SIXTH FRAMEWORK PROGRAMME
[6.1]
[Sustainable Energy Systems]

The External and Social Costs of Energy Technologies

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Social Costs

= total costs associated with the generation of 1 kWh electricity with a certain supply security

= sum of private and external costs

Objective:
Helps to support decisions about:
which technologies for the generation of electricity should be built, promoted, supported, penalized now and in future?
Which are the best technologies from the perspective of the society?

Private Costs

- private costs = all costs per kWh borne by the electricity producer, but without taxes (VAT) and subsidies
- includes investment, operation and maintenance, fuel, supplies and services, dismantling, waste disposal
- Includes back-up costs (provision of reserve capacity), estimated by comparing scenarios of energy systems with and without the assessed technology with the same supply security
- estimation / projection of costs for plants built 2025 and some educated guesses for 2050

External Costs

Externalities arise, when the social or economic activities of a participant in the economy have negative or positive impacts on another participant and these impacts are not fully accounted for or compensated by the first participant.
External costs are externalities, that are transformed into monetary values to allow a comparison between externalities and with private costs.

Externalities of all stages of the production process have to be considered, including construction, dismantling, fuel cycle.

Which External Costs Are Included ?

Environmental externalities: the release of a substance or energy (noise, radiation) into environmental media (air, indoor air, soil, water), that causes - after transport and transformation - considerable (not negligible) harm to ecosystems, humans, crops or materials.
Land use change (typical conditions)
Global warming impacts: damage costs and avoidance cost approach used.

Accidents: Public and partly occupational risks caused by accidents (use of expectation value).

Insecurity of oil supply addressed, but small – further work needed.

Which Effects Are Not Included ?

As they are not considered as externalities:

- **Effects on employment**
- **Depletion of non-renewable resources (oil, gas, silicon, copper, …)**
- **Research and development (sunk costs)**
- **Income distribution**
- **Local damage to natural and seminatural biotopes (however addressed and fully or at least partly compensated within the Environmental Impact Assessment)**

Which Effects Are Not Included ?

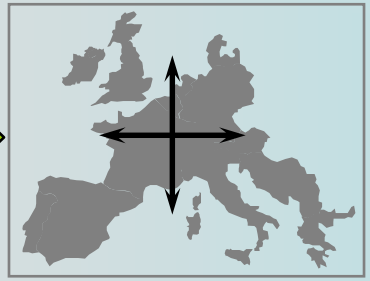
as agreed methods or reliable information are not available, though impacts on the result may be large :

- **Assessment of Damocles risks (low probability- high damage risks) – agreed method not available**
- **Risk caused by terrorism – information not publicly available**
- **Visual annoyance - large spatial and temporal variability, thus benefit transfer not possible**
- **Risk analysis of carbon storage – no quantitative information yet available**
- **Security of supply for natural gas - methodology not available**

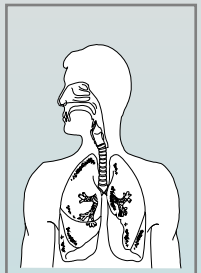
Estimation of Environmental External Costs: The Impact Pathway Approach

Pollutant Emissions

Transport and Chemical Transformation



Differences of Physical Impacts



Monetary Valuation

Calculation is made twice: with and without project!

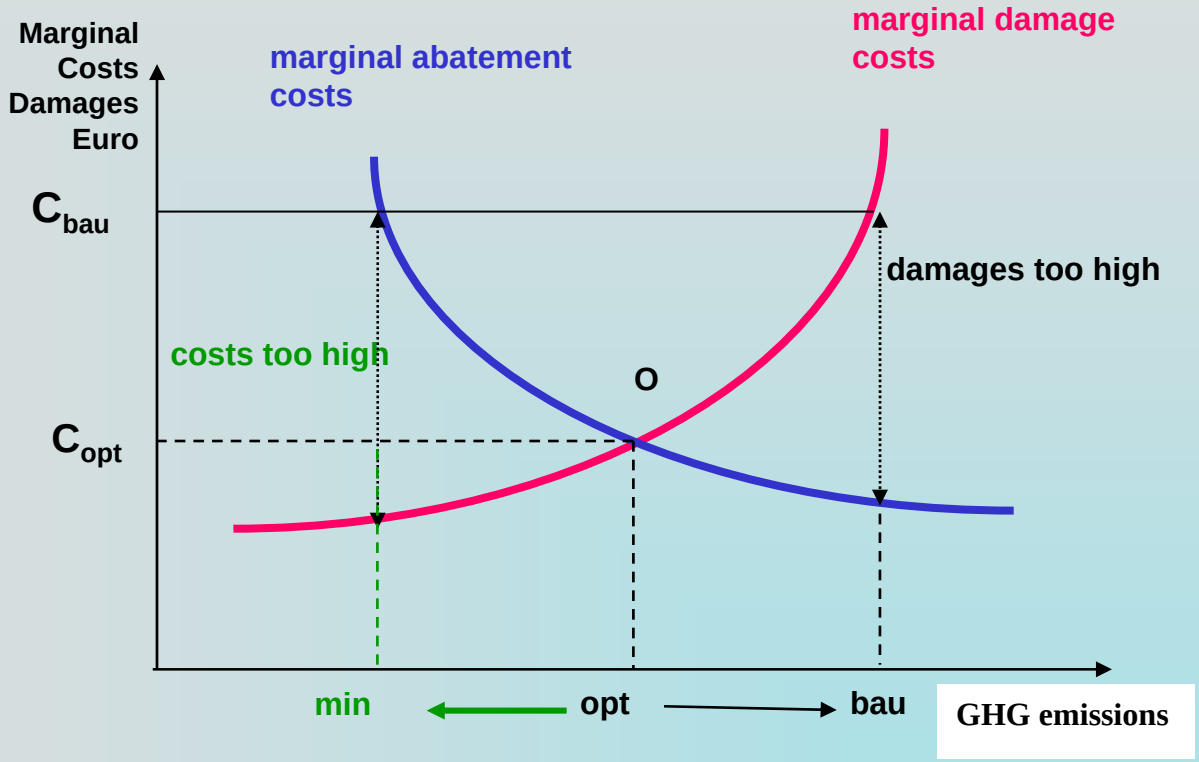
Improvement of the ExternE methodology

Atmospheric modelling:

- Eulerian regional model, hemispheric model, local model and urban increment
- Site dependent multi-media modelling including food trade for heavy metals
- new methodology for assessing biodiversity losses due to eutrophication, acidification and land use change
- Survey for valuing changes in life expectancy
- Updates for concentration-response-relationships, monetary values

Rules for assessing external effects of greenhouse gas emissions

1) Marginal damage (= avoidance) costs for the pareto optimal state should be used.



2) Marginal avoidance costs should increase with time (under the assumption, that marginal damage costs increase with time).

Ex Ante Values for Assessing Greenhouse Gas Emissions

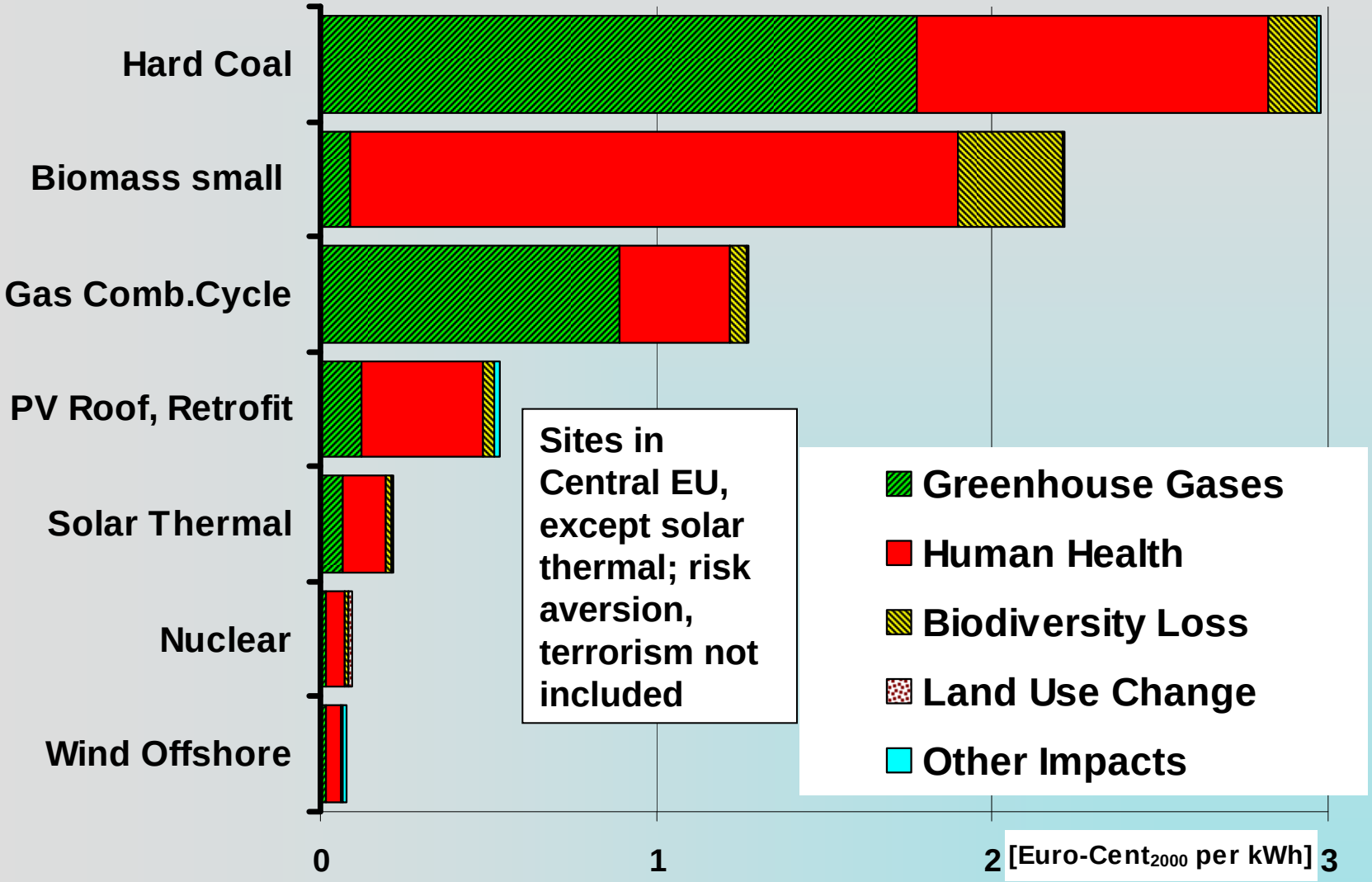
[Euro 2005 per tonne CO2 eq]	2010	2015	2025	2035	2045	2050
MDC_NoEW	9	11	14	15	17	22
Kyoto/20% plus	**23.5**	**27**	**32**	**37**	**66**	**77**
Max 2°	**23.5**	**31**	**52**	**89**	**152**	**198**

The internalisation of the Kyoto/20%+ values would likely lead to a fulfillment of the Kyoto aim 2010, 20% GHG reduction 2020 and further considerable reduction after 2020

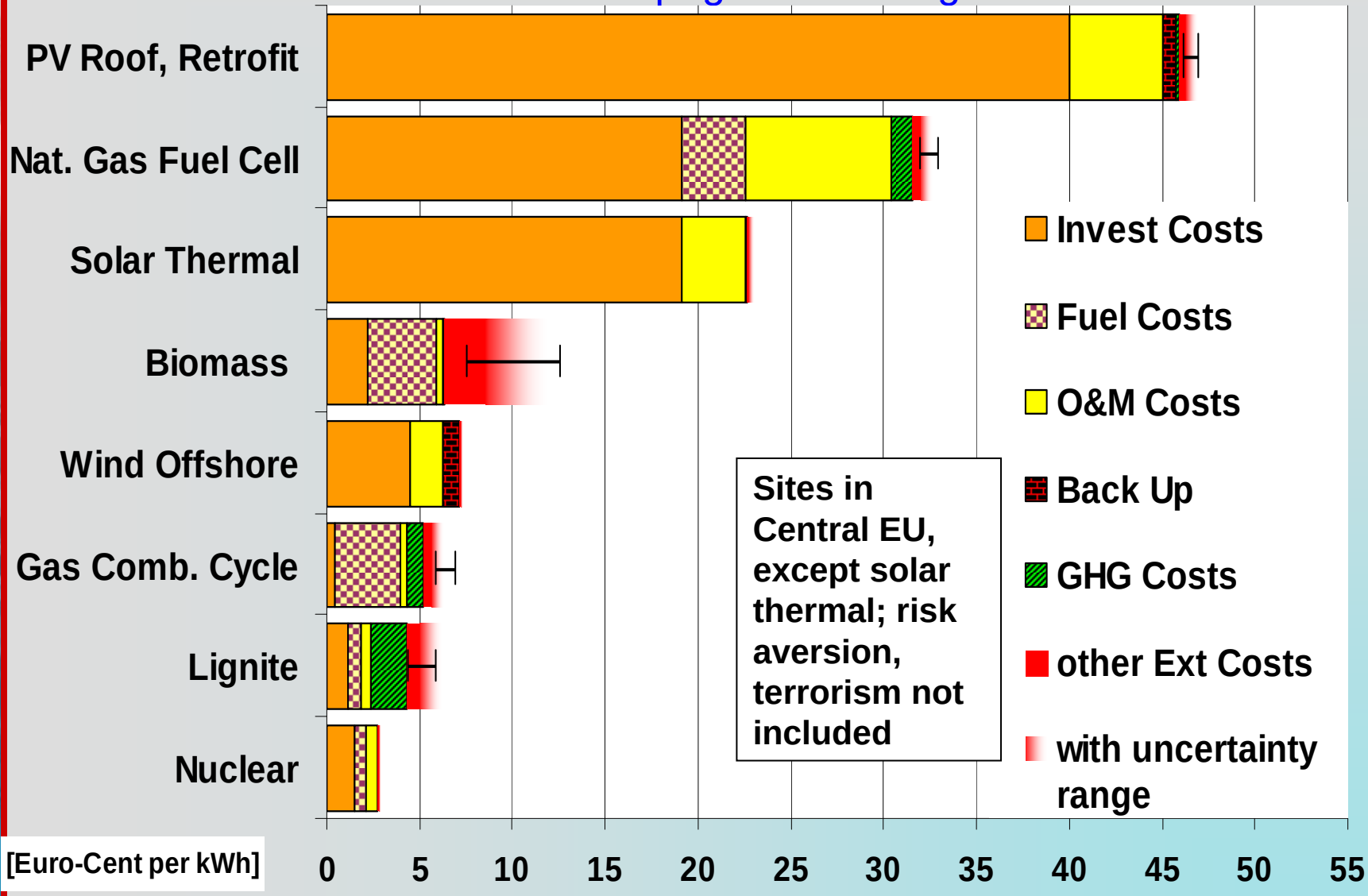
The internalisation of the 2° max values, if internalised in OECD countries with contributions from China and India, would probably lead to not exceeding a temperature increase of 2°

MDC_NoEQ: estimates of quantifiable marginal damage costs without equity weighting, estimated with the FUND model

Quantifiable External Costs 2009 for Selected Electricity Generation Technologies



Social Costs 2009 with uncertainty range for external costs except greenhouse gases



Explanation for the following slides

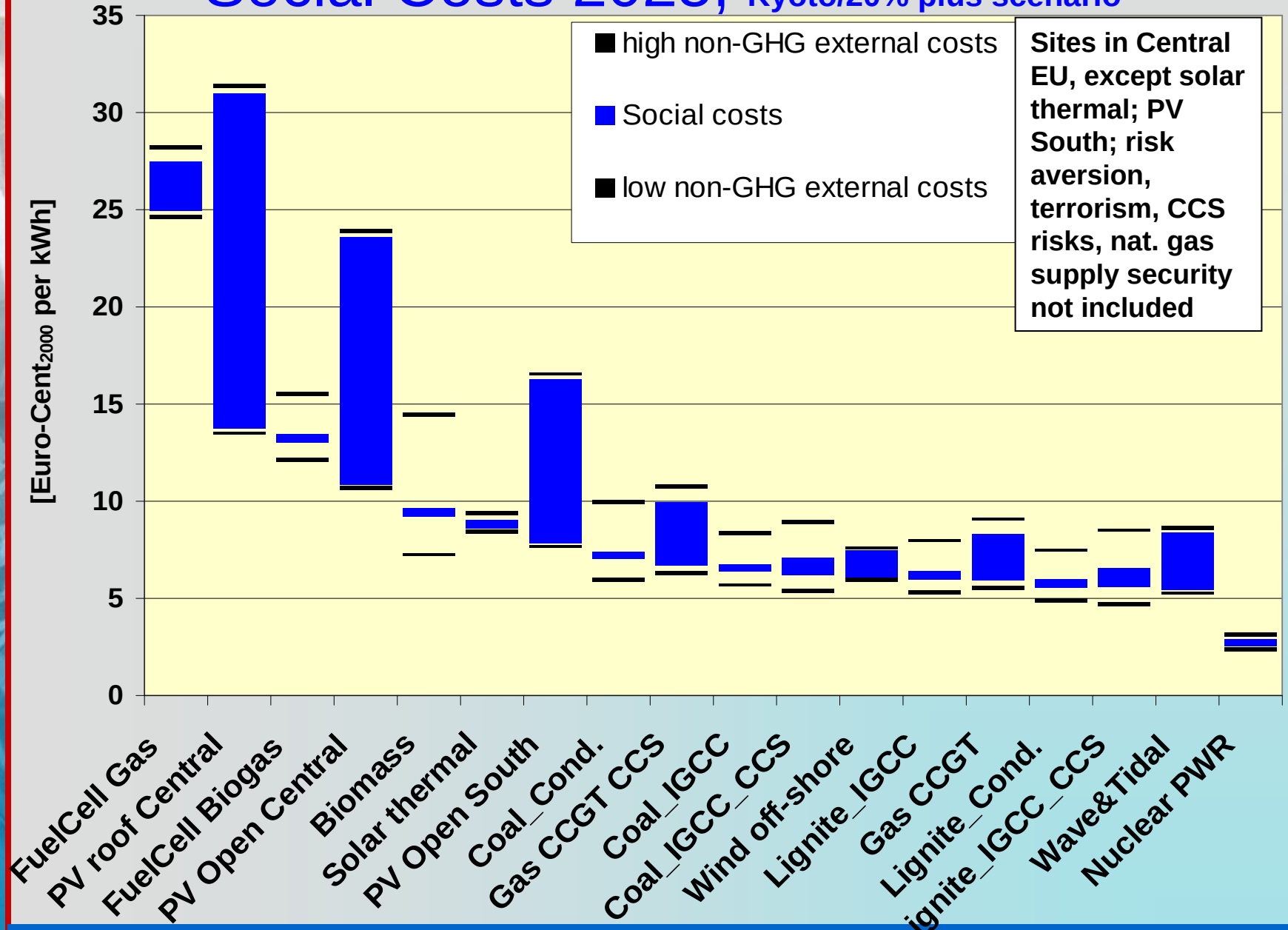
Bars show quantifiable social costs for technologies with the first year of operation in the year as shown in the heading of the slide. The blue bar shows the sum of

- best guess of external non-GHG costs
- external costs of greenhouse gases according to scenarios specified in the heading of the slide, either ‚Kyoto/20% plus' or ‚max 2°'
- range of values of private costs. The lower end of the range represents values from the NEEDS stream1a realistic-optimistic scenario. The upper bound uses
  - a realistic-less optimistic estimation for renewables
  - 70% higher prices for natural gas
  - doubling of estimated costs for carbon transport and storage.
  - 20% (2025) respectively 80% (2050) higher investment costs for nuclear.

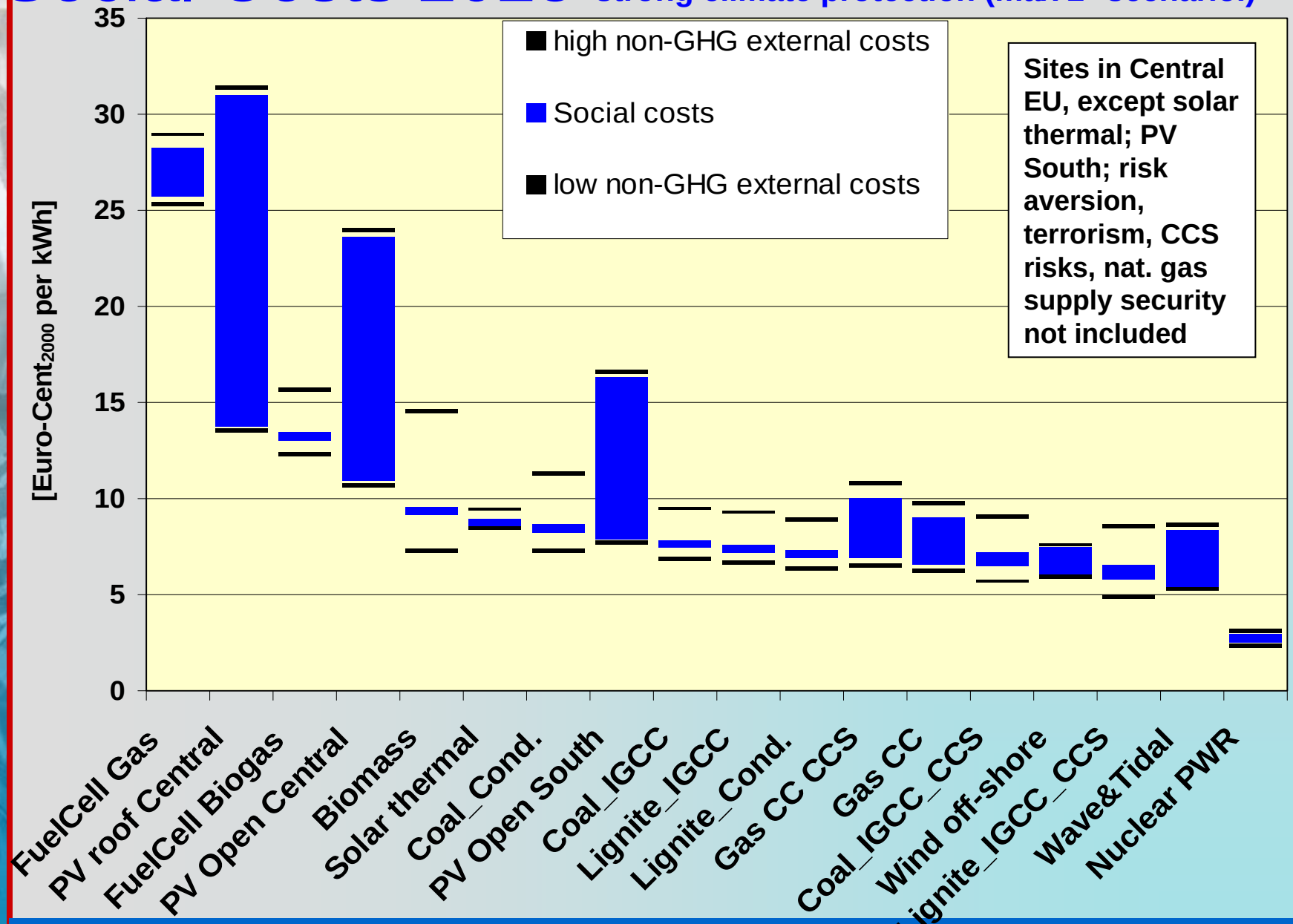
The lower black dash shows the value for social costs combining GHG external costs with lowest private costs and with lowest non-GHG external costs (lower barrier of range of standard deviation). The upper black dash combines GHG external costs with highest private costs and with highest non-GHG external costs.

Technologies are ranked (from left to right) according to the lower barrier of the blue bar (buest guess external costs, realistic-optimistic private costs).

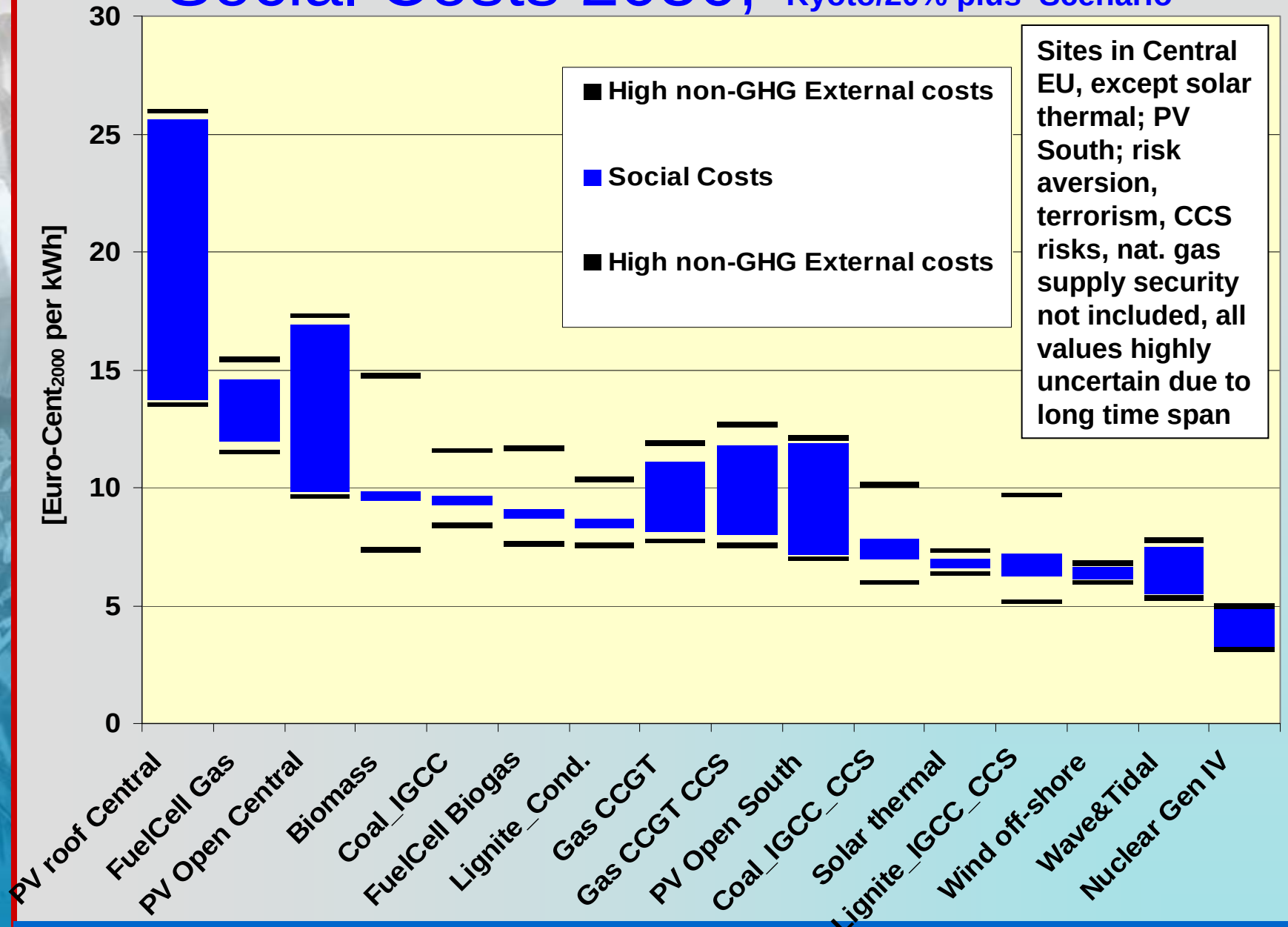
Social Costs 2025, Kyoto/20% plus scenario



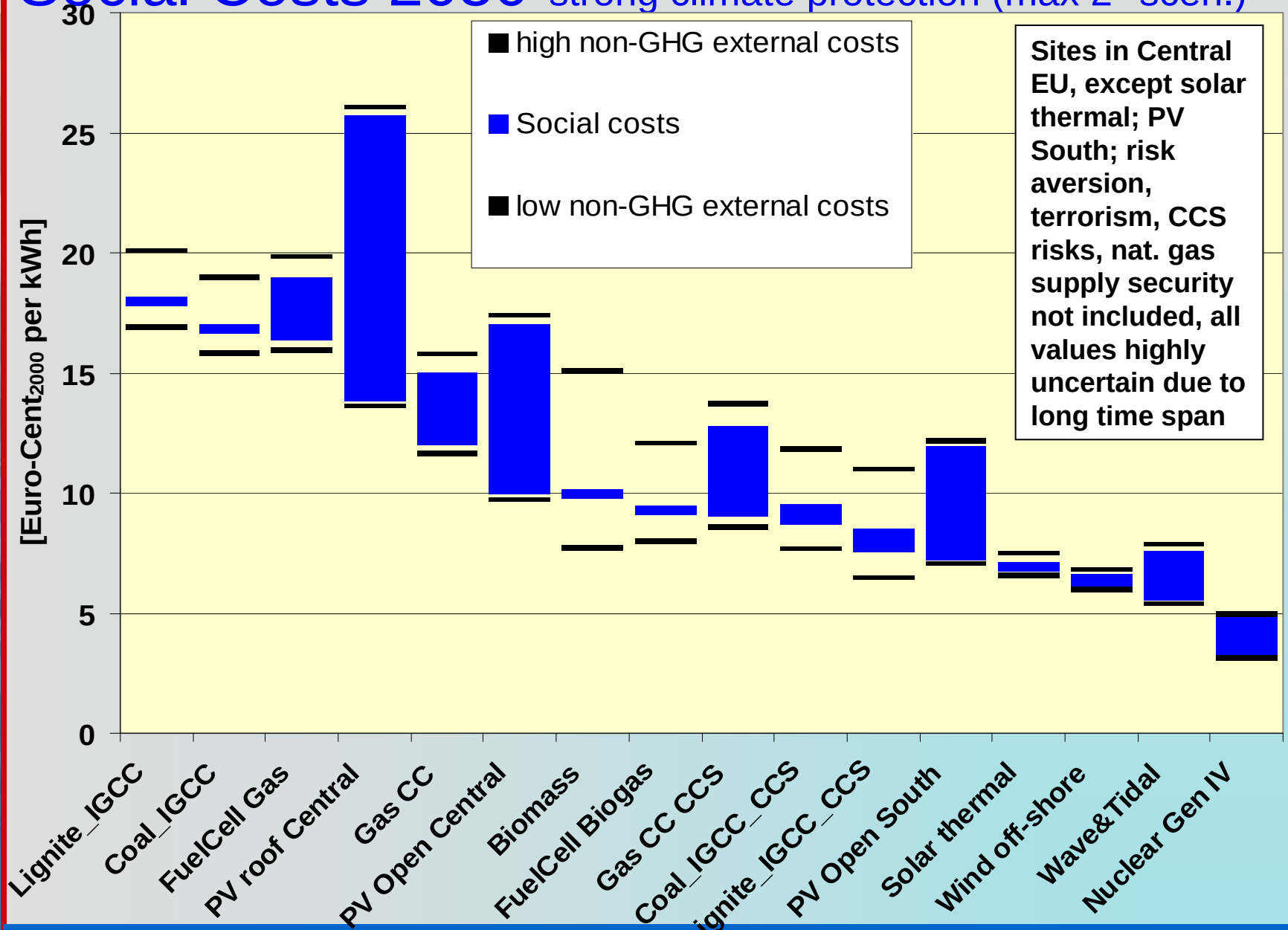
Social Costs 2025 strong climate protection (max 2° scenario.)



Social Costs 2050, 'Kyoto/20% plus' Scenario



Social Costs 2050 strong climate protection (max 2° scen.)



Conclusions I

- Nuclear, wind, run-off water, wave and tidal energy are electricity generating options with lower external and social costs. However, wind and water have a limited potential, wind and tidal need back-up capacity, e.g. coal; for nuclear (EPR now, Generation IV after 2030) and on-shore wind low acceptability in some countries due to risk aversion / visual annoyance might occur.
- Lignite where available and coal will continue to play a major role, – with CCS, if CCS turns out to have low environmental and technical risks, unless the costs for transport and storage are higher than anticipated and the level of ambition for climate protection is not too high.

Conclusions II

- Natural gas will only play a role replacing coal, if the price for gas (and oil) is expected to stay moderate, then however without CCS.
- Biomass has relatively high external and social costs. The use of residual biomass in large plants might be a favourable option.
- Electricity production with solar plants continues to have the highest quantifiable social costs at least until 2030. After coal and gas fired plants, solar thermal systems in Mediterranean countries would be the next best option with high potential– especially, if the climate protection goals are very ambitious and CCS turns out to be a less efficient or safe option or has a limited potential.