Environment
  - Lower NOx
  - CO_2
- Customers
  - Lower capital
  - Lower maintenance
  - More flexibility
- Fuels
  - Flexibility and non-gas
- Energy Savings
  - Increases

CHAPNET

CHP

Gas Turbine Technology

Required Developments

- Market Pressures for :
  - Lower Emissions
    - Water or Steam Injection
    - Dry Low Emissions Combustion
  - Fuel Flexibility
    - New combustion and fuel systems
    - New coatings
  - Improved Reliability & Availability
    - Longer Component Lives
    - Intelligent Control Systems
    - Condition Monitoring
  - –

Gas Turbine Technology

Required Developments

- Market Pressures for :
  - Improved Efficiency
    - Improved individual component efficiencies
      - » Tighter tolerances, improved aerodynamics
      - » More complicated to manufacture !
    - Higher Firing Temperatures
      - » More exotic materials
      - » Reaching firing temperature limits for effectiveness of DLE !
  - Reduced Costs
    - Increased Power Density
      - » Higher firing temperatures & new component designs
    - More compact turbomachinery with lower component counts
      - » More highly loaded components !

Gas Turbine Technology

The Results of Technology Development

- Over the past 20 years, improvements in design have led to:
  - Reduced size
    - 13MW gas turbine of today requires same package space envelope as a 6.5MW gas turbine of 1980
  - Improved Efficiencies
    - 35% electrical efficiency compared to 30% in 1980
  - Reduced Emissions
    - Single digit NOx possible on natural gas
- Further improvements in efficiency & power density possible, but small incremental changes only

Gas Turbine Technology

Future Possibilities

- To make step change in efficiency and power density, it is necessary to more to ‘Complex Cycle’ technologies
  - Combined Cycle
  - Reheat
  - Cheng Cycle
  - Recuperated
  - Intercooled Recuperated
  - Wet Cycles
  - Humid Air Turbine (HAT) Cycles
  - Integration with high temperature Fuel Cells
    - Solid Oxide or Molten Carbonate

Gas Turbine Technology

Summary

- Simple Cycle designs are approaching their limits
  - Application flexible
- Complex Cycles offer improved efficiencies and higher power densities
  - More complicated designs
  - Danger of becoming application specific
  - Optimum component technologies may differ from simple cycle designs
- Uncertain market conditions
  - Will conditions allow commercialisation of new technologies ?

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CHAPNET WEEK

- 15 – 19 September
- Details on www.chp-research.com
- Network conference 17 September
- Other workshops on
  - component integration
  - Micro-CHP
  - Gas Engines
  - Trigeneration
- Brussels location
- Probably free!!!

Thank you for your attention!

www.cogen.org