Belgian Nuclear Society Young Generation Network

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European Nuclear Society
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Nuclear Energy and CO2

COP-15

Maxime Havet
Arnaud Meert

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Table of contents

Table of contents

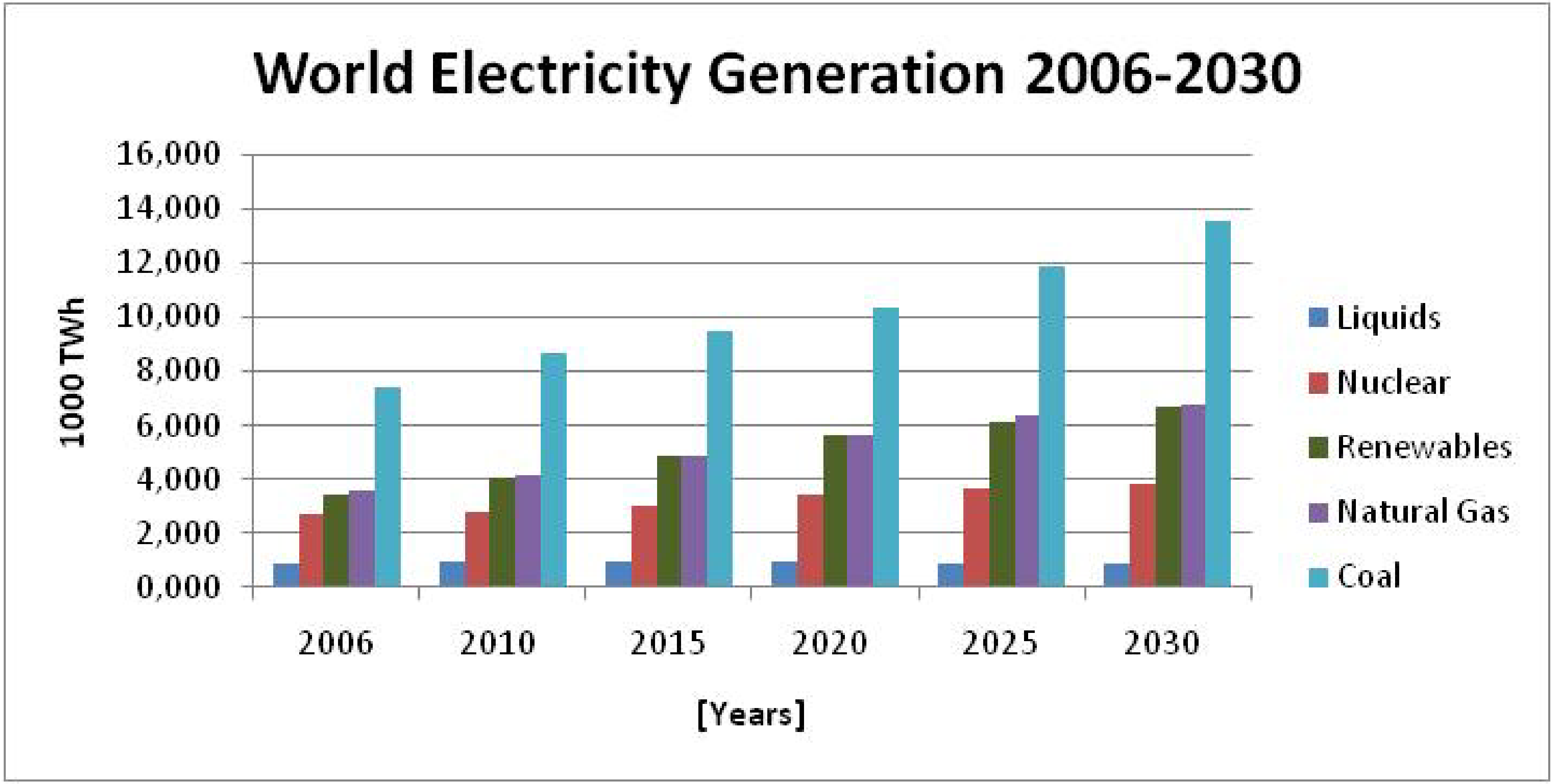
- Introduction
  - Main figures about the energy
  - Energy demand growth: 2000 → 2030: focus on the electricity
  - Perspective of the nuclear production – link with CO_2 credits
  - Kyoto, nuclear and CO_2
- CO_2 costs of the nuclear energy : 3 models
  - VITO & KUL study
  - Storm van Leeuwen, Smith
  - Australian study (Lenden *et al.*)
- Long Term Operation (LTO) and CO_2
- Conclusion

Main figures about the energy

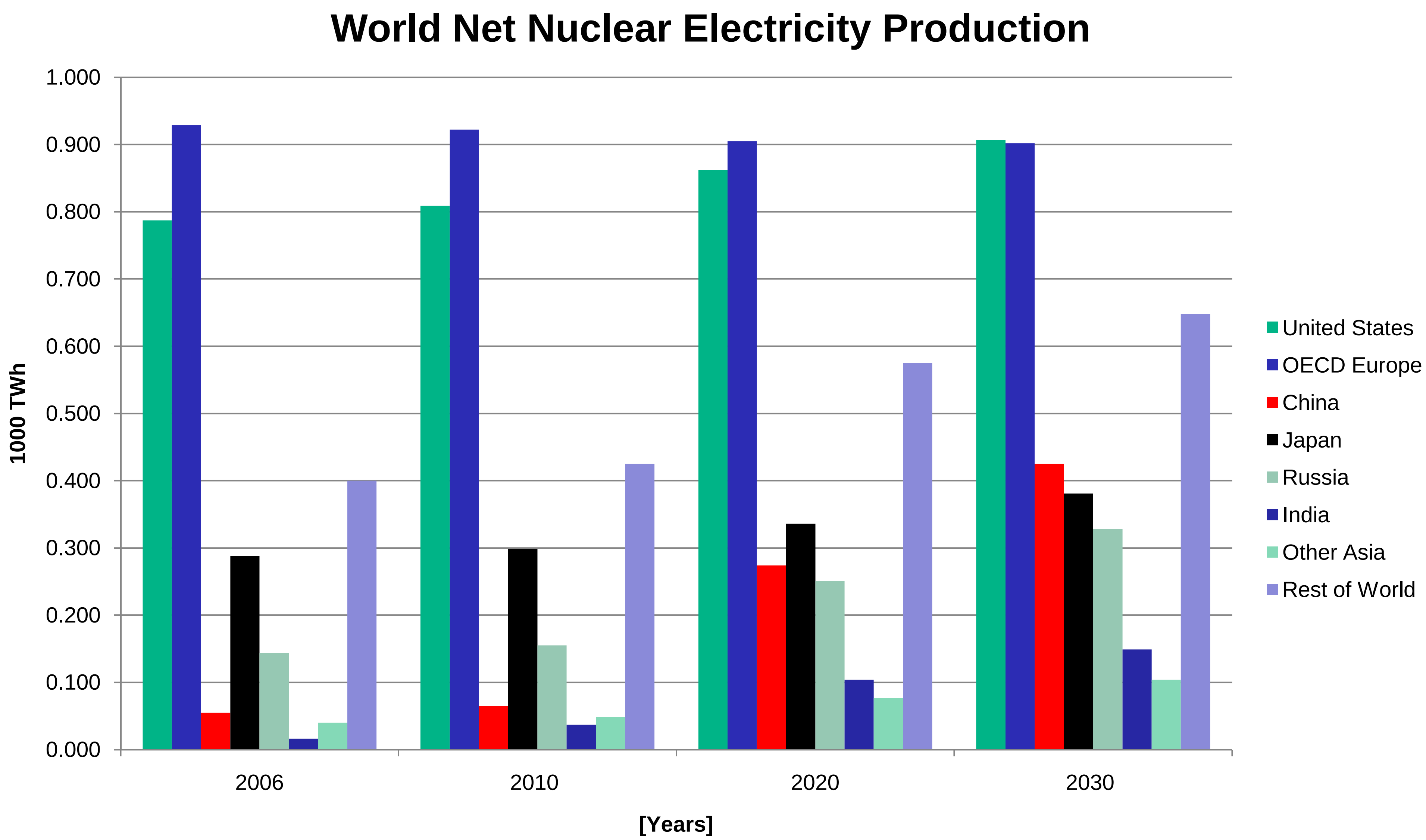
- Europe:
  - According to figures of 2007 (E.E.C.), from now to 2030
    - EU economic growth ~ 2% / year
    - Energy demand growth ~ 0.6% / year
  - Discordance due to:
    - Modernization and restructuring of the main energy consuming activities (heavy industry,…)
    - Demand Saturation
    - Improved energy efficiency
    - Application of environmental policies
      - Rem: Gross National Product linearly correlated to final energy consumption → impact of the crisis?
- Developing Countries
  - Energy demand growth ~ 2% / year
  - Greater demography and lower energy efficiency

Energetical growth [2006 → 2030]: focus on the electricity

- Electricity (worldwide): +3% / year
  - Europe: +1.5% / year



Energetical growth [2006 → 2030]: focus on the electricity



Perspective of the nuclear production

- Nuclear in Europe:
  - 155 NPP in Europe at 1/1/2006
  - 974 TWh produced in 2005 (~30% of the total European electricity production)

- Evolution (worldwide):
  - Between 2010 and 2020, electronuclear production will remain constant (according to EEC)
  - Between 2020 and 2030, the production will increase (+3.3%/year according to EEC)
  - Between 2030 and 2050, production will raise to +4%/year according to WETO study (EEC, 2006)
    - Main reason: the cost of **CO2 emissions** will favor nuclear energy at that time.

Kyoto

- Kyoto Protocol (KP) target (first commitment period 2008 – 2012)
  - global target -5,2% (for Annex 1 countries) compared to base year 1990
- Measures
  - direct actions 'at home' (reducing CO_2 emissions)
  - work through 'flexible mechanisms' (market-based mechanisms)
    1. International Emissions Trading (CO_2 emissions trading between the country of Annex 1)
    2. Joint Implementation (get credits by building clean technology in industrialised countries of Annex 1)
    3. Clean Development Mechanism (get credits by building clean technology in Countries of Non-Annex 1 or developing countries)
- If not respected: sanctions possible (+30% reduction)

Nuclear in the climate change negotiations

- The KP states that 'parties should refrain from using nuclear technology within the clean development mechanism': impossible to receive credits from supporting (new) nuclear in developing countries.
  - exclusion is symbolic but does not affect industrialised and developing countries' nuclear energy policies as such (CO_2 avoidances based on nuclear remain 'valid' under the KP).
  - exclusion is symbolic but important, as it complicates 'rehabilitation' of nuclear in future climate change agreements.
- Countries remain divided over the possible role of nuclear in future energy policies, but the issue has never been officially discussed in international negotiations.

Greenhouse gas (GHG) emission gain thanks to nuclear energy (UE-15)

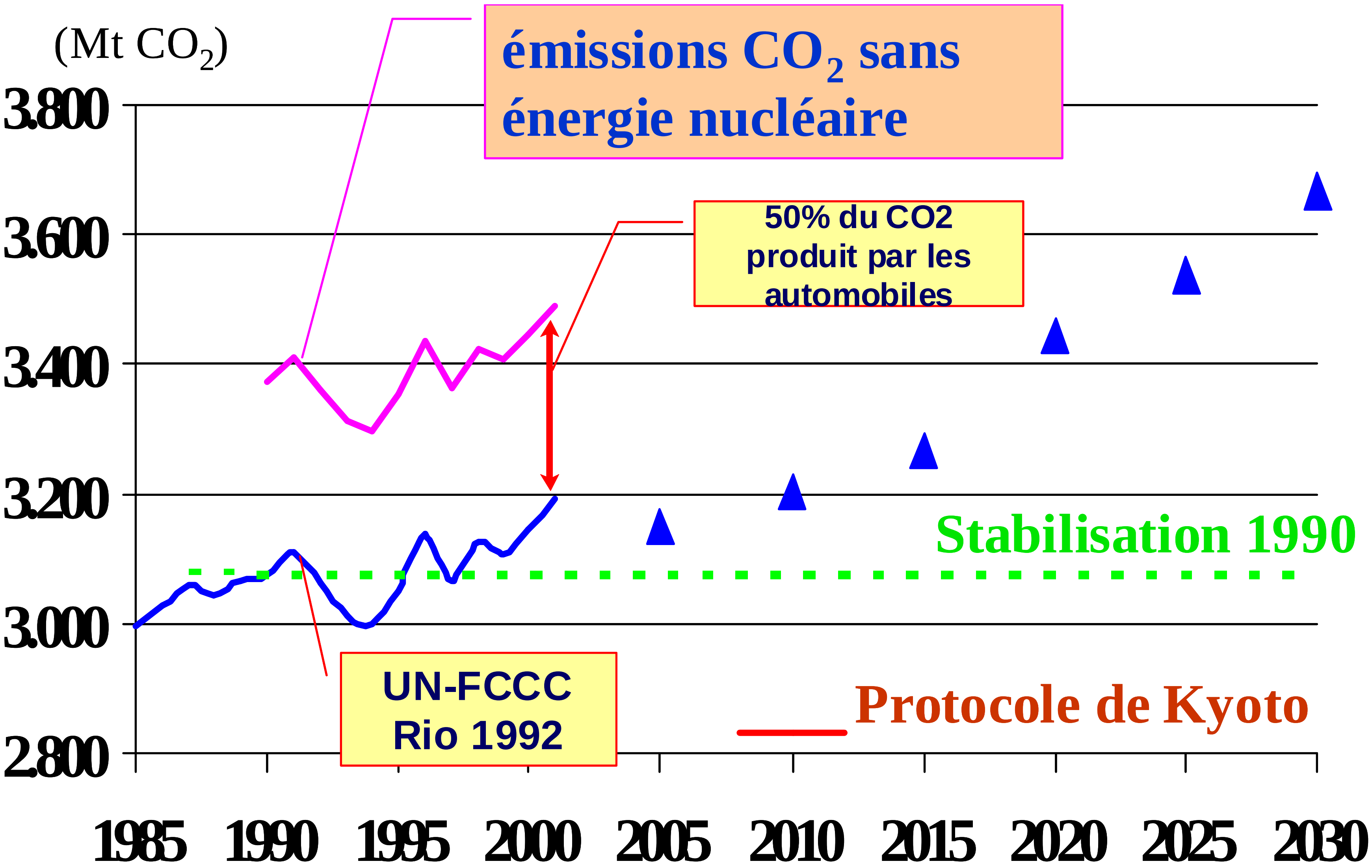


Figure out of [1]. Courtesy of the author.

How to reach the KP objectives ?

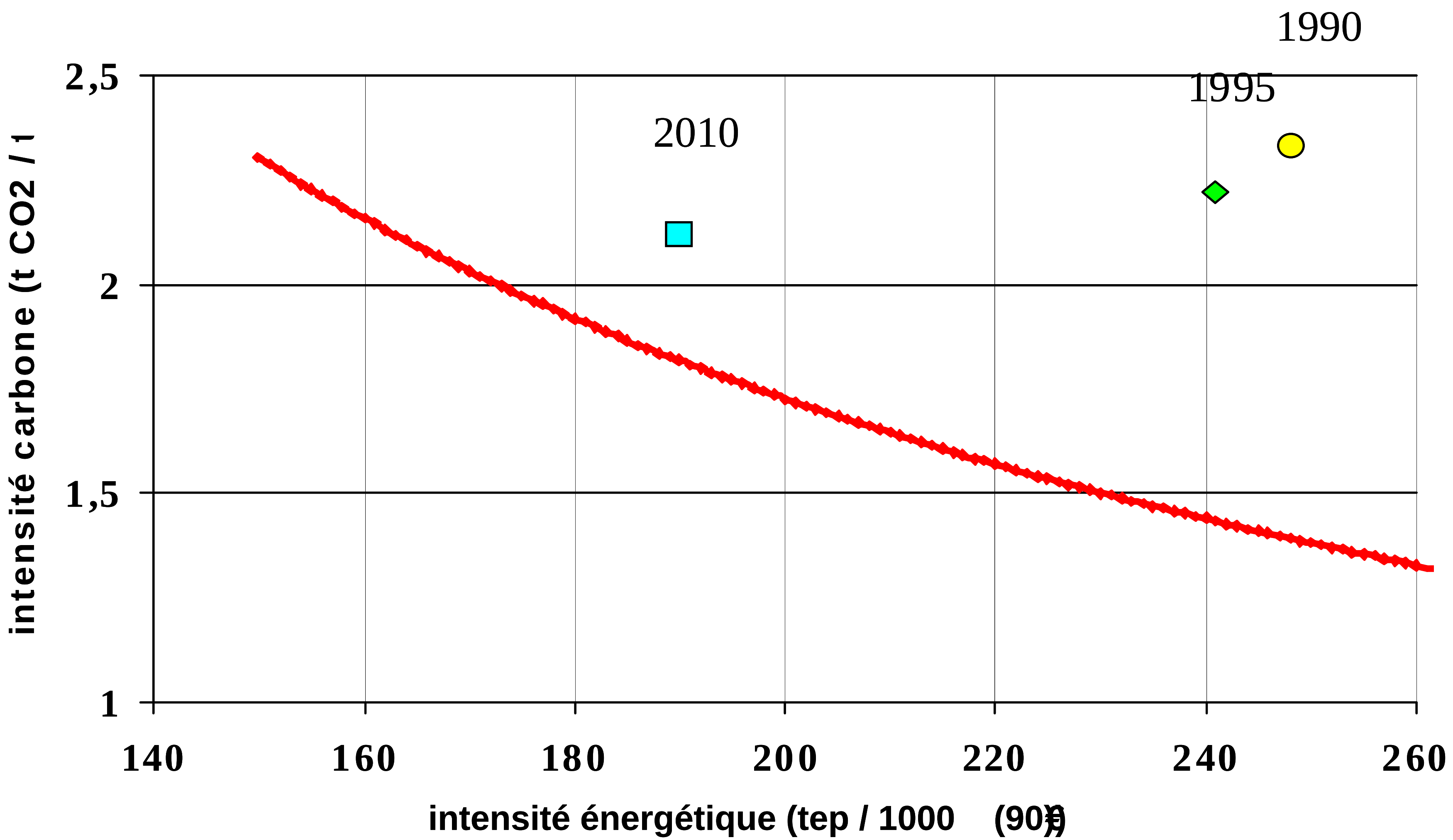


Figure out of [1]. Courtesy of the author.

GHG Emissions of “C0$_2$ Free” Technologies

- Emissions of fossil-fired power plants: direct (fuel burning) + indirect emissions
  - Direct emissions can be measured
- Emissions of non-fossil Power Plants (nuclear, solar Photovoltaic, wind…): indirect emissions only
  - Difficult to evaluate
    - Many parameters to consider: construction/production, mining (nuclear and solar), transport, recycling, waste disposal, decommissioning (nuclear)…
    - Data not always available: approximations, models
    - Dependence on external parameters (solar panels emissions highly depend on insulation)
  - Results vary significantly (5-340 g CO2-eq./kWh for nuclear)

Table of contents

VITO & KUL - assumptions

- Vito Study: ordered by Belgian electricity producers (Electrabel and SPE) [1998].
- KUL study: performed for the same research project.
- Both have been combined here.
- Main assumptions of the model:

	Assumption
Burn up *[MWd/kg U]*	45
Yield of the NPP *[%]*	33
Capacity factor *[%]*	85.4
Life time of the plant	40
Ore quality [% U3O8]	0.2

- Studies performed in the Belgian context

VITO& KUL goals and main result:

- The purpose of the study was the evaluation of:
  - Greenhouse and acid gas emission and the energy consumption from the starting up to the decommissioning [Vito]
  - Electricity generation units as final customer [Vito]
  - Indirect emissions coming from electric power plants during their life time (Construction, Operation and decommissioning of so called ‘emission-free’ power plants) [KUL]

- Main result for NPP:
  - 7,7 g CO_2-eq./kWh_e
  - Range: 5,9 - 16,5 g CO_2eq/kWh_e

Synthesis VITO/KUL study

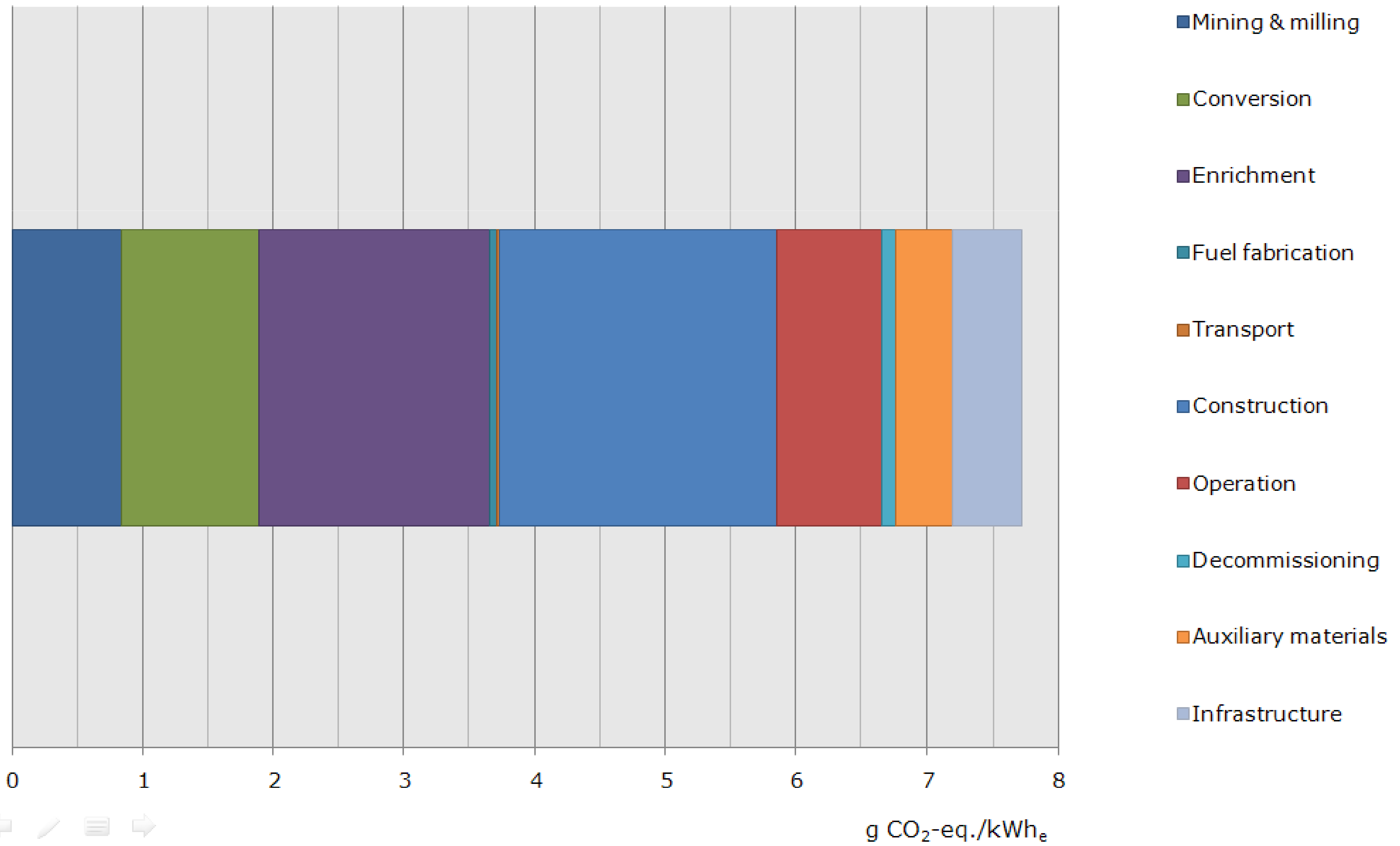


Table of contents

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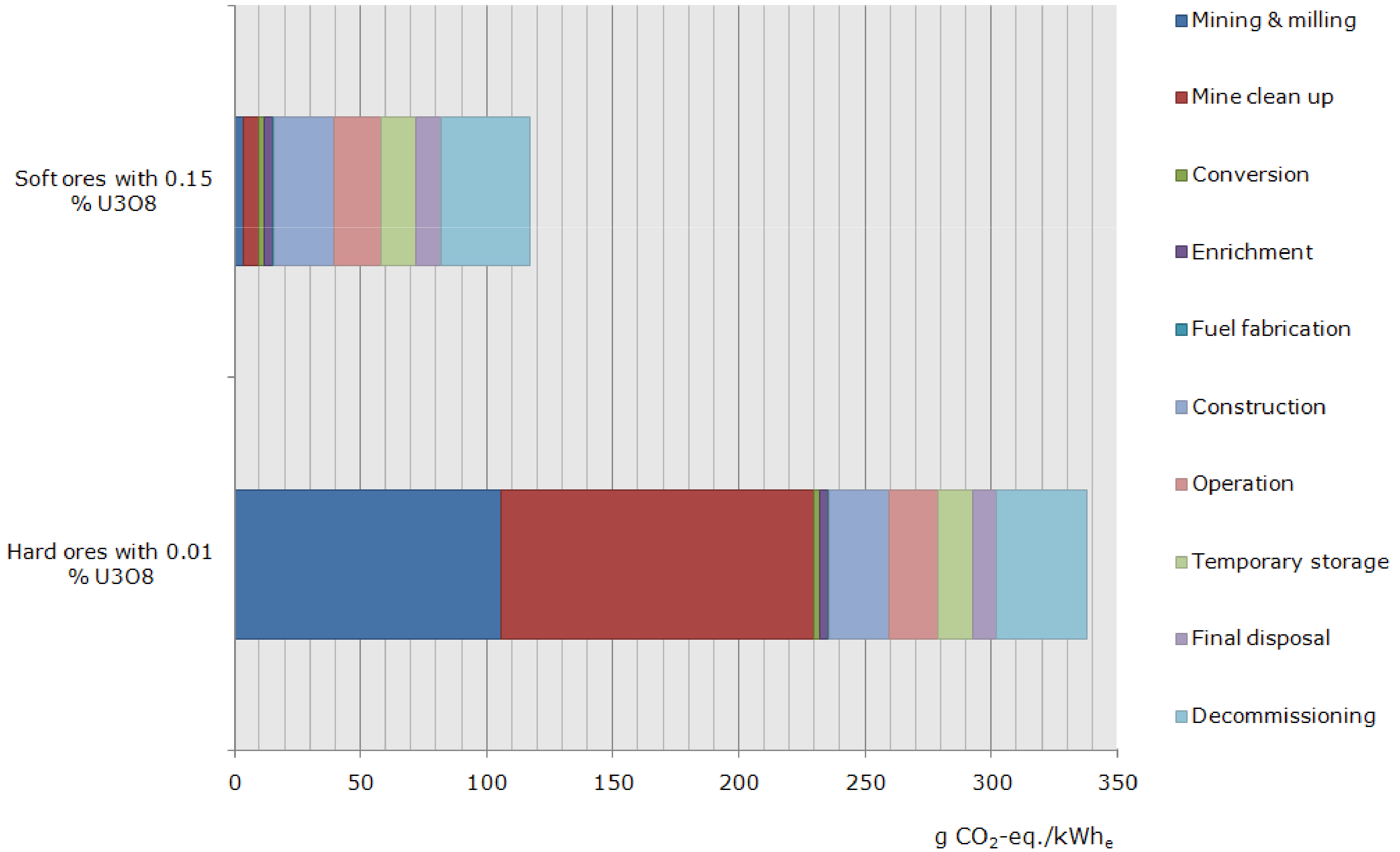
Study of Storm van Leeuwen and Smith

- Study ordered by the green parties in the EU parliament
- Results range from 110 to ~340 g CO_2-eq./kWh
  - To be compared with the 5,9 to 16,5 g CO2-eq./kWh of the KUL-VITO study
- The study considers two scenarios
  - One corresponding to the current situation
    - Uranium ore corresponding to world average (0.15% U_3O_8)
    - Result: 110 g CO_2-eq./kWh
  - One assuming a decreasing Uranium quantity
    - Mining of lower quality ores (0.01% U_3O_8)
    - Result: 340 g CO_2-eq./kWh
- Second study: nuclear not a long term solution, as Uranium availability decreases

Study of Storm van Leeuwen and Smith - Overview



Study of Storm van Leeuwen and Smith - Comments

- The main difference between the results comes from:
  - Mining and milling
  - Mine clean-up
- Mining and milling
  - Higuest estimates used for mining
  - Fact that other materials can be mined at the same time (splitting of energy costs) not taken into account
  - No consideration of “G4” reactors or recycling
    - May become highly competitive as Uranium gets rare
- Mine clean-up
  - Only study taking this step into account
    - Not really done in practice nowadays
    - Based on an hypothetical model
  - Difficult to validate due to lack of data

Study of Storm van Leeuwen and Smith – Comments (2)

- For the current situation scenario, one of the main GHG costs is the construction
  - Estimation based on monetary cost of the construction in the US
  - Large range (1.4-6G$[1982] / GW)
  - Cost multiplied by “energy spent per dollar spent” factor corresponding to the construction sector
  - Many factors not taken into account
    - Cost depends also on administrative tasks and licensing
    - Safety–related components more expensive due to higher quality standards
  - Much larger results than two other studies

Study of Storm van Leeuwen and Smith – Comments (3)

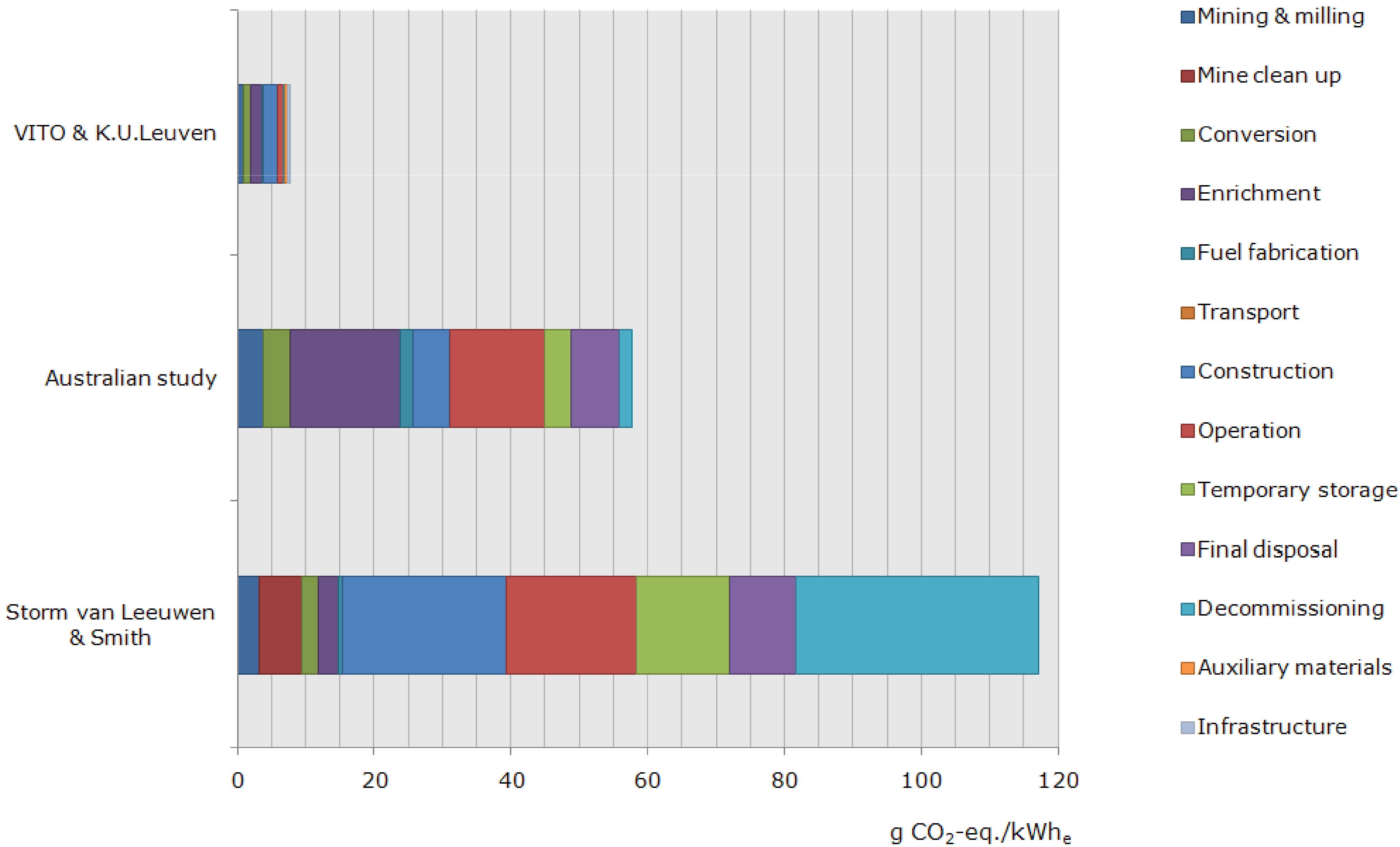
- Very high estimates used for the energy expenditure of the construction
- Overall impact on the final result:
  - Decommissioning and Final Disposal energy expenditure related to construction costs
  - For the current situation scenario, construction and decommissioning amount to ~ 50% of the total
- Assumed lifetime (29 years) has consequently a great impact on the final result

Table of contents

Australian study (Lenzen *et al.*)

- This study (2006) ordered by prime minister of Australia
  - Goal: evaluating the nuclear option for decreasing GHG gas emissions
- Large range of values
  - 10-130 g CO_2 eq./kWh
  - 57.7 g CO_2 eq./kWh as a best-estimate for Australia
- Results in between those of the two previously discussed studies
  - KUL-VITO: 5,9 - 16,5 g CO2-eq./kWh
  - Storm Van Leeuwen, Smith: 110 - 340 g CO2-eq./kWh
- Mine clean–up not taken into account

Overview of the three studies for current situation



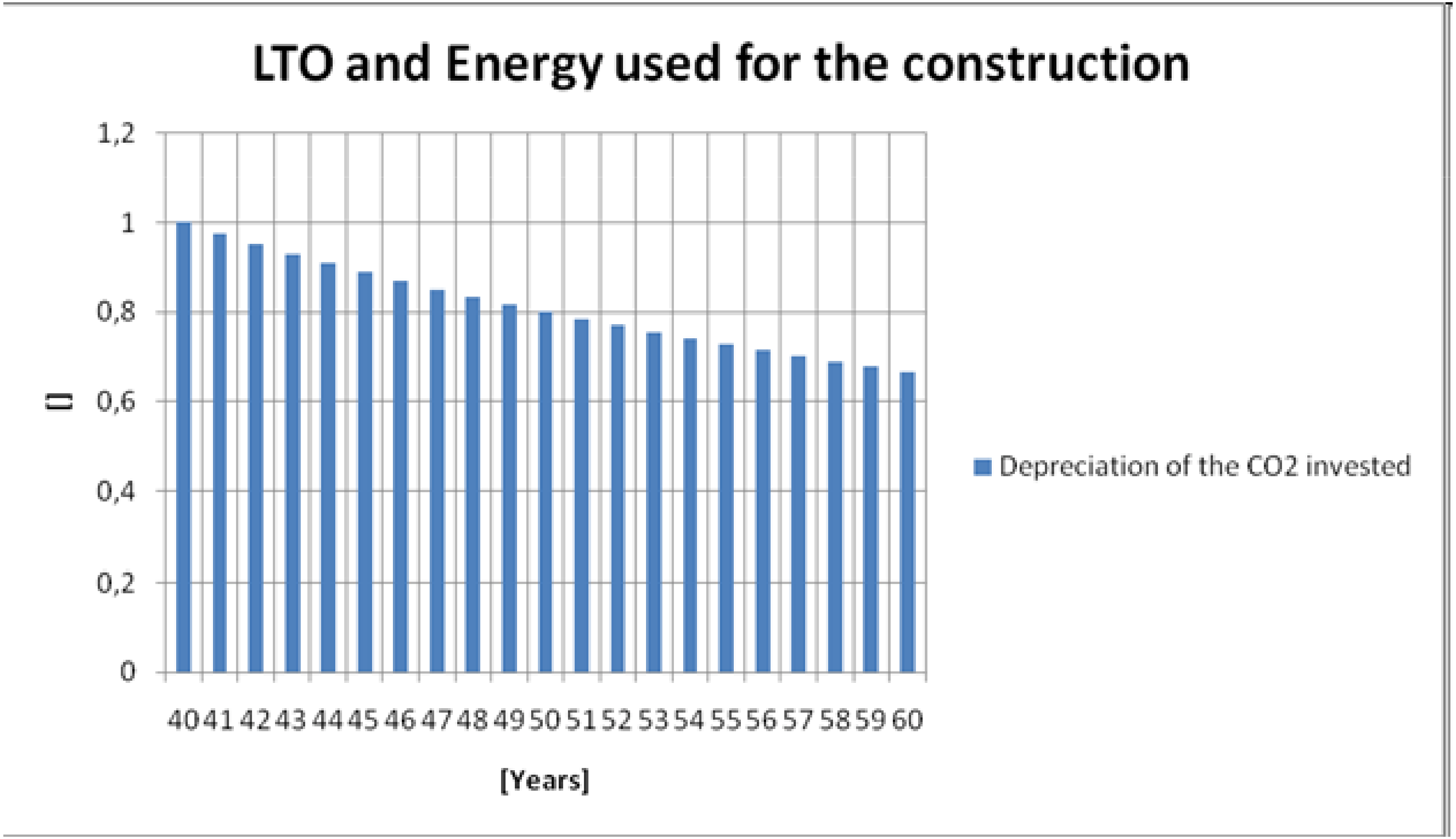
Long Term Operation (LTO) & CO_2

- As it has been shown, several assumptions have been made for the life time of the NPP and for energy used in the construction/dismantling:

Study	NPP life time [years]	Energy for the construction [GWhp/GWhe]	Energy for the decommissioning [kWhp/kWhe]
Vito & KUL	40	1500-3972	0,0004
SvL&S	29	28854	0,2060
Australian study	35	4100	0,0058

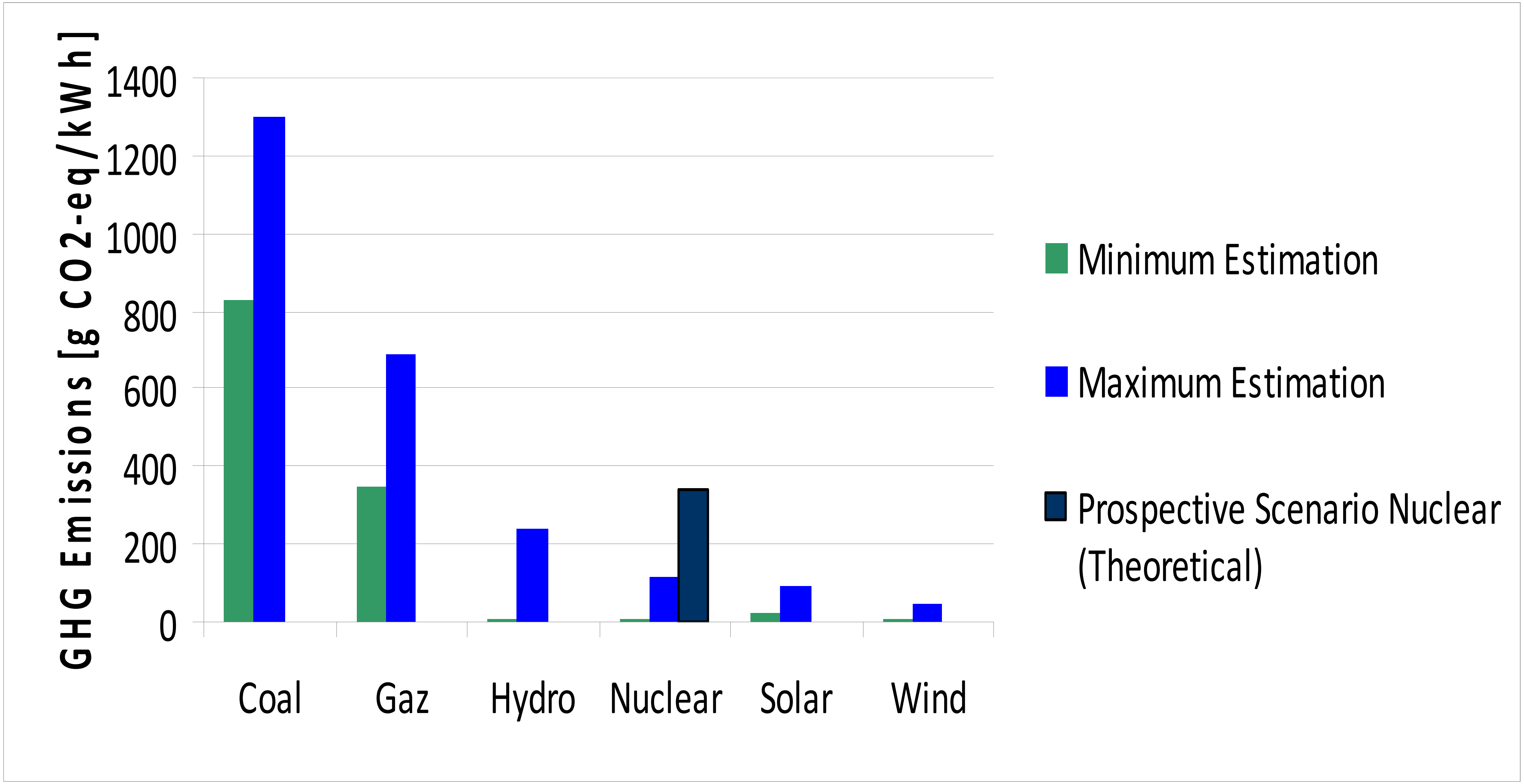
- We propose to build the ratio Energy/life time

Ratio Energy used for the construction / years



GHG emissions of different types of technologies

Comparison with other technologies (CO_2 equivalent)



Conclusion

- Evaluating indirect emissions is difficult
  - Depends on the assumptions, models used, data available
  - Many steps taken into account
- The three studies have weaknesses
- Most pessimistic study corresponds to prospective theoretical scenario
  - Uses excessively high estimates and unrealistic assumptions
- For current situation, most pessimistic study leads to results
  - ~3x less CO_2 than gas
  - ~10x less CO_2 than coal
  - Comparable or better than other “CO_2 free” technologies (hydro, solar)
- Results get better with a higher lifetime

Bibliography

- Special thanks to Dr. S. Furfari (slides 9,10)

- Main references used:

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