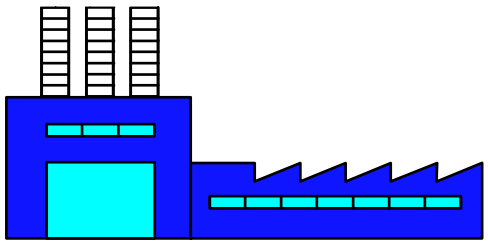
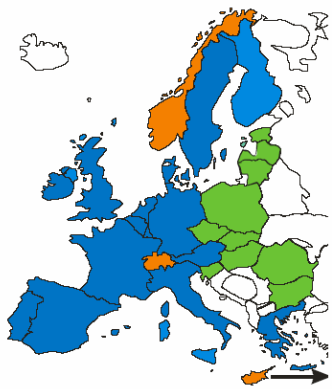
Sharing cogeneration experience of Europe

Twinning project: Improvement of energy efficiency in Turkey





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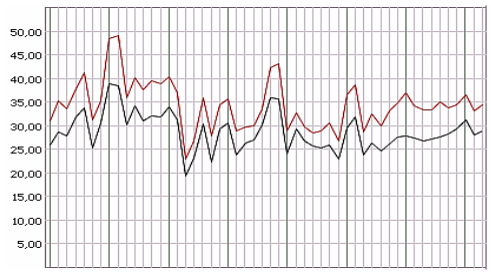
Visiting Faculty, Asian Institute of Technology (AIT)

Ankara
08 June 2006

Energy situation in Europe (EU25)

- Need for massive investment in new capacity
- But new investment risks for large power plants

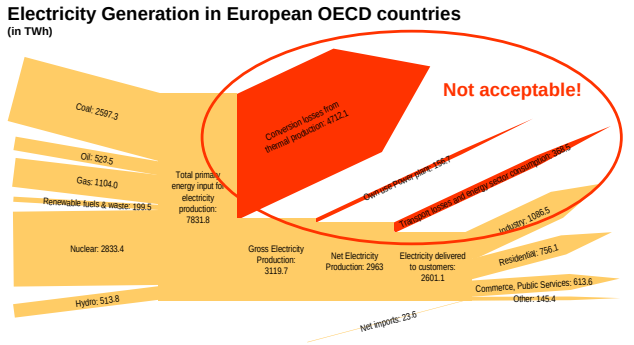
- Electricity price likely to go up
- Price volatility: chances for flexible systems which "surf the markets"



- Power cuts: Security of supply becomes an issue
- Many possibilities to prioritise and support cogeneration

Relevance of cogeneration in Europe

- Cogeneration is the most efficient energy conversion technique
- Europe is world leader in cogeneration, with 75 GWe installed capacity
- Saves around 280 million tonnes CO_2 (EU25)
- Reduces energy dependence by 1500 PJ/annum
- Target to increase the share of CHP from 9% in 1994 to 18% in 2010



33% total efficiency of the electricity supply system

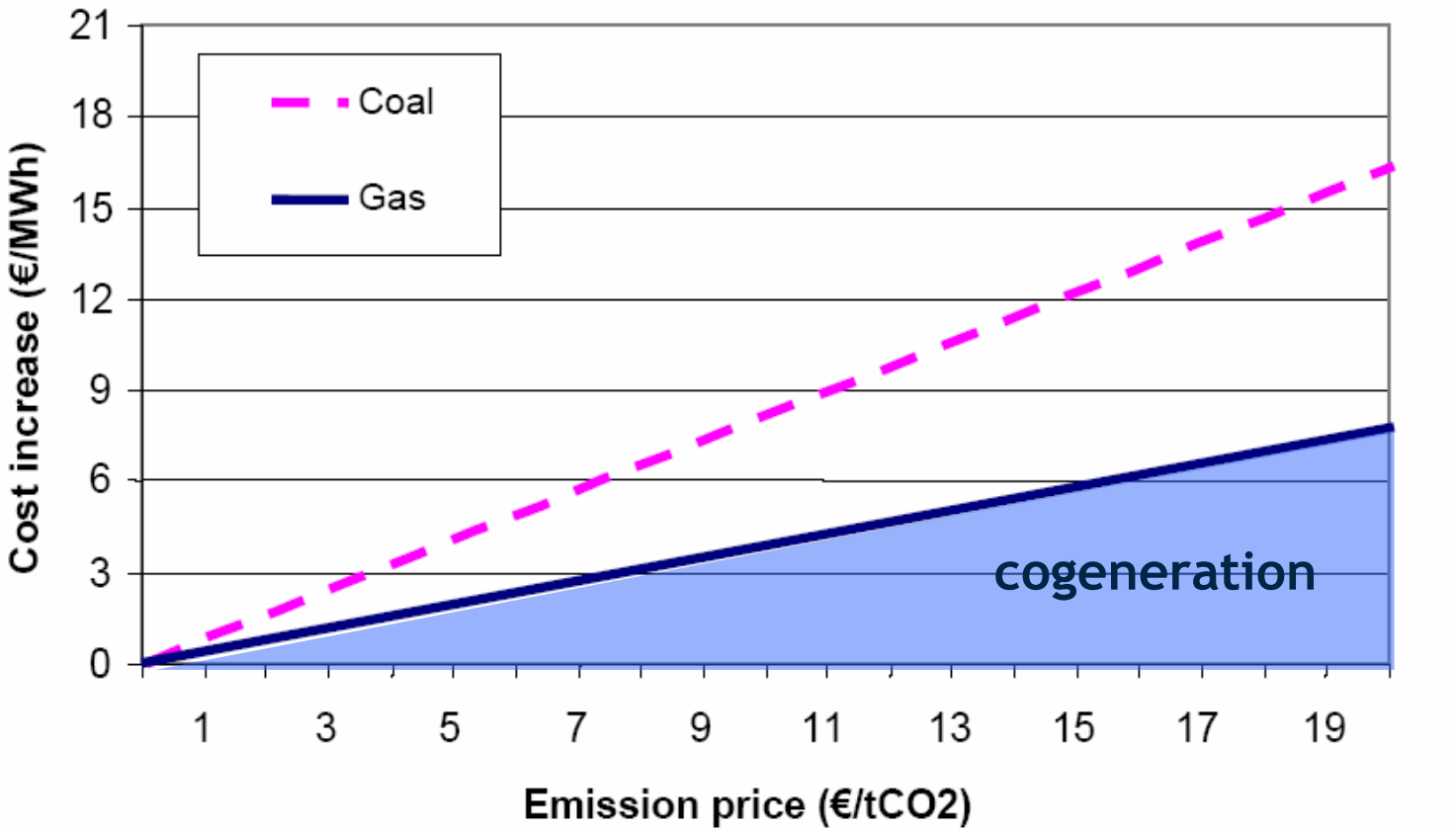
Source: OECD 1999

Energy saving potential in Europe

Potential savings (Mtoe)	By 2020 **Implementation of adopted measures**	Beyond 2020 **Implementation of additional measures**
Buildings: Heating/cooling Electric appliances	41 15	70 35
Industry	16	30
Transport	45	90
Combined heat & power	**40**	**60**
Other energy transformation, etc	33	75
Total energy savings	*190*	*360*

Dutch "clean, clever, competitive" agenda:
cogeneration is "single biggest solution to Kyoto"

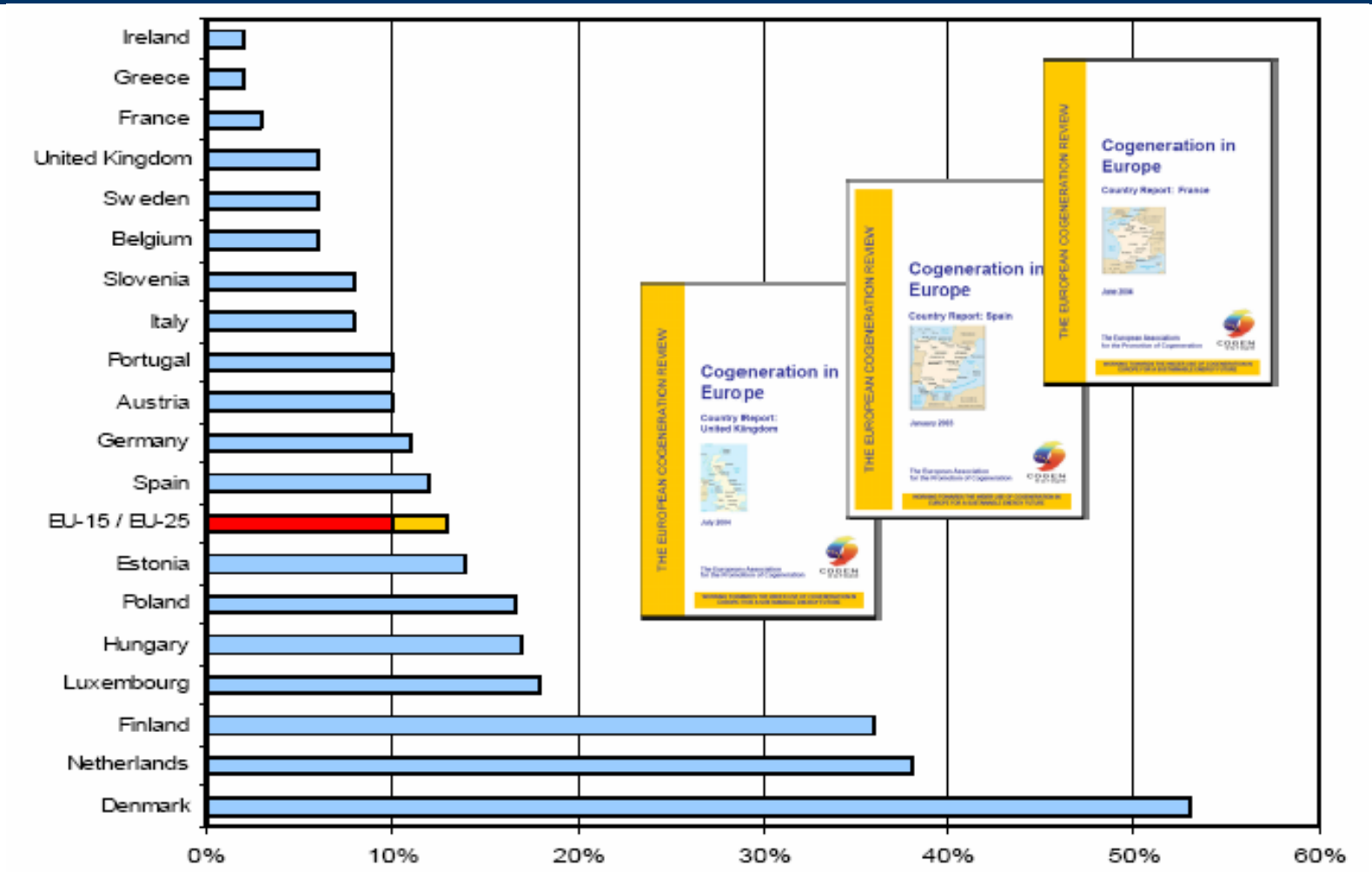
Impact of CO_2 on electricity generation cost



Effect of CO_2 cost on marginal electricity production cost

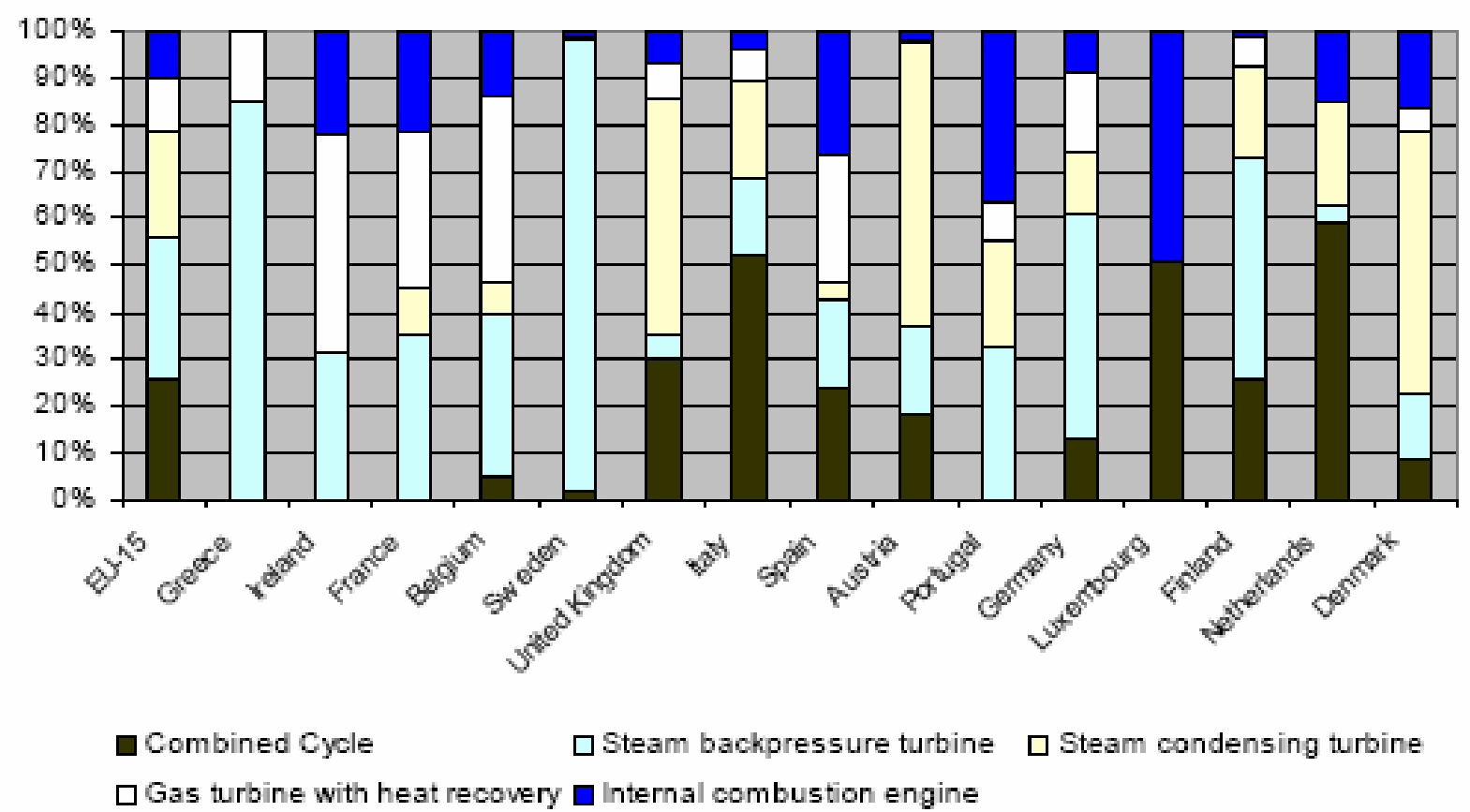
Based on efficiency ratings of 36% and 50% net HHV efficiency respectively. Source: ICF Consulting

Share of cogenerated electricity in Europe



Source: EUROSTAT 2003 & Others

Share of cogeneration technologies



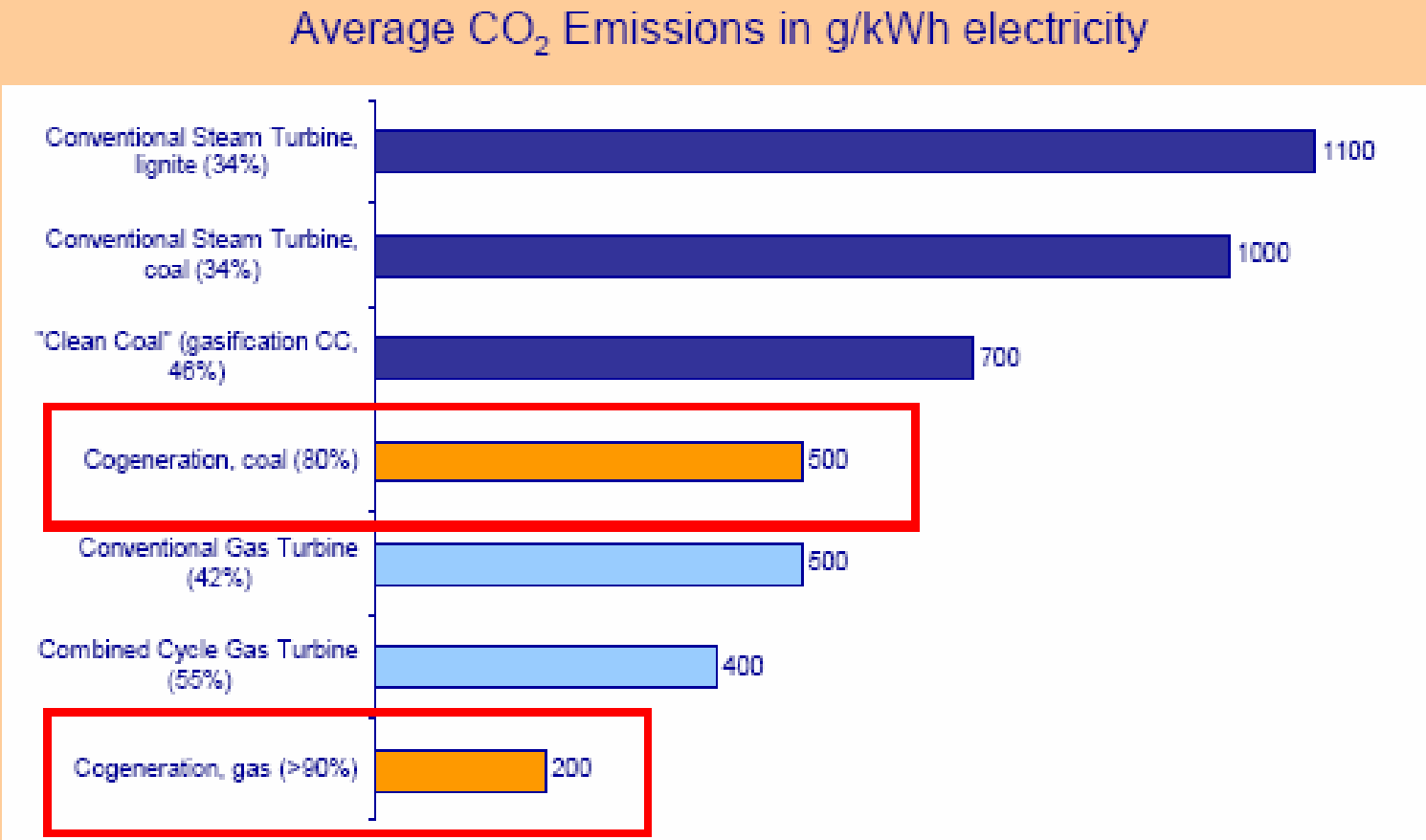
Diversity of cogeneration in Europe

- **Natural resources**
  - Countries with natural gas
  - Countries with abundant resources may not prioritise efficiency
- **Energy supply tradition**
  - District energy in cold countries
  - State monopoly traditions
- **Heat requirement**
  - High level of industrialisation
  - Warmer countries require less heat (but cooling
- **Environmental policy**
  - Some European governments tend to be greener
  - Outside Europe, environment is a lower priority

Status of cogeneration in Europe

- **Current status**
  - World leader in the use of cogeneration
  - Average of 10% penetration in electricity and heat market in Europe
  - 75 GWe installation capacity
  - Cogeneration used in all sectors of the economy
  - Modern cogeneration is mostly fired with natural gas
  - Cogeneration's competitive advantage eroded with higher gas prices and lower electricity prices
  - Many barriers to cogeneration and distributed generation

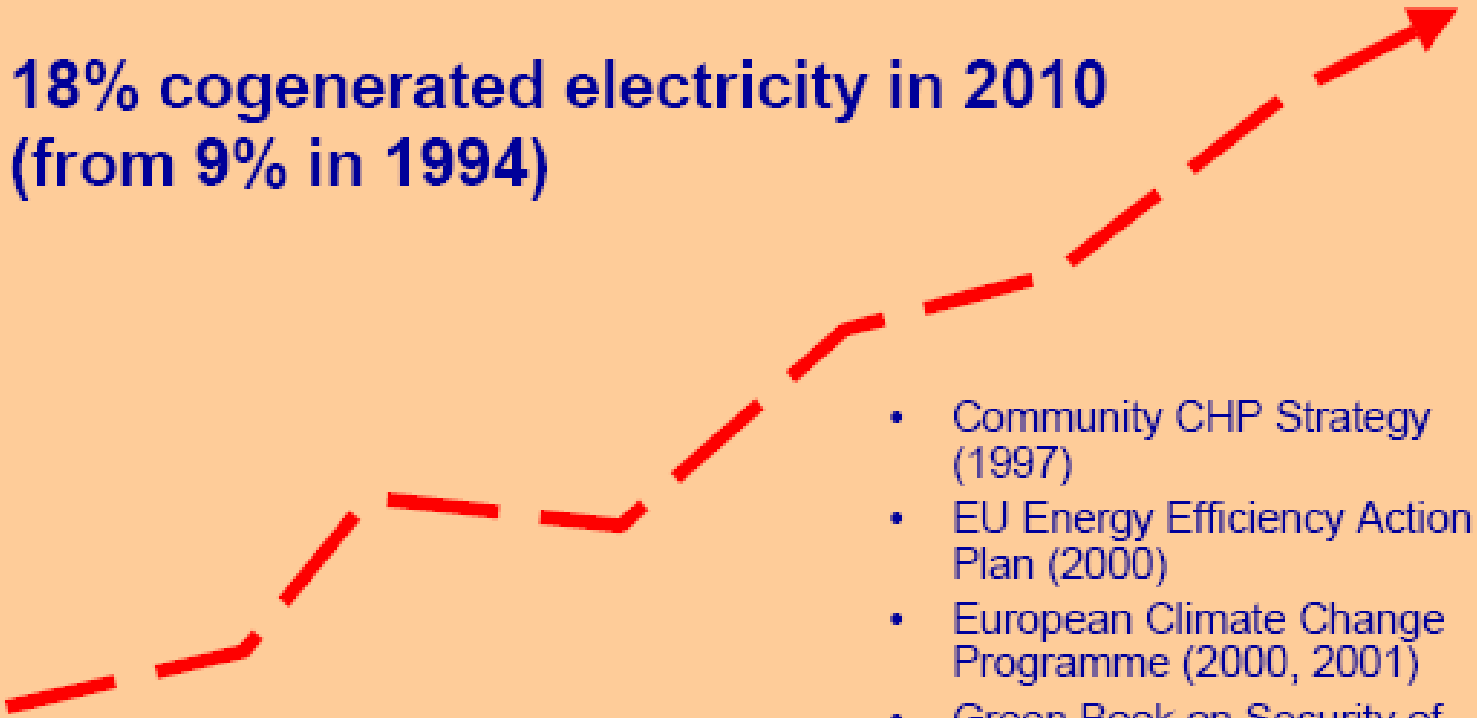
Carbon efficiency of power technologies



Source: Utrecht University, Gemis 3.0

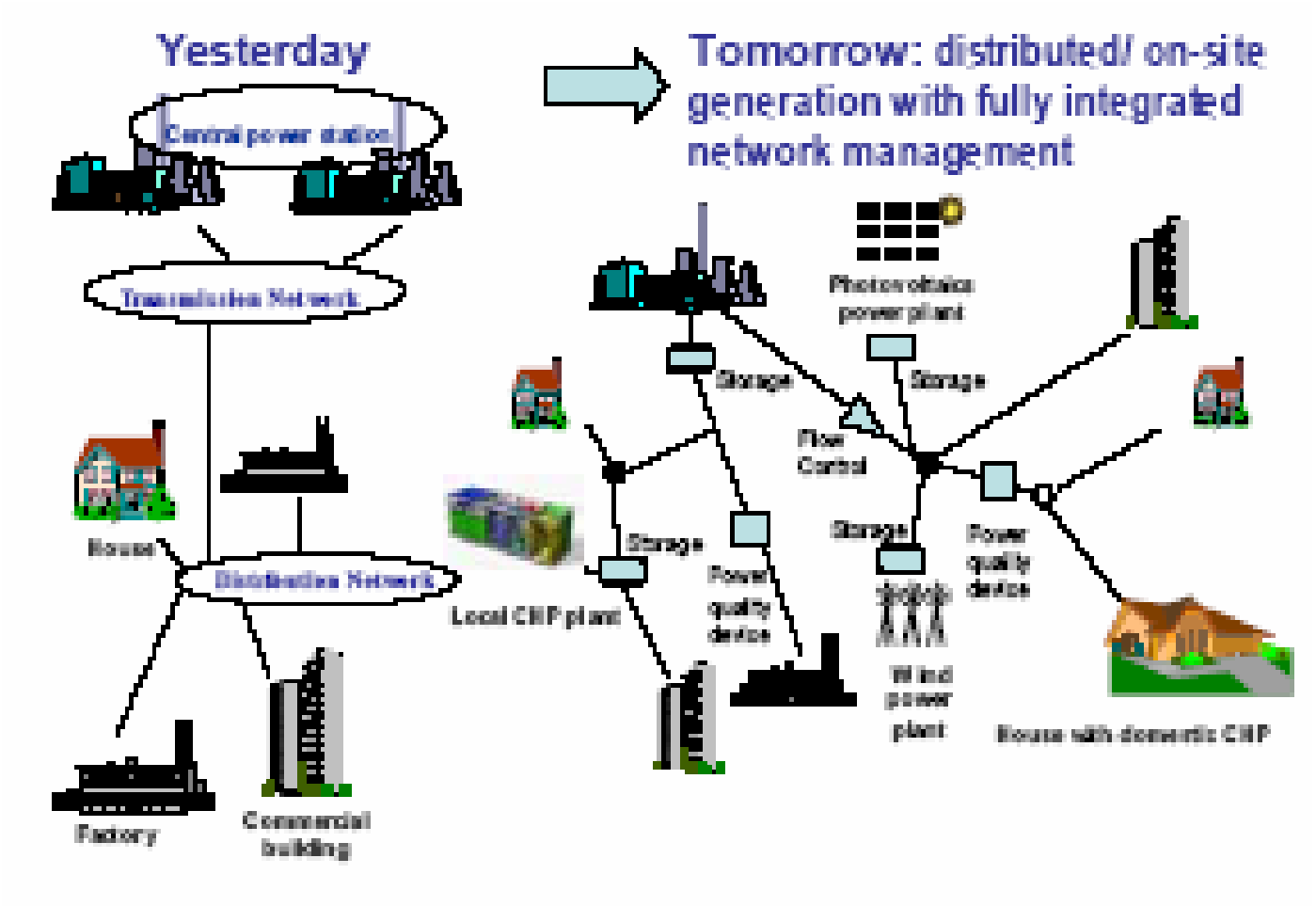
The policy wish for Europe

18% cogenerated electricity in 2010 (from 9% in 1994)

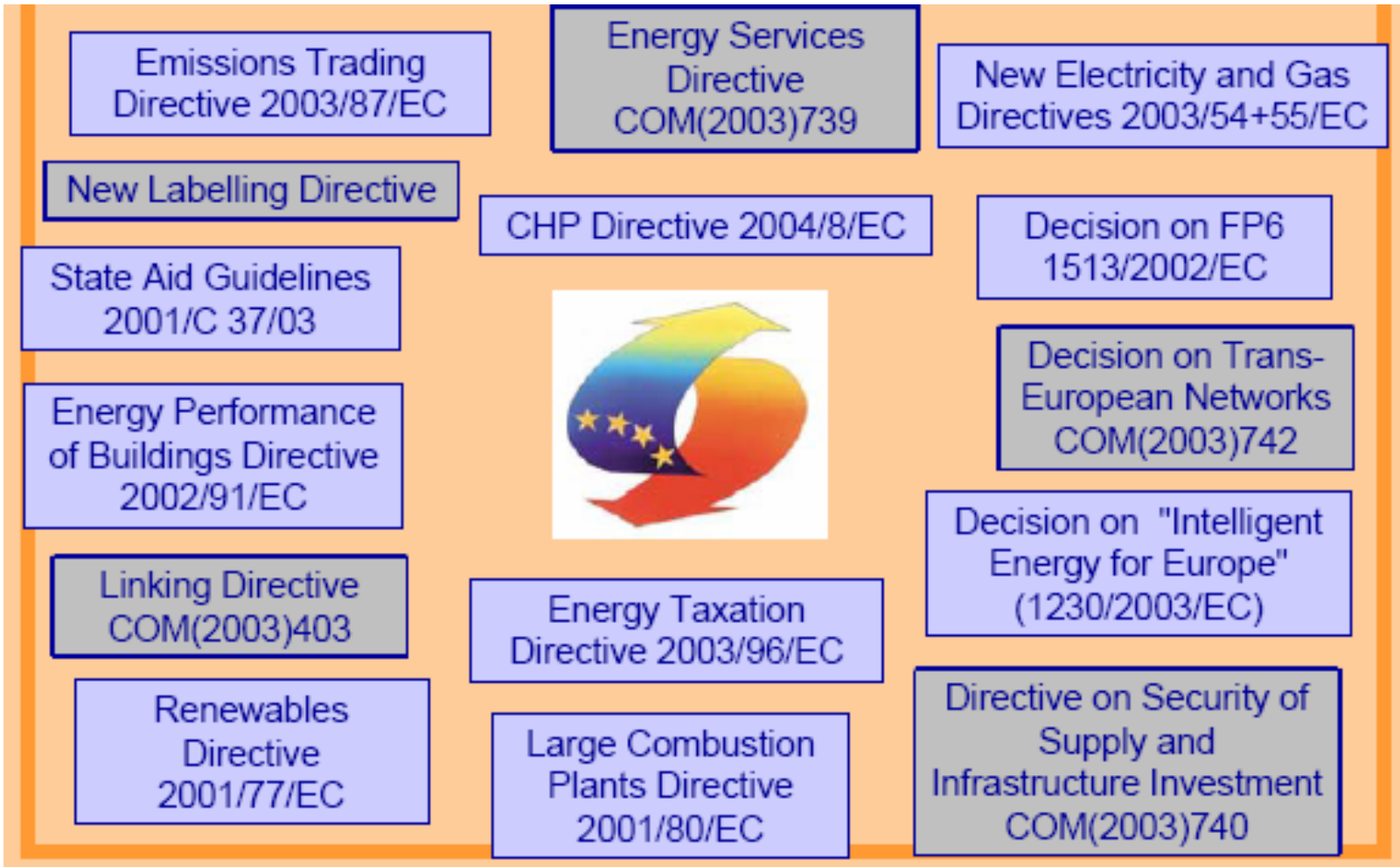


- Community CHP Strategy (1997)
- EU Energy Efficiency Action Plan (2000)
- European Climate Change Programme (2000, 2001)
- Green Book on Security of Supply (2001)
- 6th Environmental Action Programme (2002)

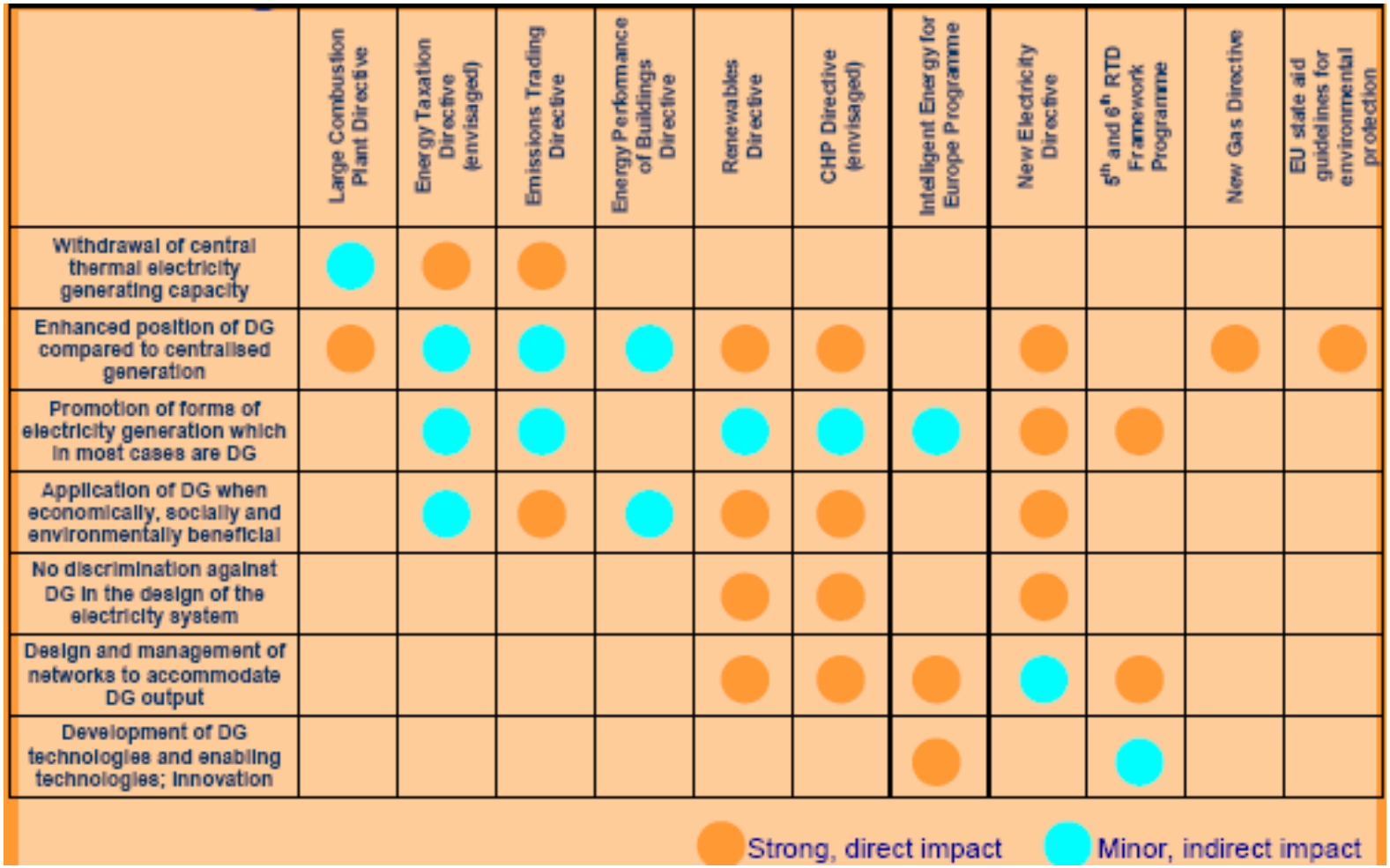
Objective: a competitive energy market



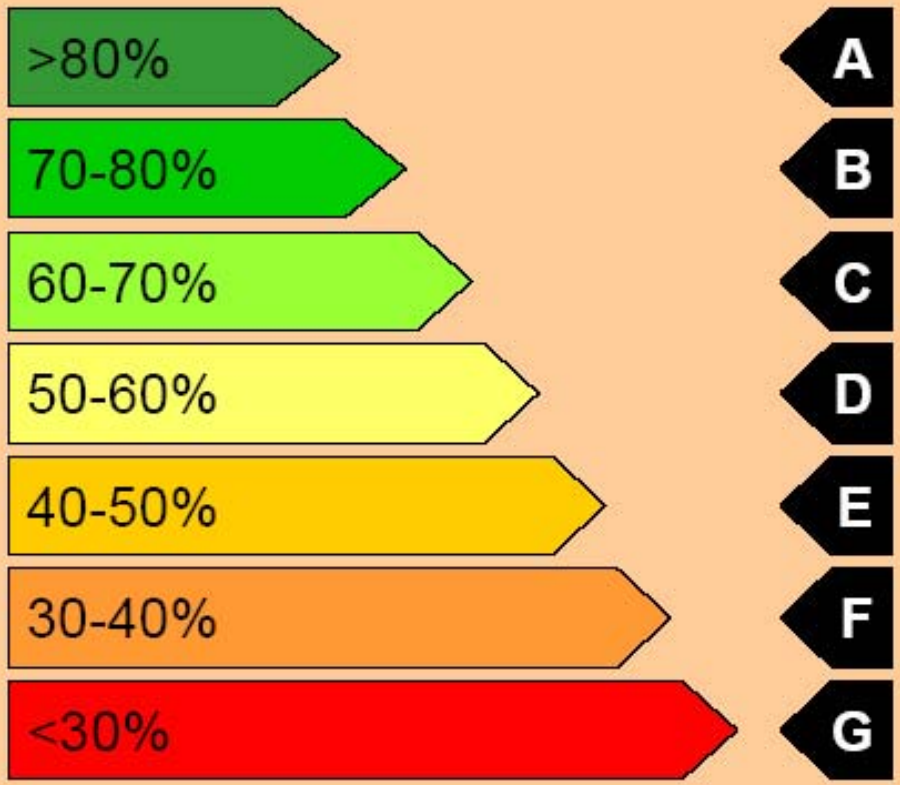
European regulations favoring cogeneration



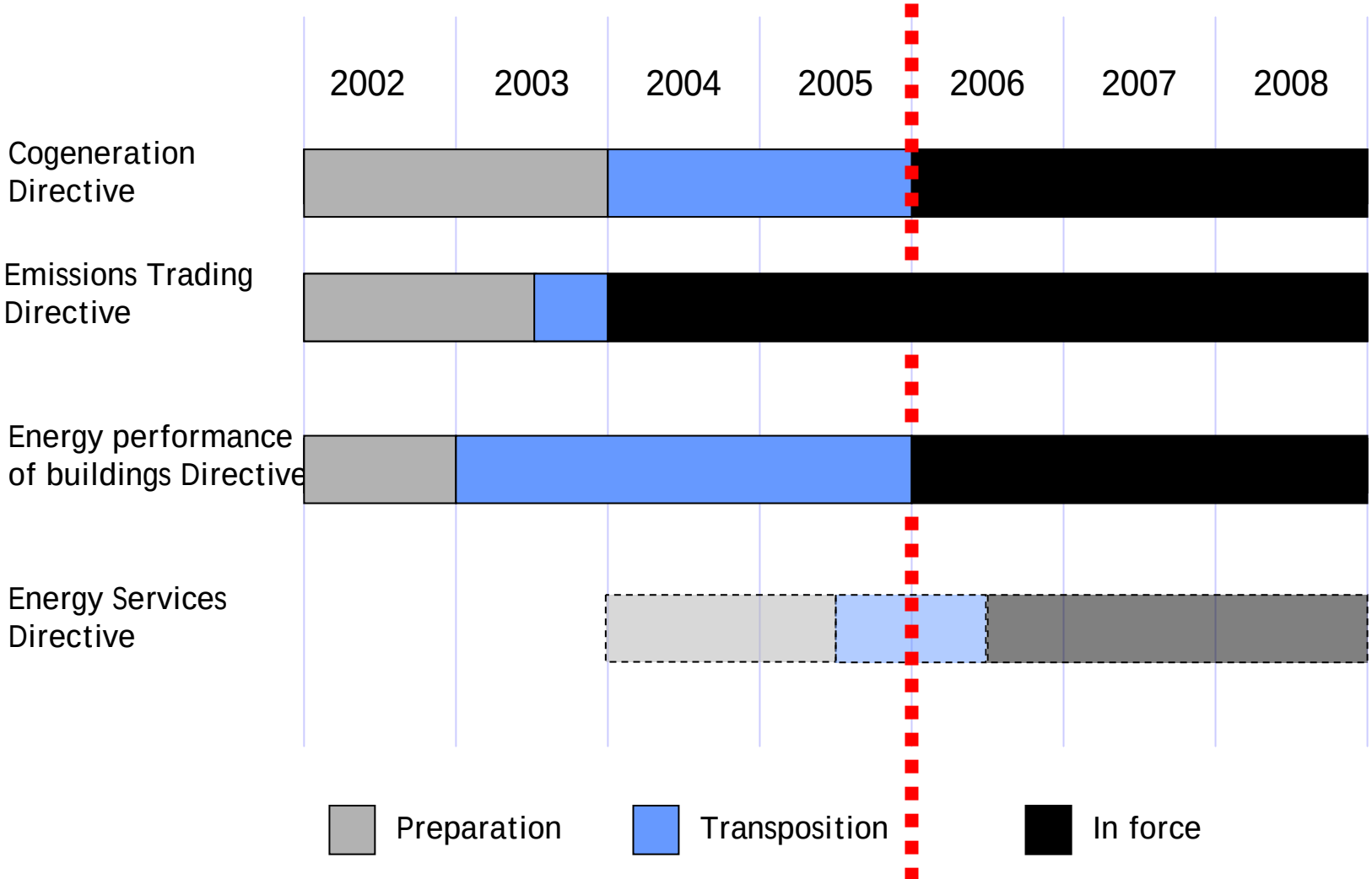
Europe cogeneration legislation



Power plant labeling on efficiency basis



European cogeneration directive



European cogeneration directive

- **Background**
  - Adopted in *February 2004*
  - Implementation deadline *February 2006*
  - Article 1: “Creating a framework for promotion and development of high efficiency cogeneration”
  - Member States must report by *February 2007* their progress towards increasing the share of high efficiency cogeneration
  - European Commission can propose new measures by February 2008, “if appropriate”
  - Informal EU target of 18% of electricity from cogeneration by 2010 (currently 11%)

European cogeneration directive

- **Legal basis for cogeneration in Europe**
- **Contents**
  - Definitions – of key terms, including micro
  - Guarantee of origin – on request
  - Analysis of national potentials and removal of barriers
  - Support directed towards high efficiency cogeneration
  - Streamlining of administrative procedures
  - Fair conditions for grid access
  - Reporting provides basis for new initiatives
  - Harmonised criteria: minimum 10% primary energy savings
  - Alternative possibilities to calculate

European building directive (2002/91/DG)

- **Raison d'être**
  - Harmonised principles for the calculation of the integrated energy performance of buildings
    - *Integration of cogeneration into calculation methods (takes into account the positive influence of electricity produced by cogeneration, or district heating and cooling systems)*
  - Minimum requirements on the energy performance of buildings
  - Energy certification of buildings
  - Regular inspection of boilers, air conditioning systems and old heating installations
  - New buildings
    - *Mandatory cogeneration feasibility study (if total useful floor area > 1000 m^2, need to consider cogeneration and district heating and cooling before construction starts*

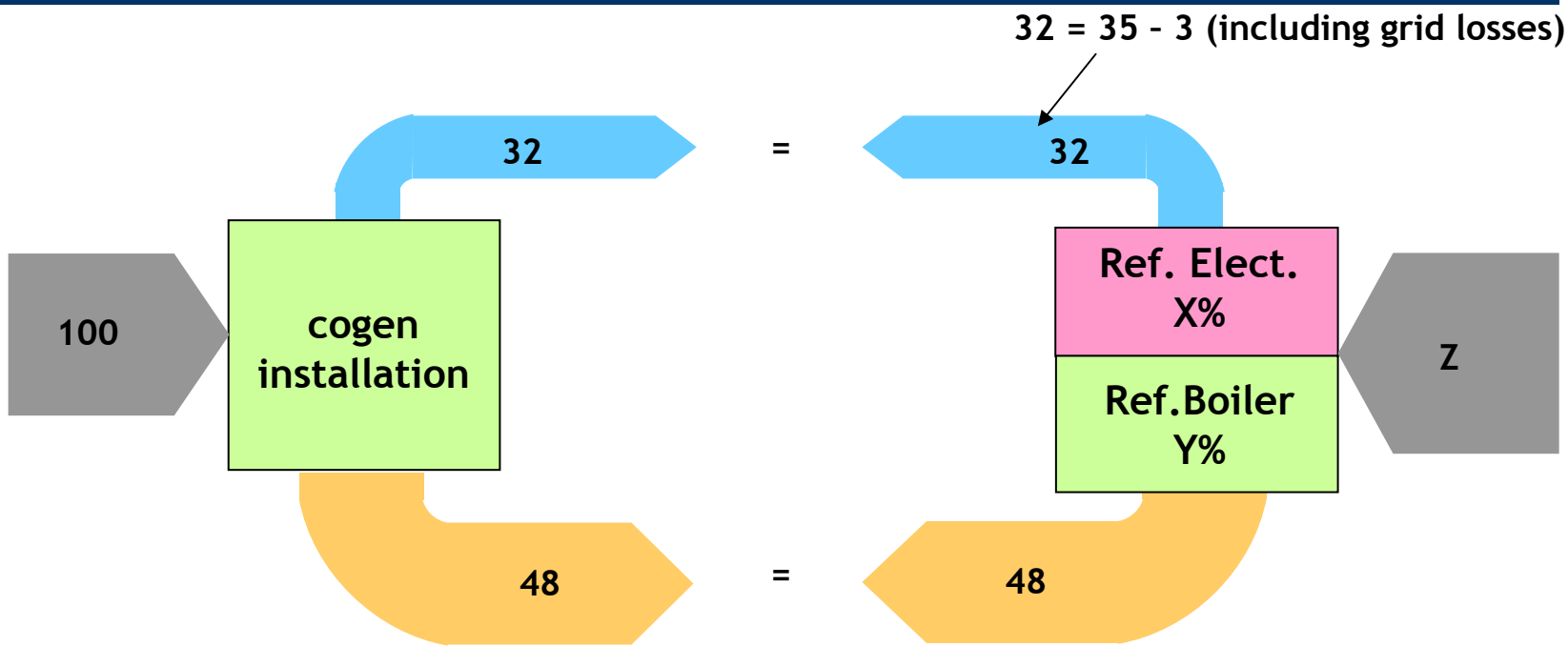
European cogeneration directive

- **Definition of high efficiency cogeneration**
  - All CHP plants up to 1 MWe, which provide any primary energy savings (PES)
  - Larger plants, which provide PES of at least 10%
  - PES is normally calculated for each individual CHP plant with following formula

$$PES = \left[1 - \frac{1}{\frac{CHP\ H\eta}{Ref\ H\eta} + \frac{CHP\ E\eta}{Ref\ E\eta}} \right] \times 100\ \%$$

  - Other PES calculation formula possible

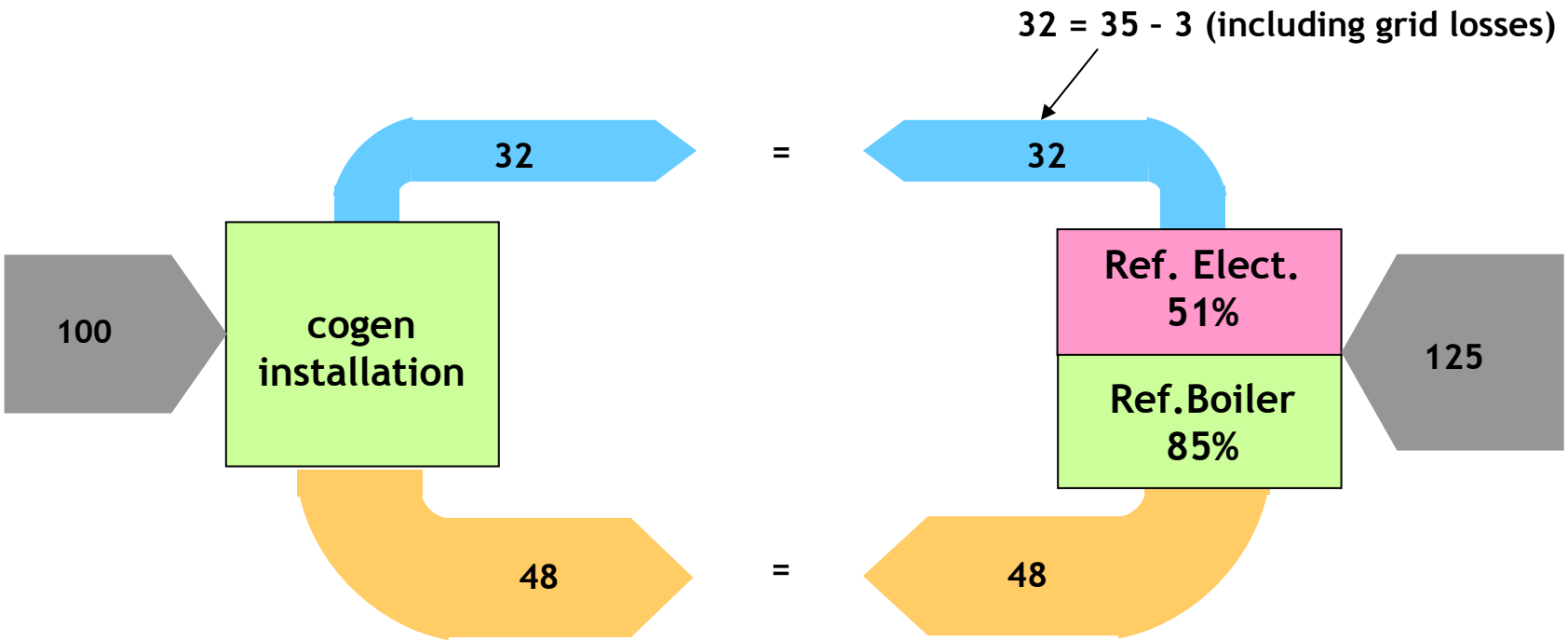
Primary energy savings



Savings > 10%

Comparison of energy consumption for cogeneration and for separate production of electricity and heat

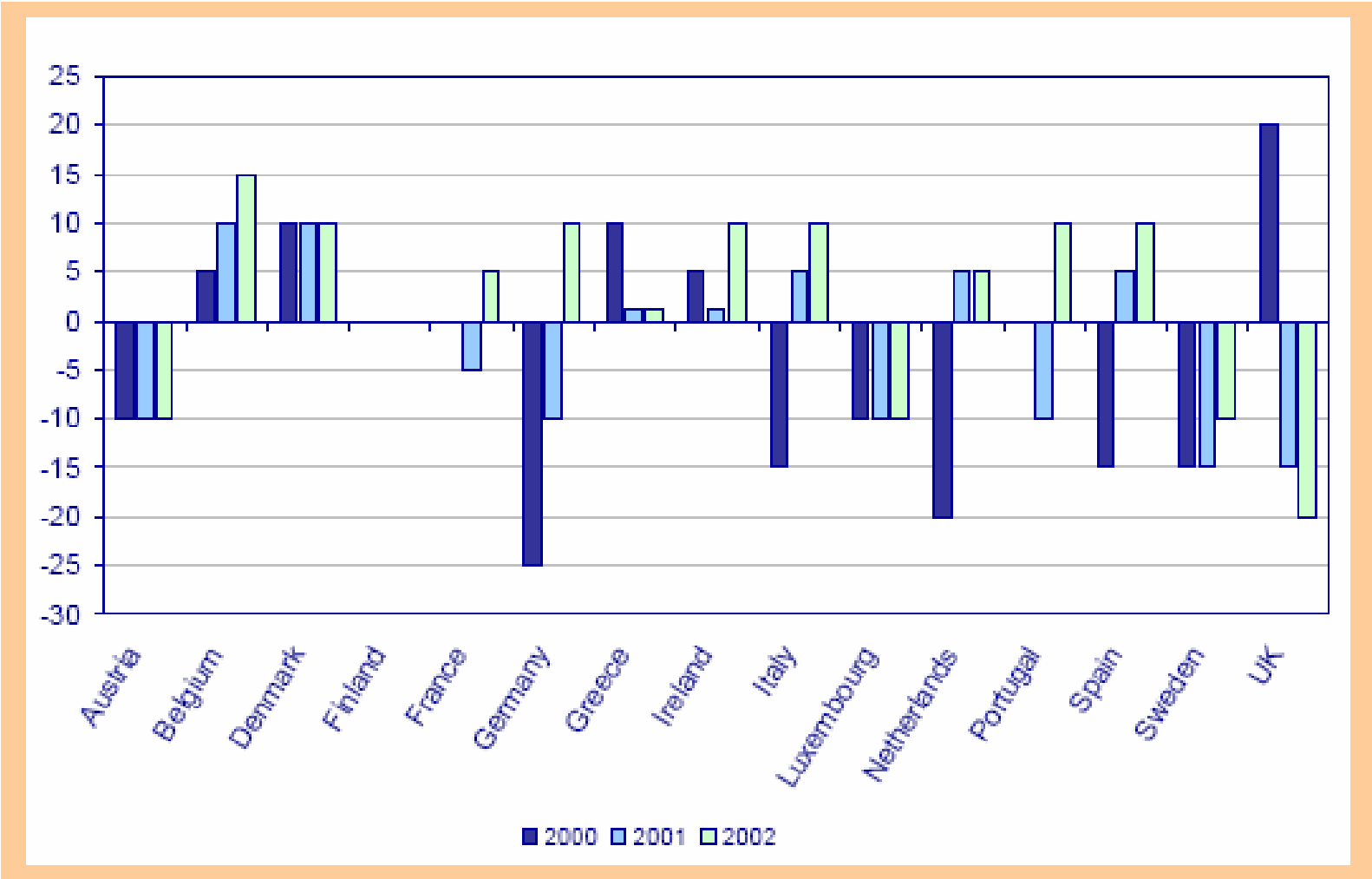
Primary energy savings



Savings = 125-100 = 25 = 20%

Comparison of energy consumption for cogeneration and for separate production of electricity and heat

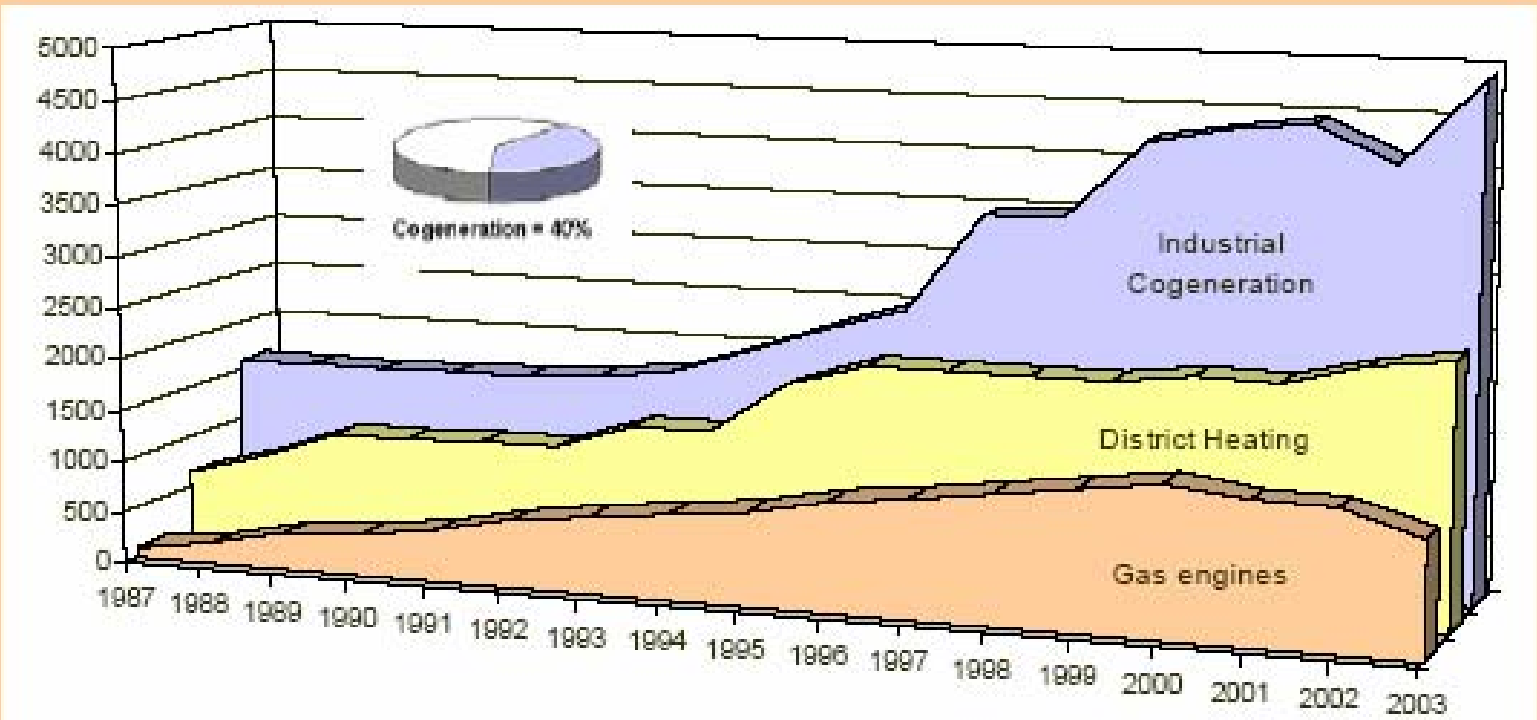
Effects of liberalisation? (2000-2002)



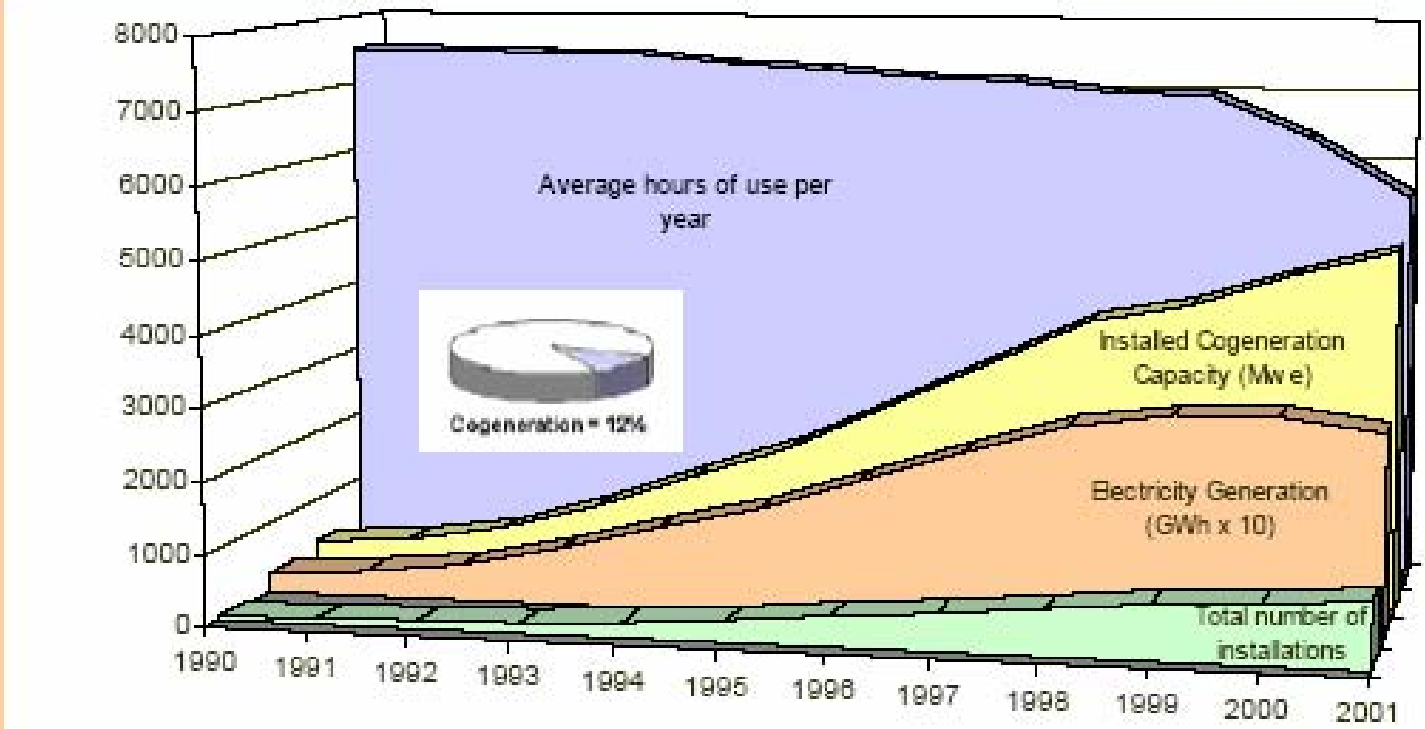
Effects of liberalisation?

- **Immediate effects**
  - Price of electricity fell below sustainable levels, marked by price wars and short-term marginal costs
  - The gas market remained unliberalised with gas pricing dominated by oil price
  - Environmental costs not integrated and thus not reflected in prices
  - Regulatory uncertainty has put investment on hold
  - It is almost impossible to build any new generating capacity

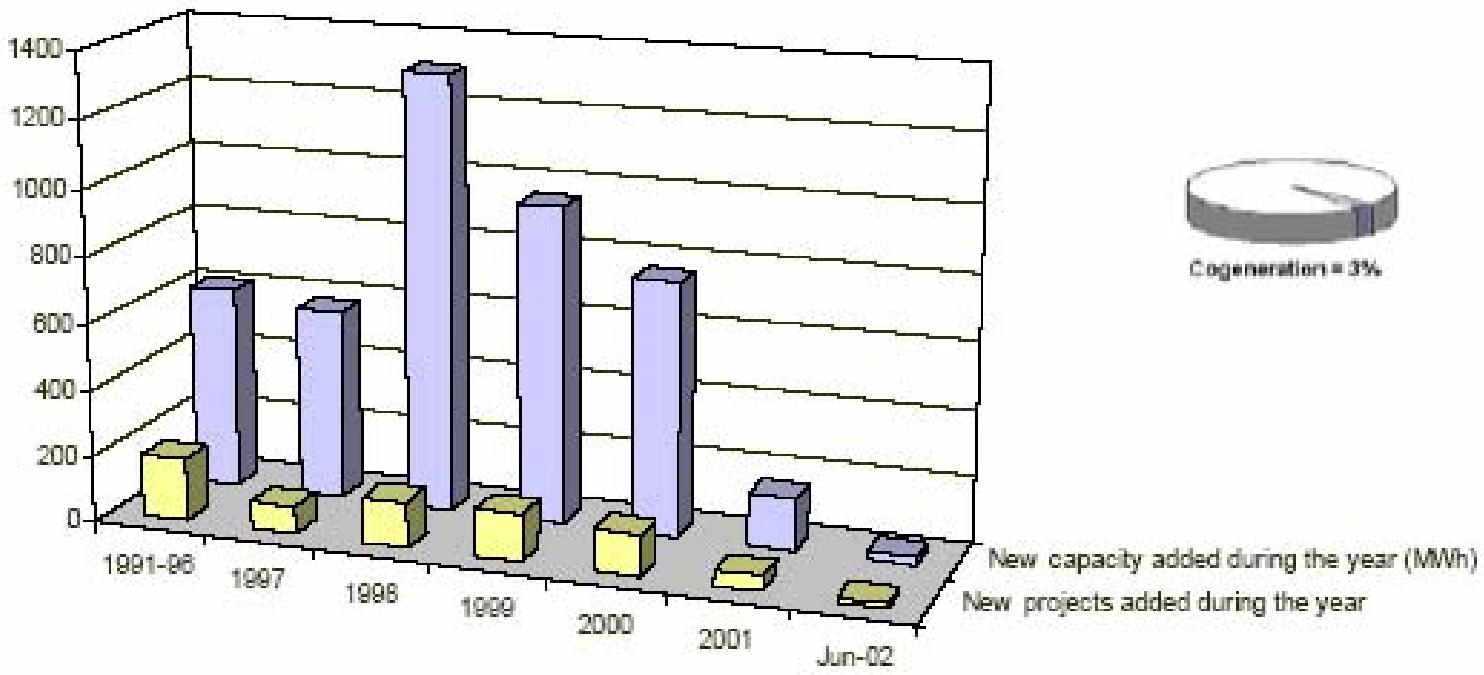
Cogeneration in the Netherlands



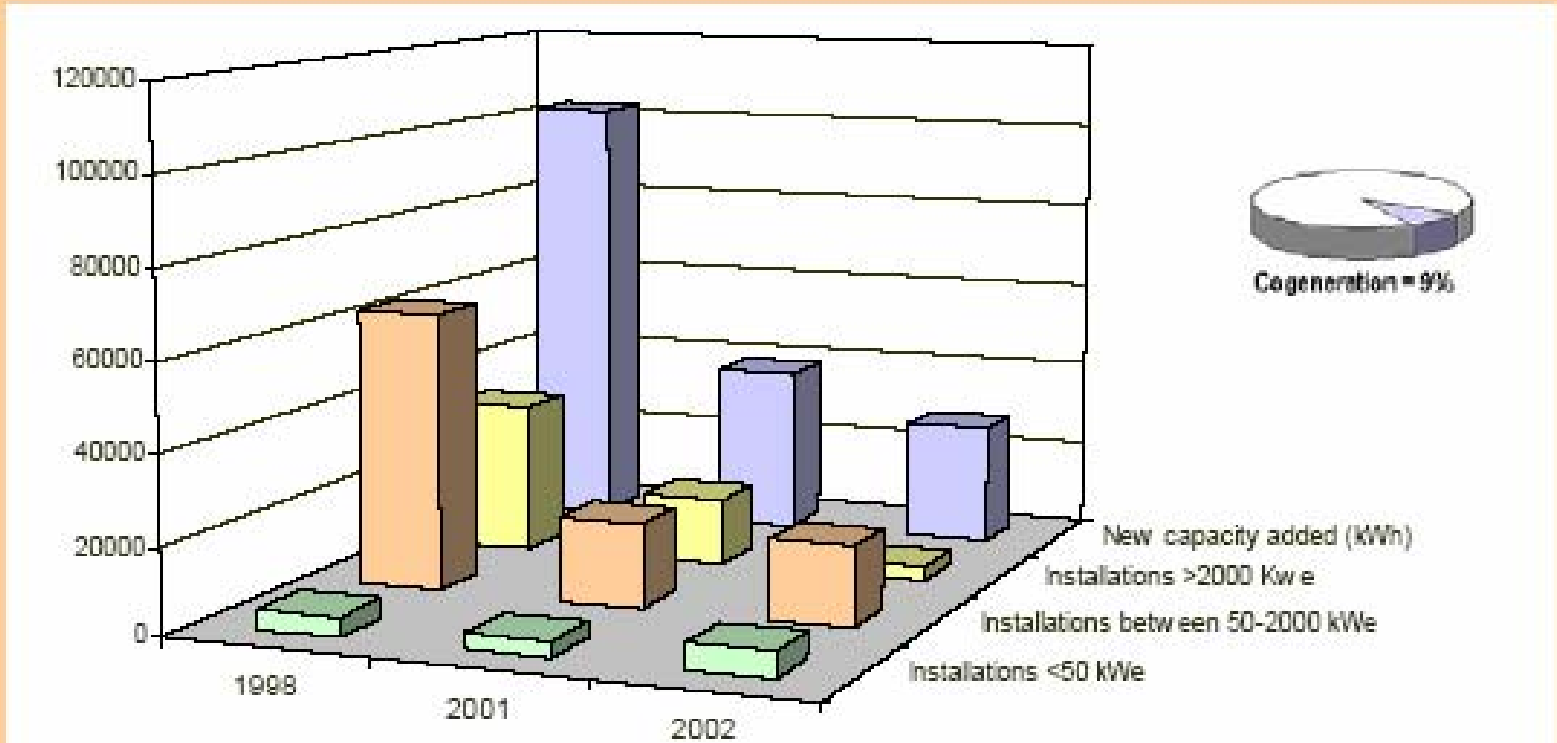
Cogeneration in Spain



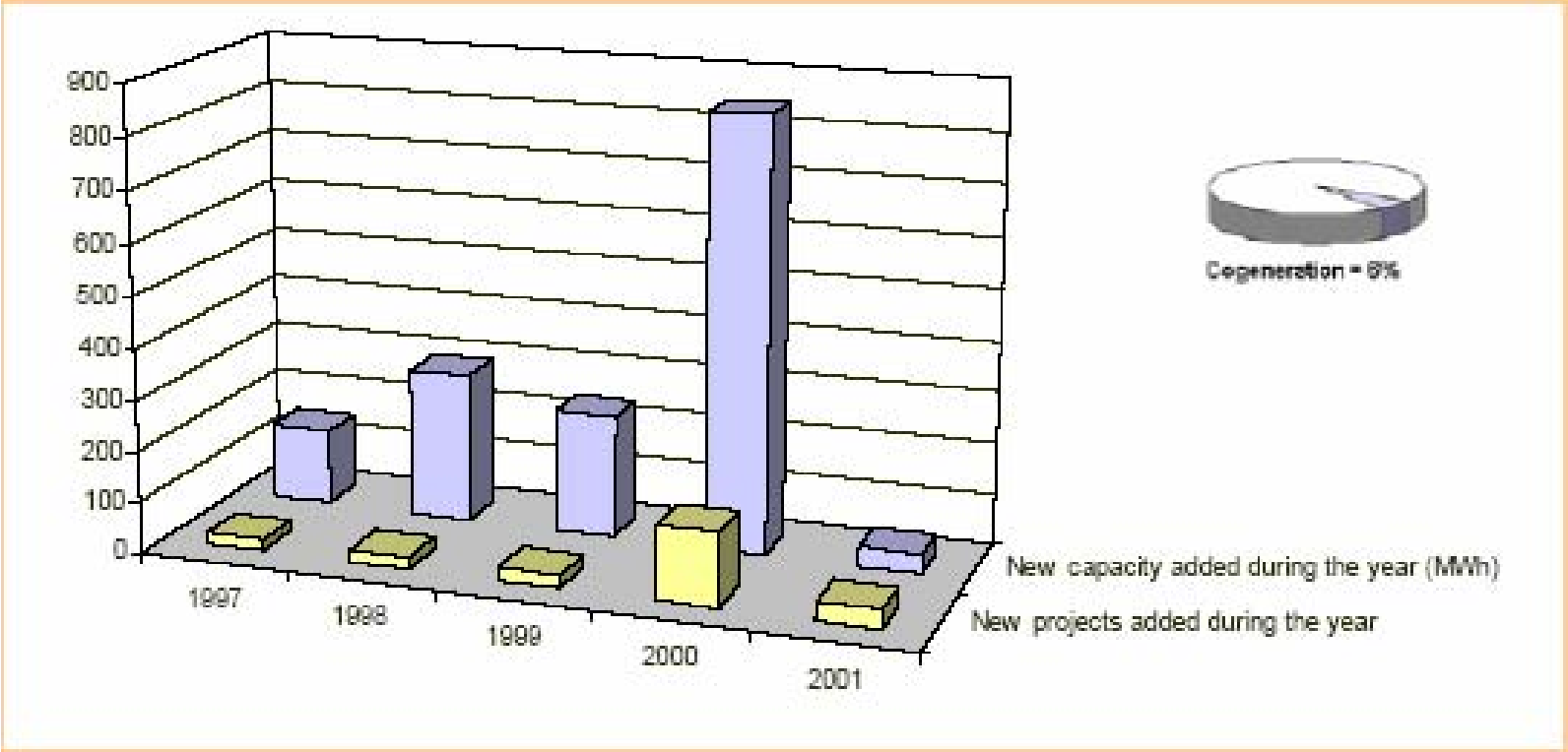
Cogeneration in France



Cogeneration in Germany



Cogeneration in the United Kingdom



Emissions trading scheme (ETS)

- ETS is the biggest single effort for fulfilment of EU climate change commitments (Cap and Trade System)
- The ETS is designed to promote low-carbon technologies such as cogeneration
- As of 1 January 2005, approximately 12 000 energy intensive installations monitor and report their CO_2 emissions
- ETS gives emission reductions a value and extra emissions a cost
- 2.2 billion allowances put into circulation annually during first National Allocation Plan (NAP) period
- In the EU-25, cogeneration plants receive very different treatment from one NAP to the other

ETS National Allocation Plans (NAPs)

- The first trading period is in effect since 1 January 2005
- All 25 national allocation plans (NAP) are accepted by the European Commission
- No harmonisation across EU25
- Due to the Commission scrutiny the amount of total emissions allowances has been cut by 290 million
- For the NAP 1 period (2005-2007), there are 2.2 billion allowances issued per year

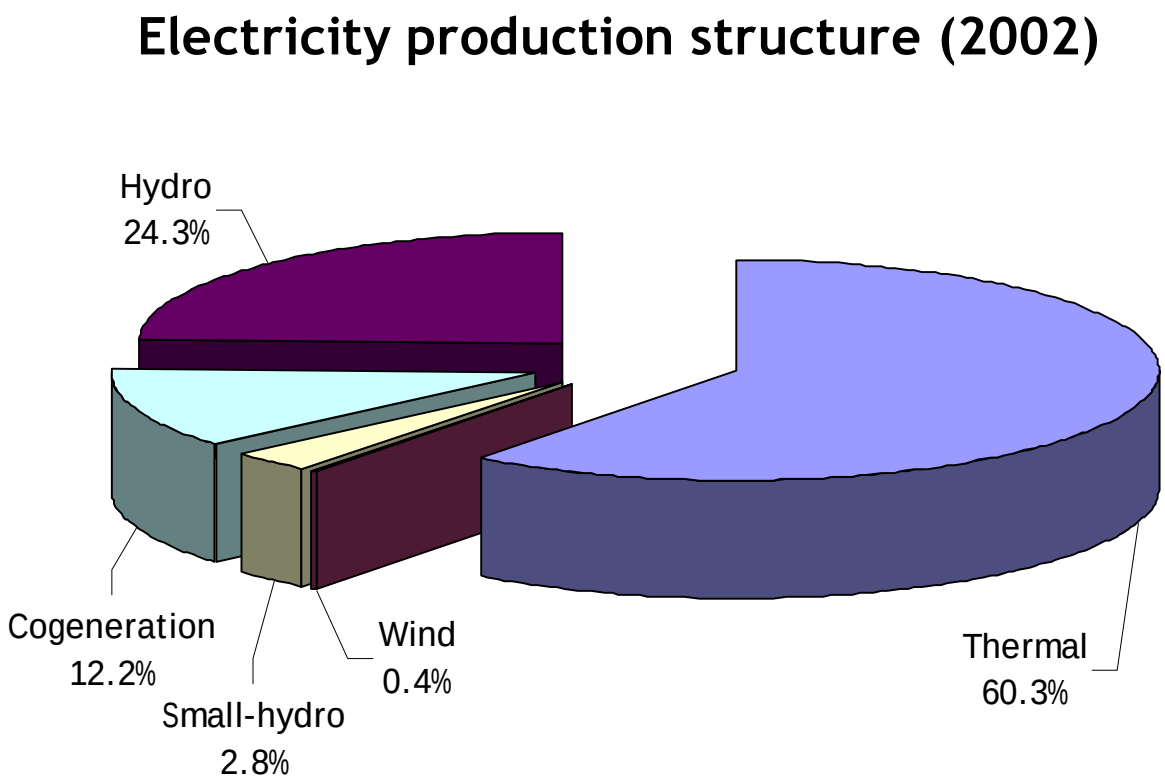
ETS: Factors affecting cogeneration

- Lengths of next NAP periods
- EU wide benchmarks
- Auctioning
- Harmonisation of allocation methods
- New entrants
- JI/CDM
- Definition of combustion installation
- Inclusion of other GHGs and sectors

Cogeneration review: Portugal

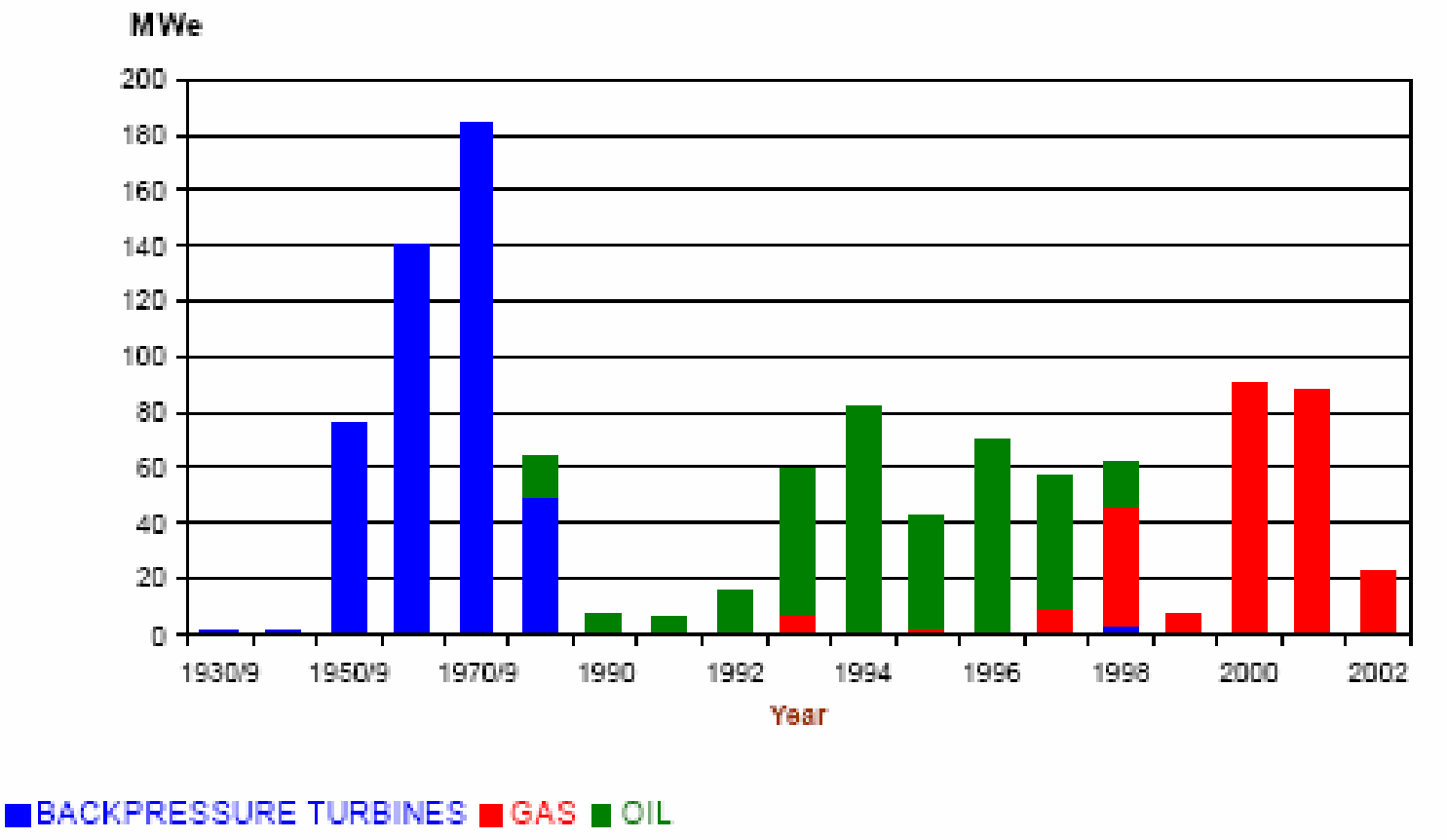
	Installed power 2001 (MW)	Power to be installed until 2010 (MW)
Cogeneration	1 200	500
Renewables		
Wind	*101*	*3 752*
Small hydro	*215*	*400*
Biomass	*10*	*150*
Biogas	*1*	*50*
Solid wastes	*66*	*130*
Waves	*0*	*50*
Solar photovoltaics	*1*	*150*
TOTAL	*394*	*4 682*

Cogeneration review: Portugal



Cogeneration review: Portugal

New cogeneration installed capacity



Cogeneration review: Portugal

- Portuguese cogeneration law
  - Allows the continuity of existing cogeneration plants
    - New efficiency requirements according to technology used
    - Recognition of all energy and environmental improvements through the different technologies employed
  - Makes the integration of multiple cogeneration plants and associated consumers
    - Rules clarification for licensing
    - Correct evaluation of global efficiency increase
  - Applies different remuneration according to type of fuel
    - Based on the avoided costs concept
    - Extending the environmental benefits to the global produced electricity

Cogeneration review: Portugal

- Feedback tariffs = avoided costs

COGENERATION:

$$SP_m = [\,FT + VT + ET\,] \times f_{losses}^{*}$$

RENEWABLES:

$$SP_m = [\,FT + VT + ET\,] \times Z \times f_{losses}$$

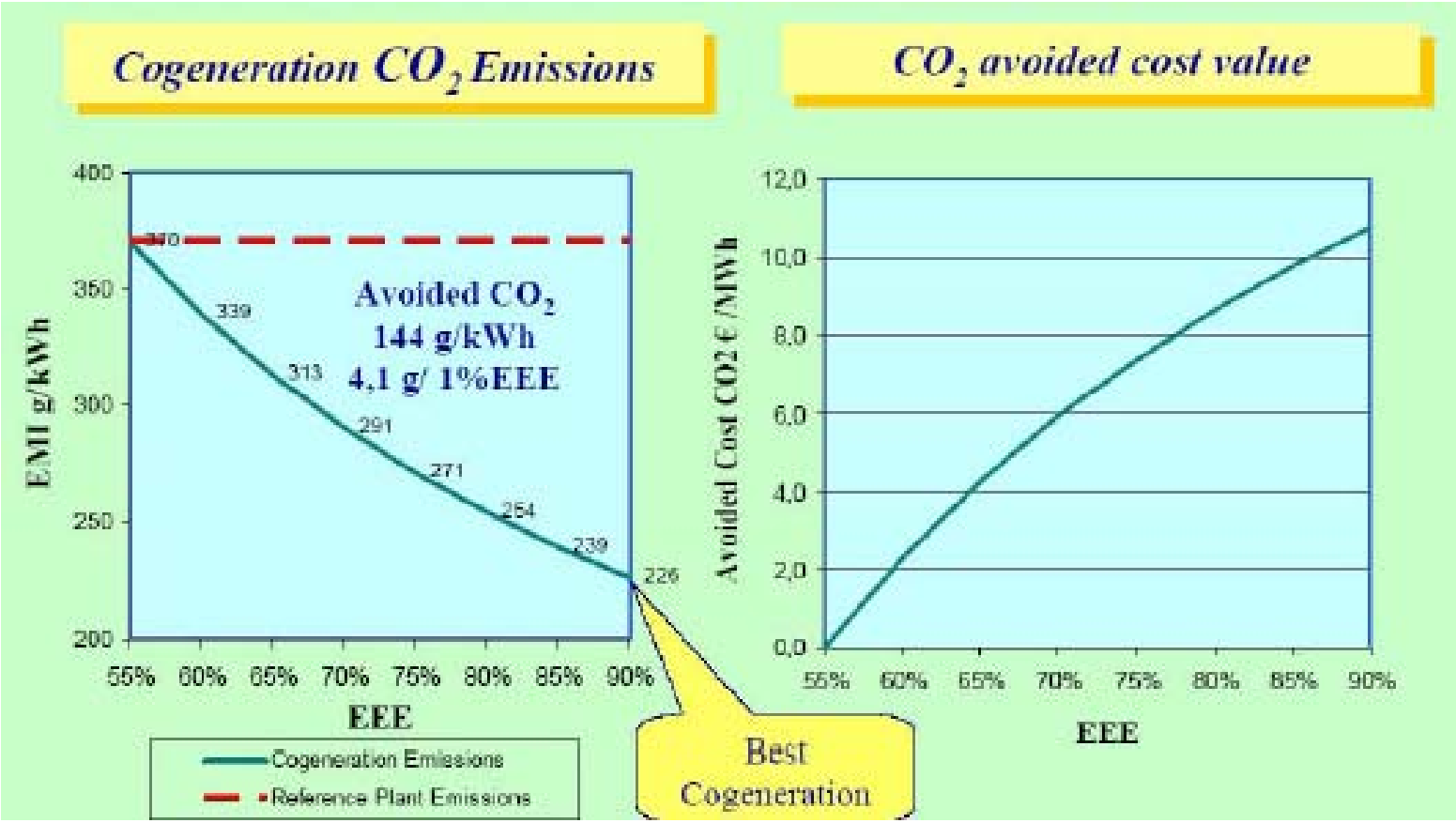
Monthly payment for electricity supplied to the network

- Fixed term → Avoided costs: -new production investment -plant availability
- Variable term → Avoided costs: -Fuel -M&O -Network investment -Network M&O
- Environmental term → Avoided costs: -CO^2
- Technology factor → -Wind according operating hours -Small Hydro -Waves -Solar Photovoltaic -Others
- Network losses factor → Avoided costs: -Transmission -Distribution

* n.a. for > 10 MW

Cogeneration review: Portugal

- Calculation of avoided environmental costs

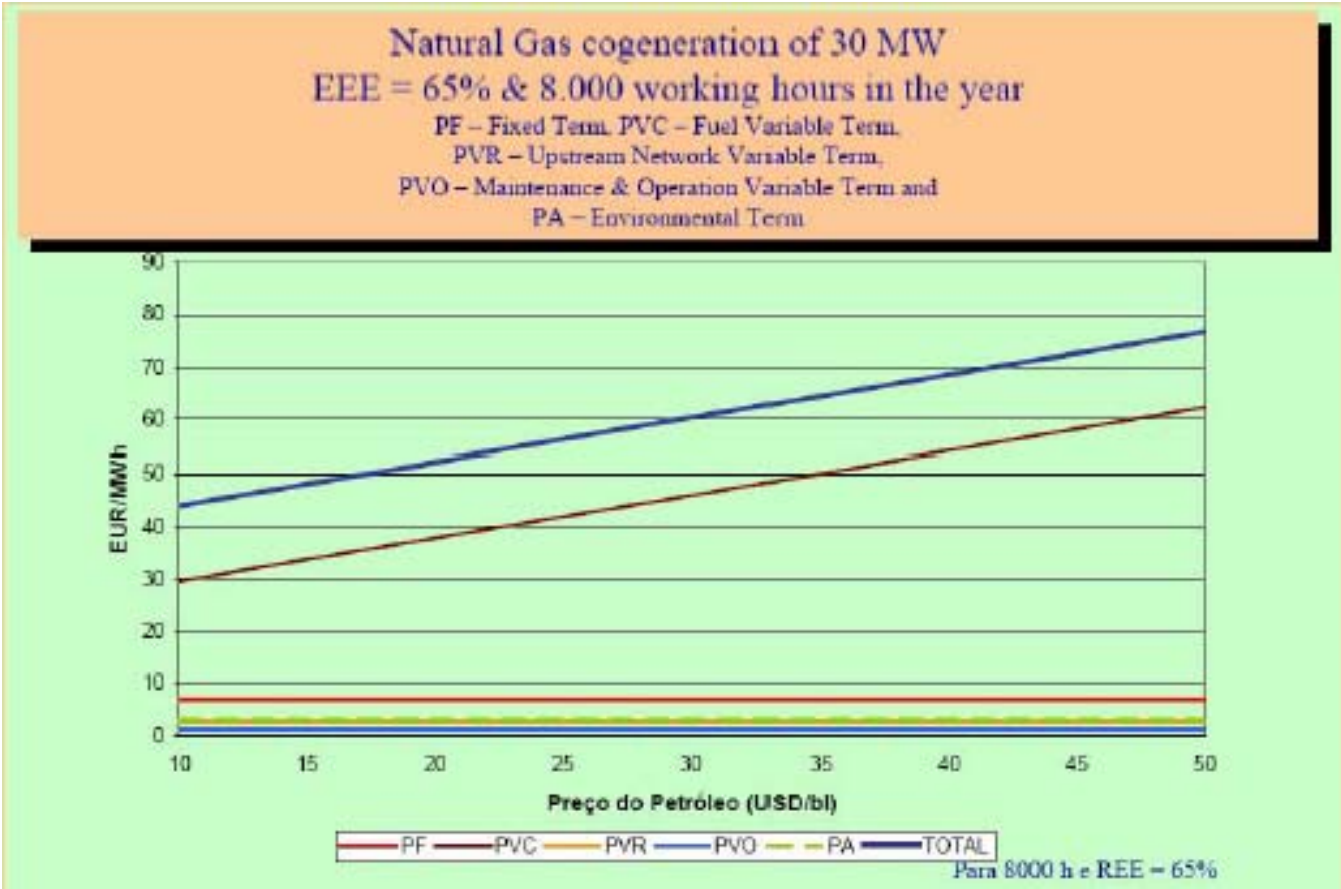


Cogeneration review: Portugal

- Regulation of feedback tariff
  - Government regulation 57/2002
    - Connection power greater than 10 MW
    - Applied to cogeneration consuming NG, LPG or LF excluding fuel-oil
  - Government regulation 58/2002
    - Connection power lower than 10 MW
    - Applied to cogeneration consuming NG, LPG or LF excluding fuel-oil
  - Government regulation 59/2002
    - Any connection power value
    - Applied to cogeneration using fuel-oil
  - Government regulation 60/2002
    - Any connection power value
    - Applied to cogeneration using fuel-oil

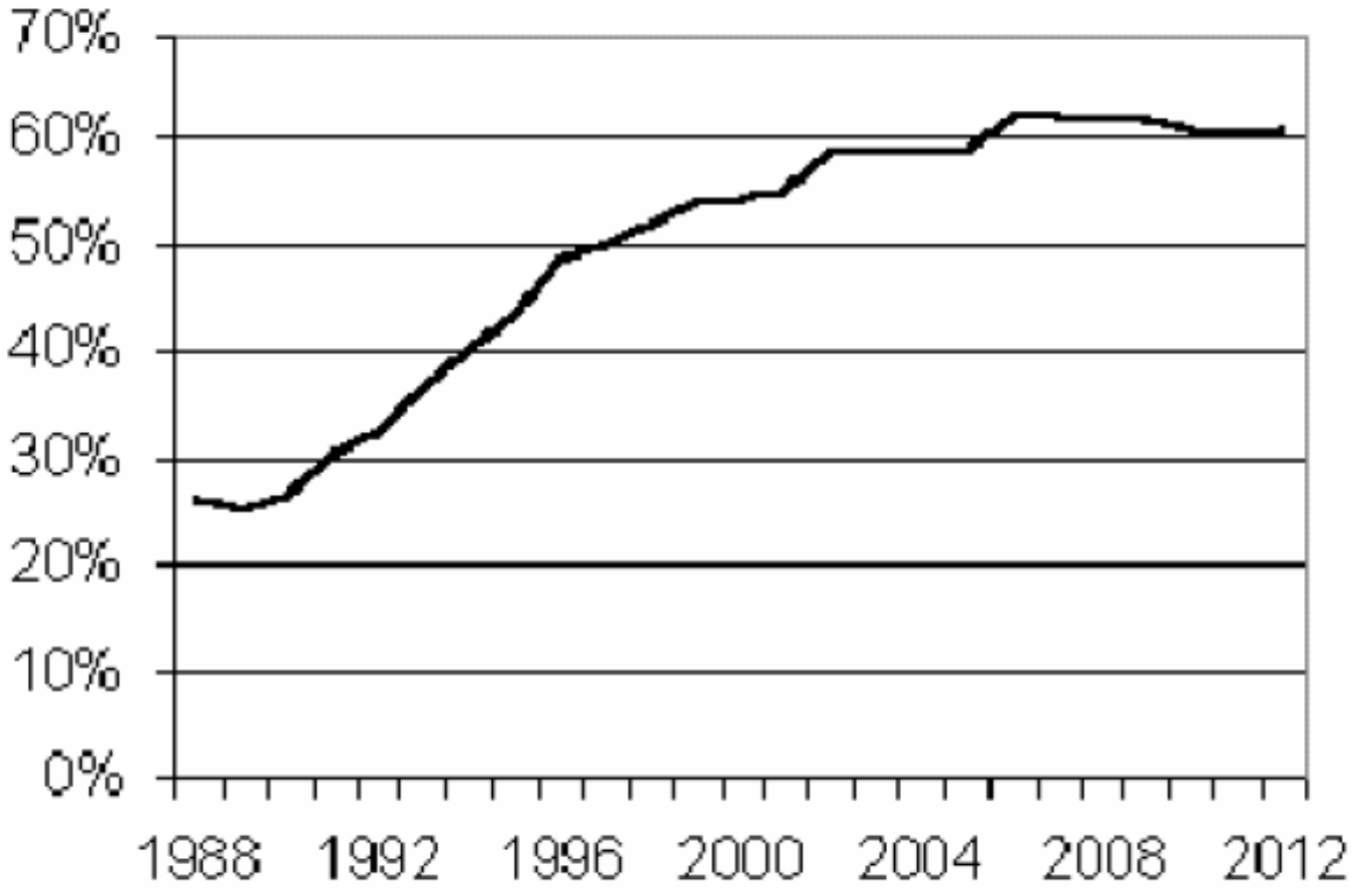
Cogeneration review: Portugal

- Example of Regulation No. 57

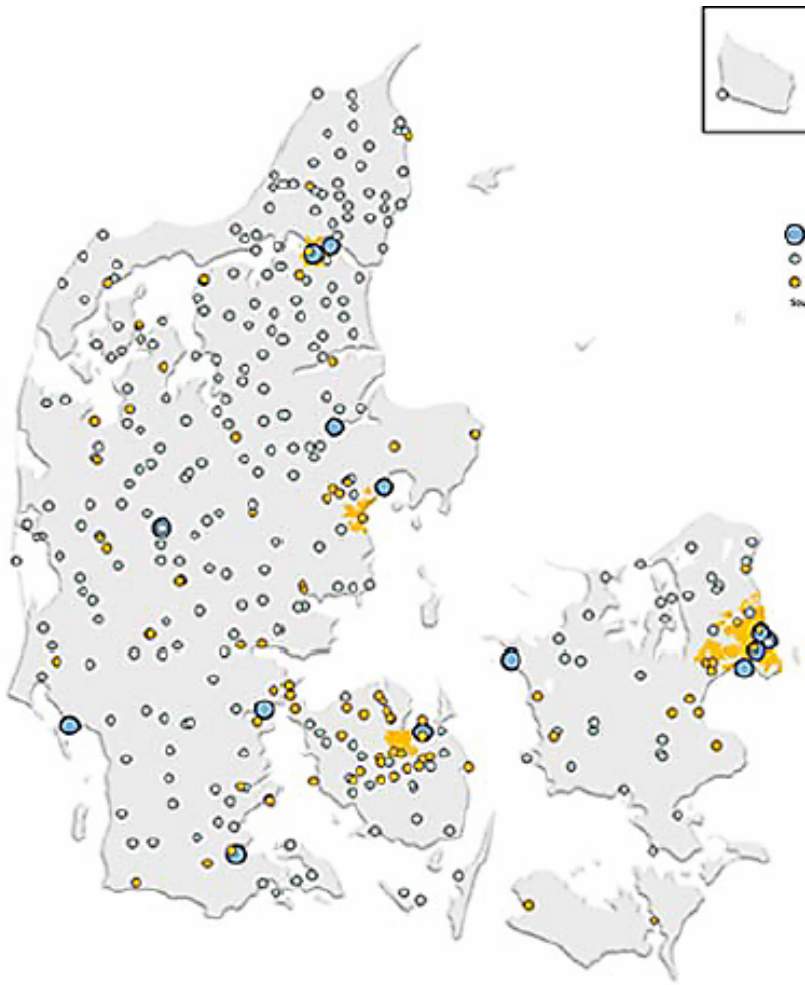


Cogeneration review: Denmark

- Share of cogeneration in electricity supply



Cogeneration review: Denmark



Danish CHP plant

Central CHP
Small scale CHP
Industrial cogeneration

0 25 50 75
kilometers

Cogeneration and big-scale DH
(since the begining of the century but kick-off after the oil schock)

CHP and mid-scale community heating
- generaly 0.5 to 10 MW -
since 1986 mainly

Industrial cogeneration

Domestic micro-cogeneration
2005+?

Cogeneration review: Denmark

- Reasons behind cogeneration expansion
  - Broad political consensus
  - Comprehensive legal framework (legislative and economic incentives) ensuring successful implementation of market conditions along with environmentally compatible energy production
  - Agreements with supply companies
  - Security of supply due to oil crisis at the beginning of the 70s
  - Transparent interconnection rules – shallow interconnection costs
  - Natural gas network in 1985 – North sea oil & gas

Cogeneration review: Denmark

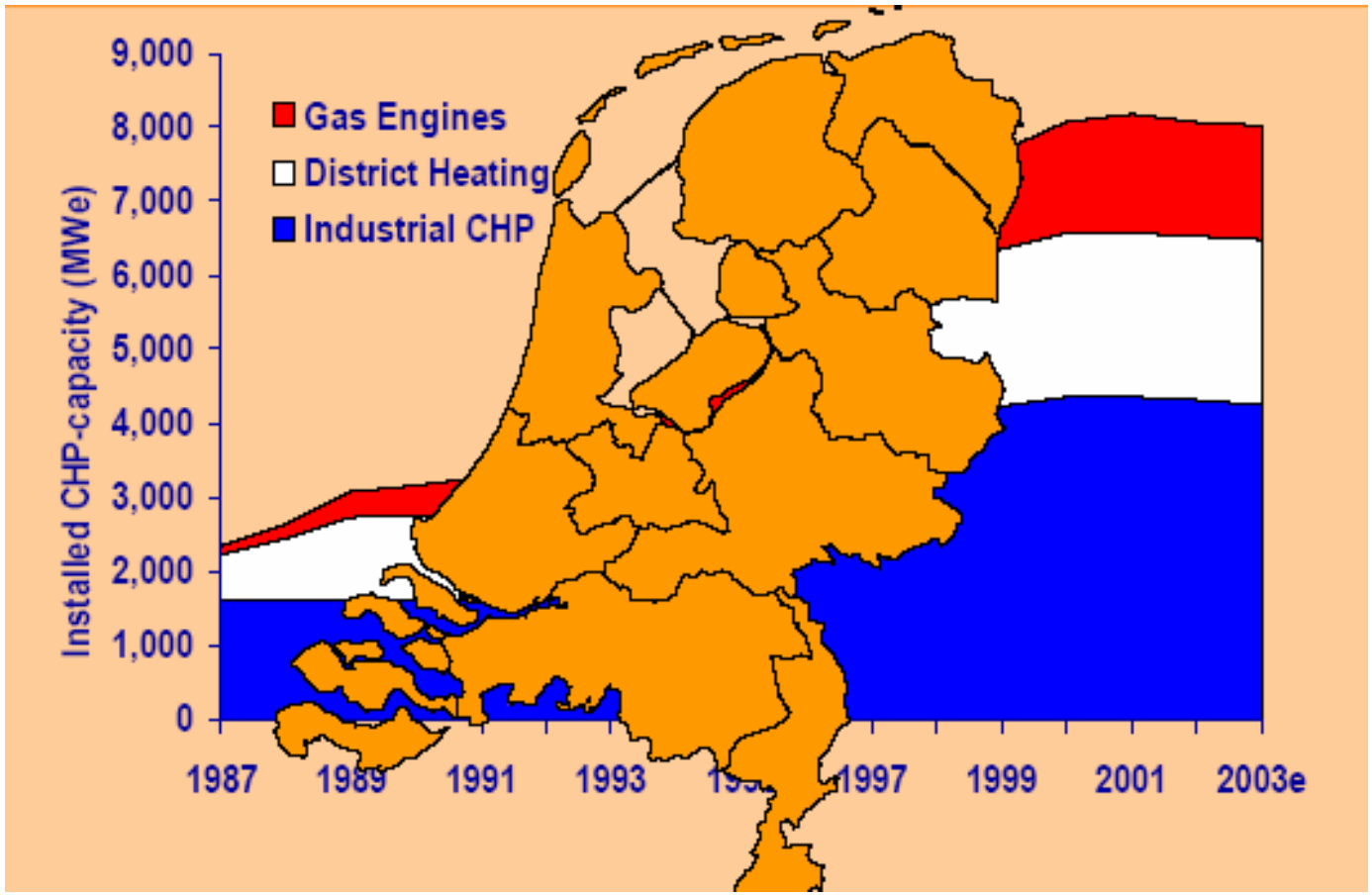
- Political agreement of 1990
  - Based on the first bill on District Heating (1979) and first political agreement on decentralised cogeneration (1986)
  - New heat planning system: Letters of condition to municipalities
  - Conversion of existing plants to combined heat and power supply – 3 phases:
    - 1990-94: large district heating plants from coal/gas to cogeneration (gas)
    - 1994-96: remaining larger coal/gas district heating plants to cogeneration, smaller ones outside gas grid converted to biomass
    - 1996-98: small gas heat-plants to cogeneration

Cogeneration review: Denmark

- Legal framework and incentives
  - Economic incentives
    - Taxes on fuel and electricity (1970s and 80s)
    - Subsidies for cogenerated electricity (1990s)
  - Administrative measures
    - Direct regulation (conversion to district heating and cogeneration)
    - Transparent interconnection rules including shallow interconnection cost
  - Information, R&D
    - Public campaigns, funds for R&D

Cogeneration review: Netherlands

- Need for revitalisation

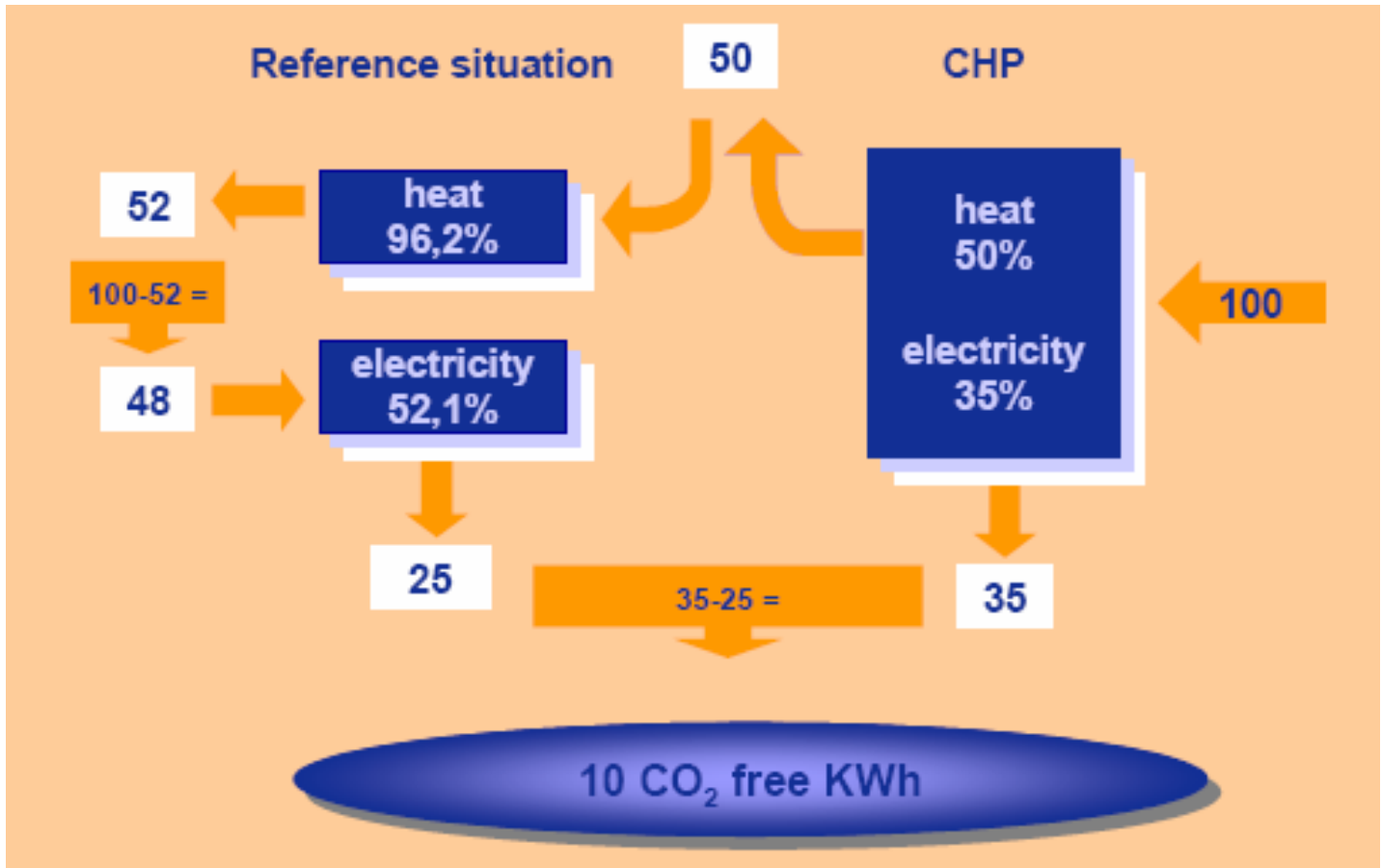


Cogeneration review: Netherlands

- Good potential for renewed cogeneration policy
  - 40% share of electricity market, falling, not cost effective and in difficulties
  - Dutch cogeneration policy needs reactivation
  - CO_2 index (since July 2004) calculated Blue electricity = CO_2 free part of cogeneration electricity
  - Cogeneration certificates reward Blue electricity
  - Cogeneration generated 85% of Dutch CO2 free electricity
  - Yet, considerable measurement and procedural issues to settle

Cogeneration review: Netherlands

- Computing of Blue electricity



Cogeneration review: Netherlands

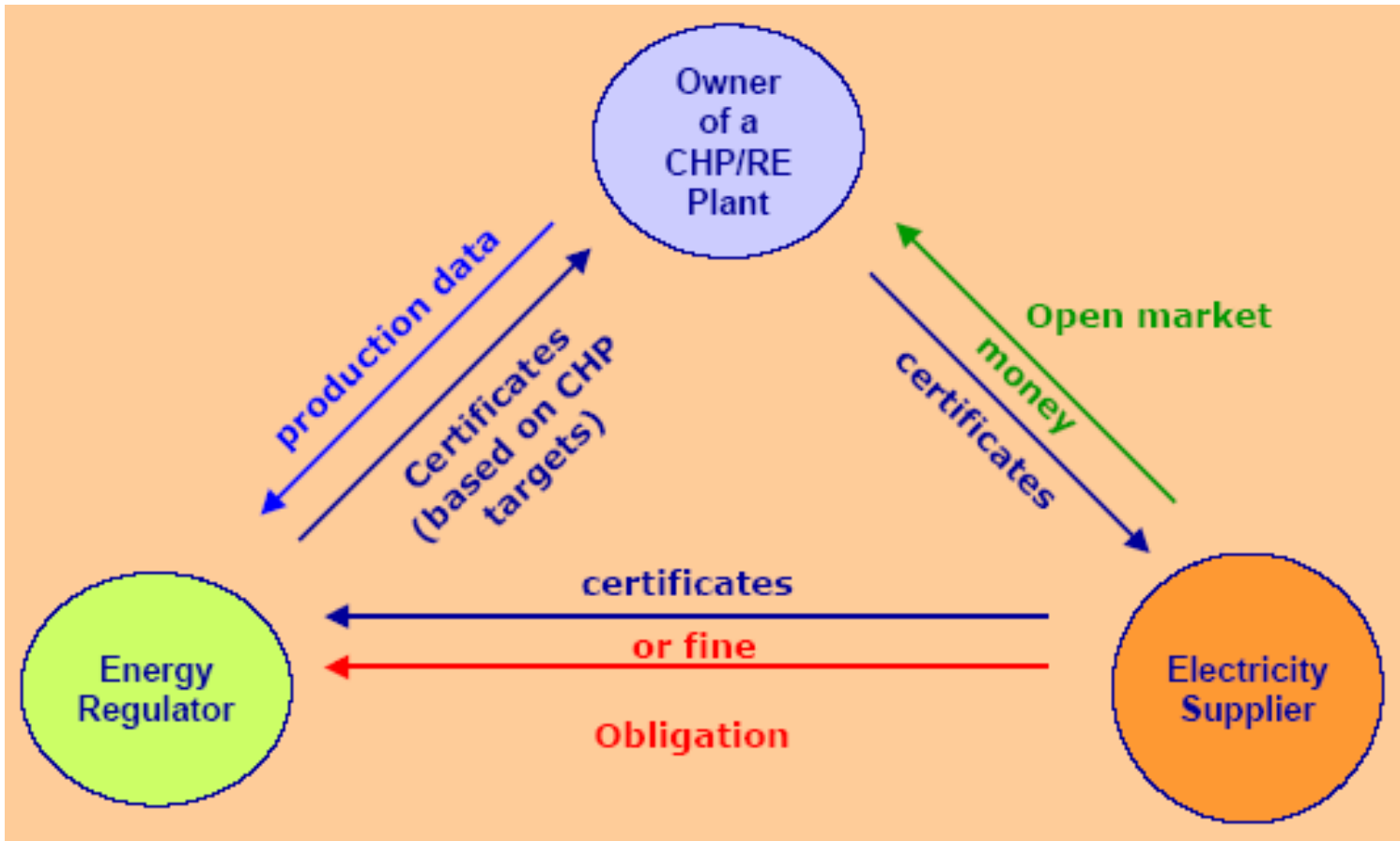
- Promotional policies
  - Long term support for cogeneration from 1985 onwards, plus progressive electricity sector due to structure and incentives
  - Energy investment deduction
  - Exemption from eco-tax for gas used in cogeneration
  - 1st 1000 GWh of cogenerated electricity delivered to the grid rewarded with ¢0.57 euro/kWh
  - Blue certificate scheme
  - Favorable status in NAP but being questioned by the EC

Cogeneration review: Belgium

- Belgian power sector (2001)
  - Total electricity consumption: 80 423 GWh
  - Fuel mix: 58% nuclear, 40% fossil fuels
- Belgian cogeneration (2001)
  - Annual electricity production: 4 511 GWh (5.65%)
  - Annual heat production: 5 885 GWh (21 186 TJ)
  - Trend: stagnation since 2000

Cogeneration review: Belgium

- Basics of certificates



Cogeneration review: Belgium

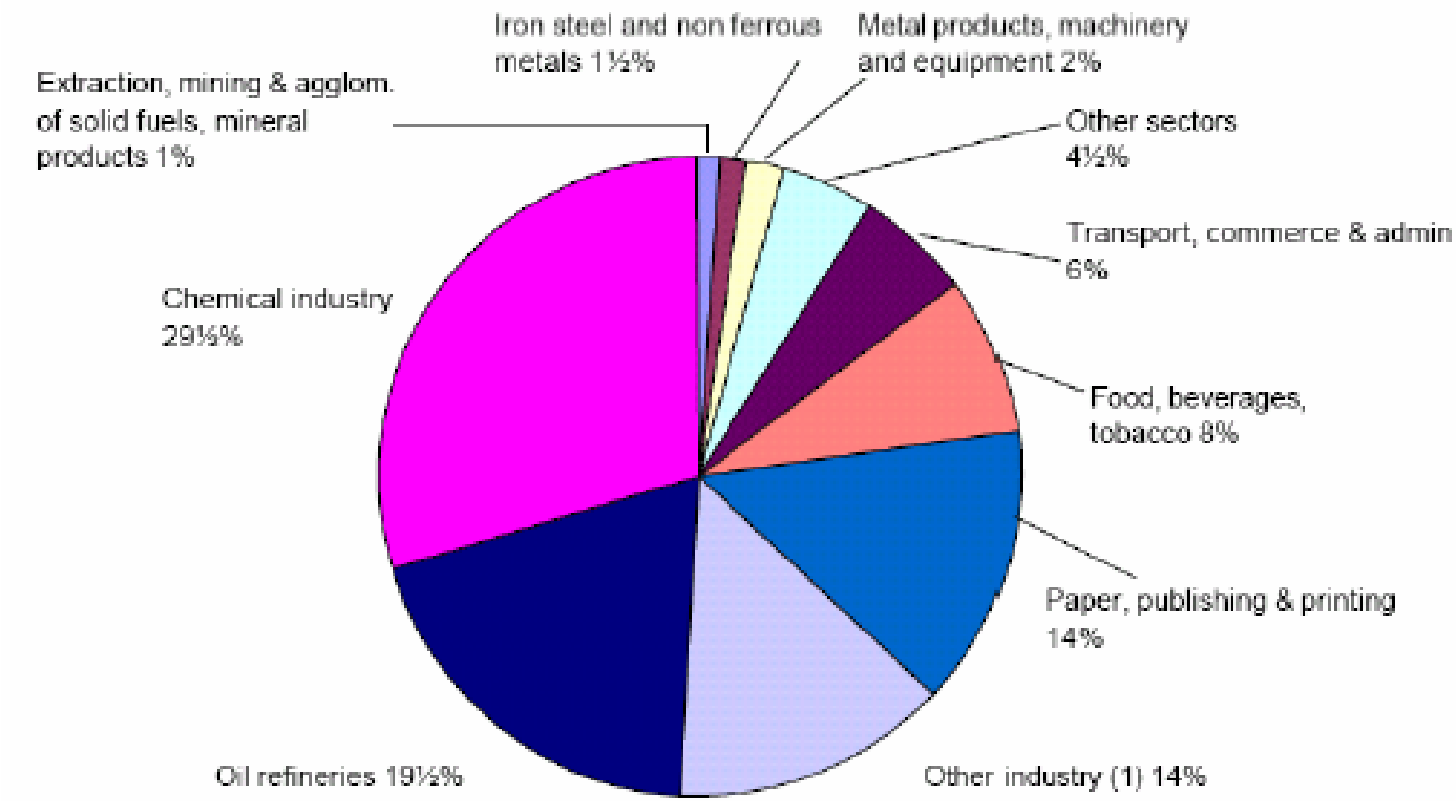
- Green certificate in the Walloon region (2003)
  - Green certificates apply for
    - High quality cogeneration
    - Renewable energy sources
  - Need for a common basis
    - CO_2 emission savings, compared to the best available technology for separate production (reference emissions)
  - One green certificate = 456 kg of avoided CO_2 (equal to emissions of 1 MWh from a 55% CCGT)
    - Emission factors for fuels (natural gas: 251 kg/MWh)
    - Reference values
      - Heat: 279 kg CO_2/MWh or 340 kg/MWh
      - Electricity: 456 kg CO_2/MWh

Cogeneration review: UK

- Past progress
  - 1980s
    - Technology transformation
    - Demonstration schemes
    - Alternative financing
    - 2000 MW_e installation capacity in 1990
  - 1990s
    - Privatisation/liberalisation of energy markets
    - No significant grants/obligations
    - Capacity more than doubles to 4500 MW_e in 2000

Cogeneration review: UK

- Cogeneration installed capacity by sector (2003)



(1) Other industry includes textiles, clothing and footwear, sewage treatment and electricity supply

Cogeneration review: UK

- Cogeneration targets
  - First target of 4 GW_e in 1991 in run up to Rio Earth Summit
  - Following good progress, target increased to 5 GWe in 1993 as part of establishing UK Climate Change Strategy
  - New target of 10 GW_e established in 1999 at Bonn Climate Change Conference
- Cogeneration potential
  - 1997 government estimates 10 – 17 GW_e in commerce and industry
  - 1998 government estimates + 2 GW_e for district energy
  - More recent district energy – up to 14 GW_e
  - Micro-cogeneration 0.4 to 1 GW_e by 2010

Cogeneration review: UK

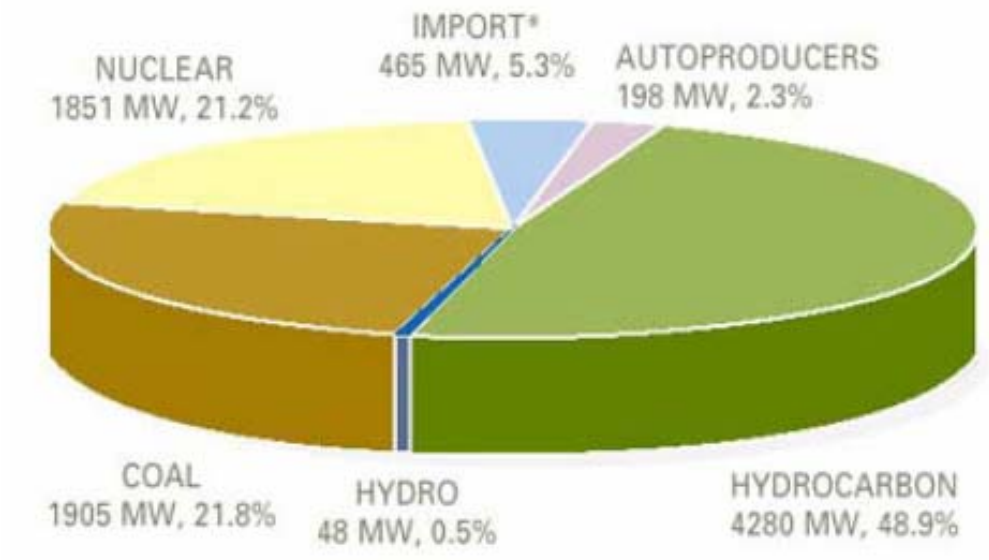
- Impact of New Electricity Trading Arrangements (late 2001)
  - No central despatch, all bilateral trades, penalties for not meeting own contract position, poor price data, poor access to market, unmanageable new imbalance risks, etc.
  - Market destroyed by liberalisation
    - Additions of new cogeneration capacity fell by 95% between 2000 and 2001
    - NETA saw the output of existing cogeneration schemes fall by 17%
    - 1 755 MW_e of consented cogeneration projects did not proceed to development
    - All major developers left the market
    - The capacity of operating cogeneration plants dropped
    - 11 MW_e of less cogeneration plant operating in 2002

Cogeneration review: UK

- **Effective government measures?**
  - **Climate Change Levy (CCL) exemption**
    - But – *two years to get full exemption*
  - **Climate Change Agreement**
    - But – *80% discounts*
  - **The UK Emissions Trading Scheme**
    - But – *Projects Mechanism introduction postponed*
  - **Business Rates exception for power generation plant and machinery**
    - But – *Originally proposed as an exemption*

Cogeneration review: Hungary

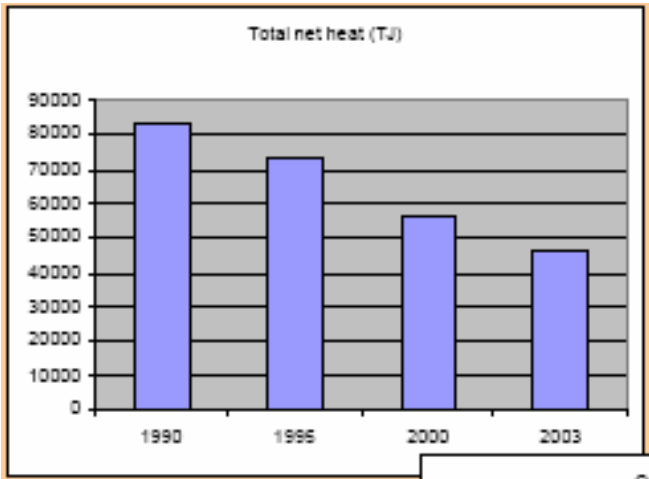
- **Installed capacity by fuel**

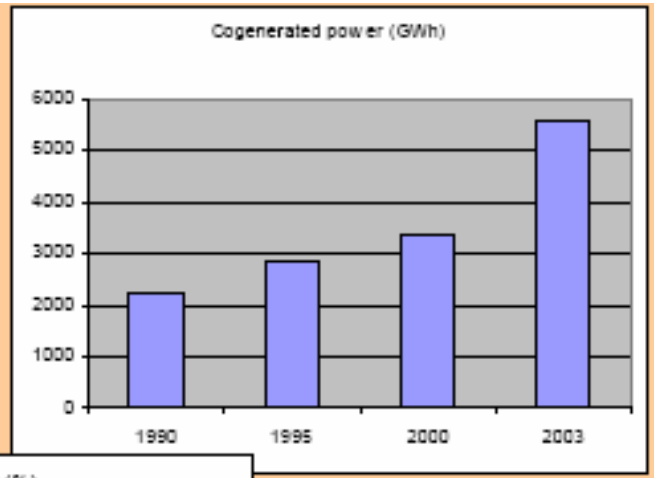


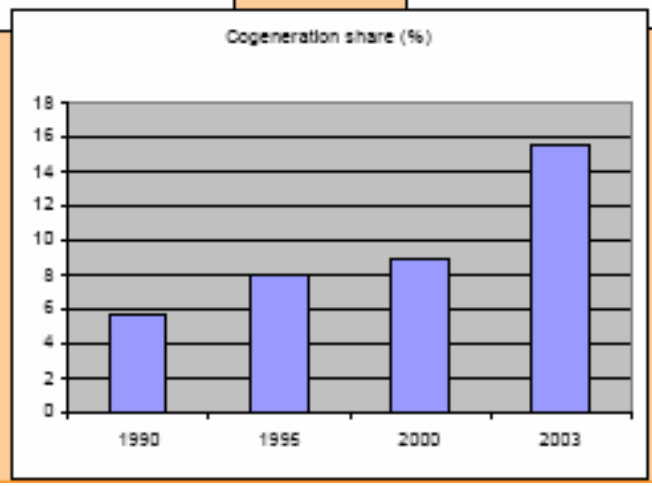
- **Types of cogeneration plants**
  - Public power supply
  - Urban district heating schemes
  - Industry
  - Small-scale

Cogeneration review: Hungary

- **Share of cogeneration in the energy system**







Cogeneration review: Hungary

- **Cogeneration potentials**
  - **Cogeneration electricity to represent 20-22% of total electricity generation by 2010**
  - **Growth expected to come from brand new installations, and from the expansion and modernisation of existing plants**
  - *According to COGEN Europe estimates, cogeneration could cover up to 40% of total electricity demand in Hungary*
    - *Extensive distribution network for natural gas (87% of towns connected by end 2001)*
    - *High number of district heating systems*
    - *Need for new generation capacity in the next few years*
    - *Successful restructuring of the energy sector*

Cogeneration review: Hungary

- **Cogeneration outlook**
  - **National district heating policy**
    - Uncertainties about regulatory framework
    - Official heat pricing does not allow basic investments to be made
    - Social barriers against heat market liberalisation
  - **Development of the power sector**
    - Government plans to stop polluting power plants from 2005
    - Shut down of 1 070 MW of installed capacity by 2006 expected
    - Old coal- and oil-fired water boilers to be replaced by natural gas fired combined cycle cogeneration plants
    - Opening of the natural gas market will have decisive influence

Cogeneration review: Italy

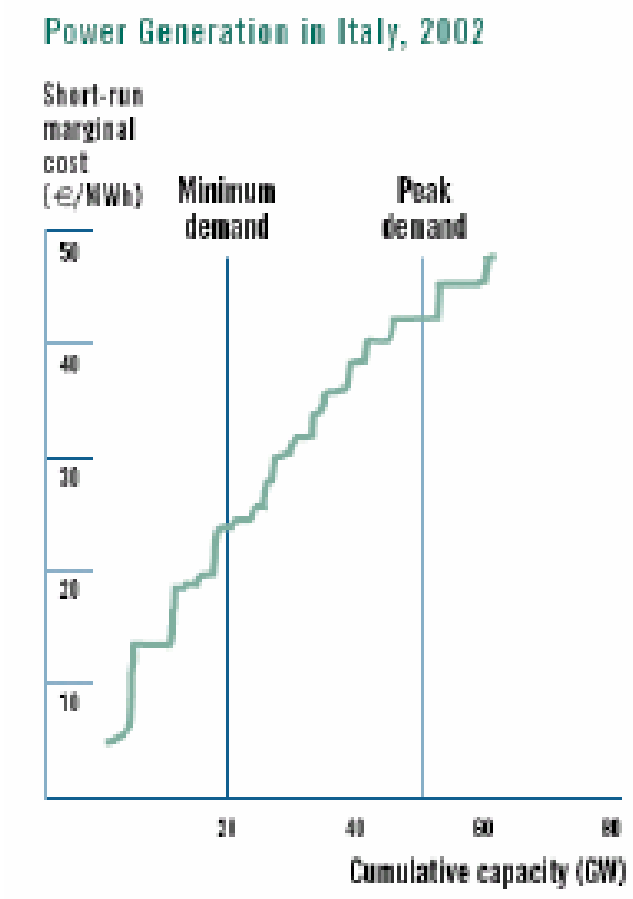
- **Cogeneration potential**
  - Very high cogeneration potential, reaching that of the Netherlands, i.e. 40% of the national production
  - Scheme ≤10 MWe capacity: 16 000 MWe
  - Annual production of 65 000 GWh
  - 28 000 jobs
  - CO2 reduction: 32.5 Mt

Cogeneration review: Italy

- **Old regulatory framework**
  - Cogeneration growth from 1994 to 1997
  - Strict criteria for recognition of cogeneration
  - Bureaucratic hurdles during authorisation and permitting
    - Same process for a 30 MWe plant and a 20 KWe engine
    - Under 300 MWt, construction permit granted by local authorities who set emission standards
    - Regions obtained more competences: Regulatory patchwork and lack of administrative capacity

Cogeneration review: Italy

- **Planned cogeneration policy**
  - Dispatch priority in the power exchange
  - Possibility to obtain energy efficiency certificates
  - Tax relief (very important for civil users)



Policy & Regulatory aspects

- **Conclusions**
  - Doubling electricity from cogeneration is possible, but only in the best-case scenario
  - Climate change and the Kyoto Protocol are key drivers
  - Liberalisation can support cogeneration, but only if regulated
  - The European Commission has an important policy role to play
  - Market factors need to be implemented (e.g. certificates, definition of cogeneration)

Lessons learnt

- **Experiences of the countries**
  - Despite European regulatory framework, national policies make the difference
  - Hungary: planned transition to a high-efficiency, low-carbon energy system
  - Belgium and Netherlands: Quota and certificate systems work well but need to be simple and robust
  - Portugal: Fair and stable feedback tariffs that reflect the energy efficiency, environmental and security of supply benefits of cogeneration
  - UK: Liberalisation is not bad, but markets must not be designed to penalise cogeneration
  - The system has to reward the efficiency of cogeneration

Principles of a fair regulatory regime

- **Principles**
  1. There must be a fully independent and properly resourced regulator of the system
  2. Electricity system pricing should be fully cost reflective with no cross subsidisation
  3. Power generation and supply companies should have no ownership or management interest in the network
  4. All generators of electricity should have fair and non-discriminatory access to the grid
  5. Use of T&D networks should be priced according to the services they provide and not in such a way as to incentivise distribution companies to avoid DE interconnection

Principles of a fair regulatory regime

- **Principles**
  5. Use of T&D networks should be priced according to the services they provide and not in such a way as to incentivise distribution companies to avoid cogeneration interconnection
  6. Utilities should be required to engage in cost benefit analysis which can enable cogeneration to be developed in areas where its local benefits outweigh the costs of constructing or upgrading new distribution facilities
  7. Any benefits which cogenerators provide to the system should be fully and fairly reflected in system pricing

General conclusions

- Cogeneration helps to save primary energy consumption directly in the supply chain, reduces transmission and distribution losses, improving balance of trade and foreign exchange savings
- High share of cogeneration can be achieved with the right policies
- Fix feed-in tariff (or fixed bonuses) and transparent grid-interconnection rules give the “best” and quickest development
- Cogeneration requires less total investments in the electricity supply sector compared to traditional central electricity supply
- Easy financing through a dedicated funding mechanism should be available
- ESCO concept could improve cogeneration development