Implications of Methane Hydrates Availability for Future Energy Systems

A model-based scenario analysis

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Scenario & Model Sensitivity Analysis

- **Based on intermediary energy demand scenario** (~ SRES B2)

- **Conservative technology outlook of B2**
  - limited availability of unconventional oil/gas
  - slow/medium improvements of alternatives
  - "fallback options": coal and nuclear

- **Study energy systems implications of alternative**
  - availability and
  - costs of methane hydrates

- **Outputs**
  - methane hydrates production
  - potential market size
  - GHG emissions

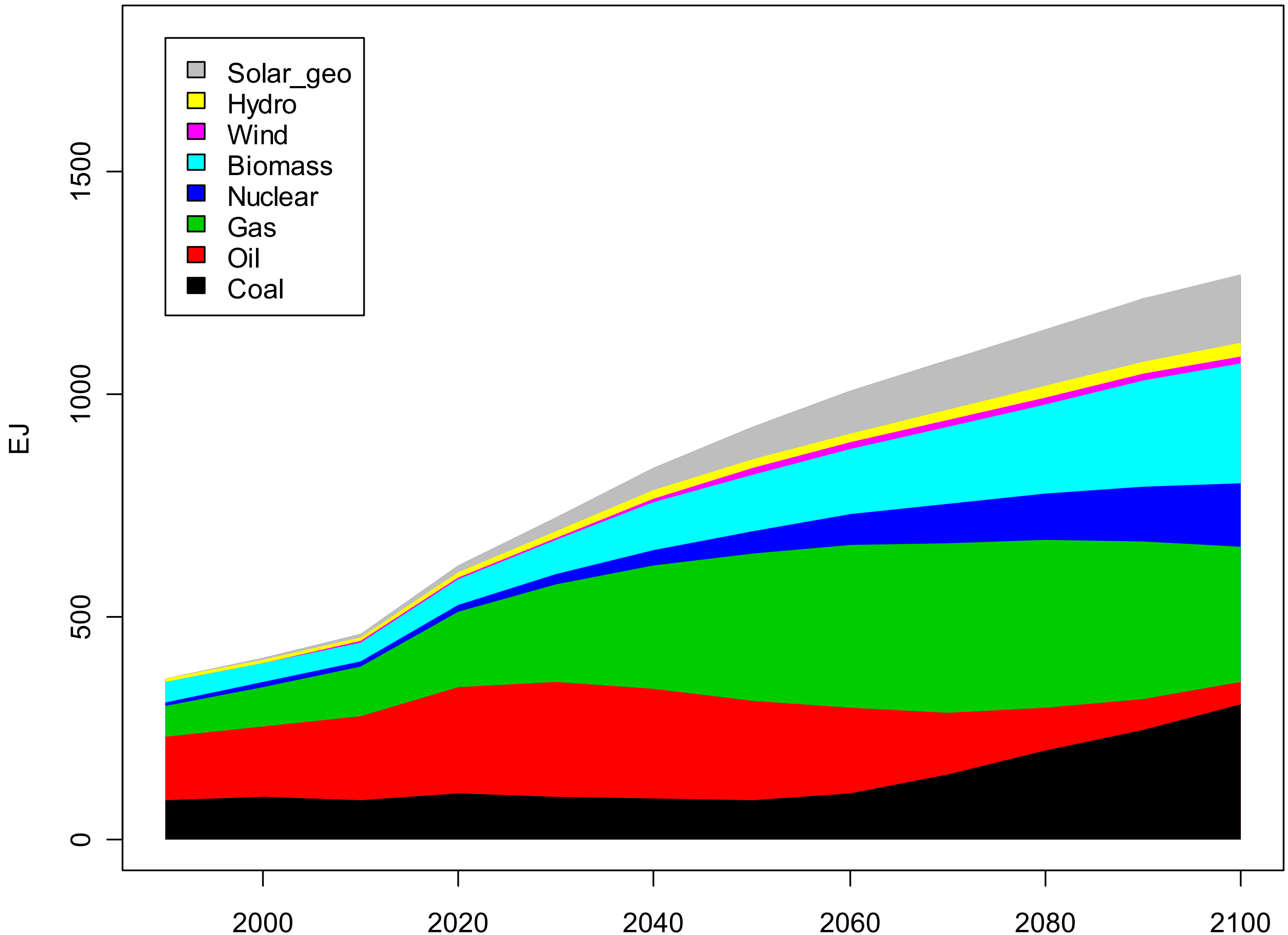
B2 Scenario in Context (by 2100)

	2100	Scenario Literature 10th perc. Median B2 90th perc.
Population	10.4 bln.	7 … 15
GDP/cap	22.9 k$_{90}$	15 … 75
TPES	1265 EJ	650 … 2200
CO_2 emissions	13.4 GtC	5.7 … 29.8

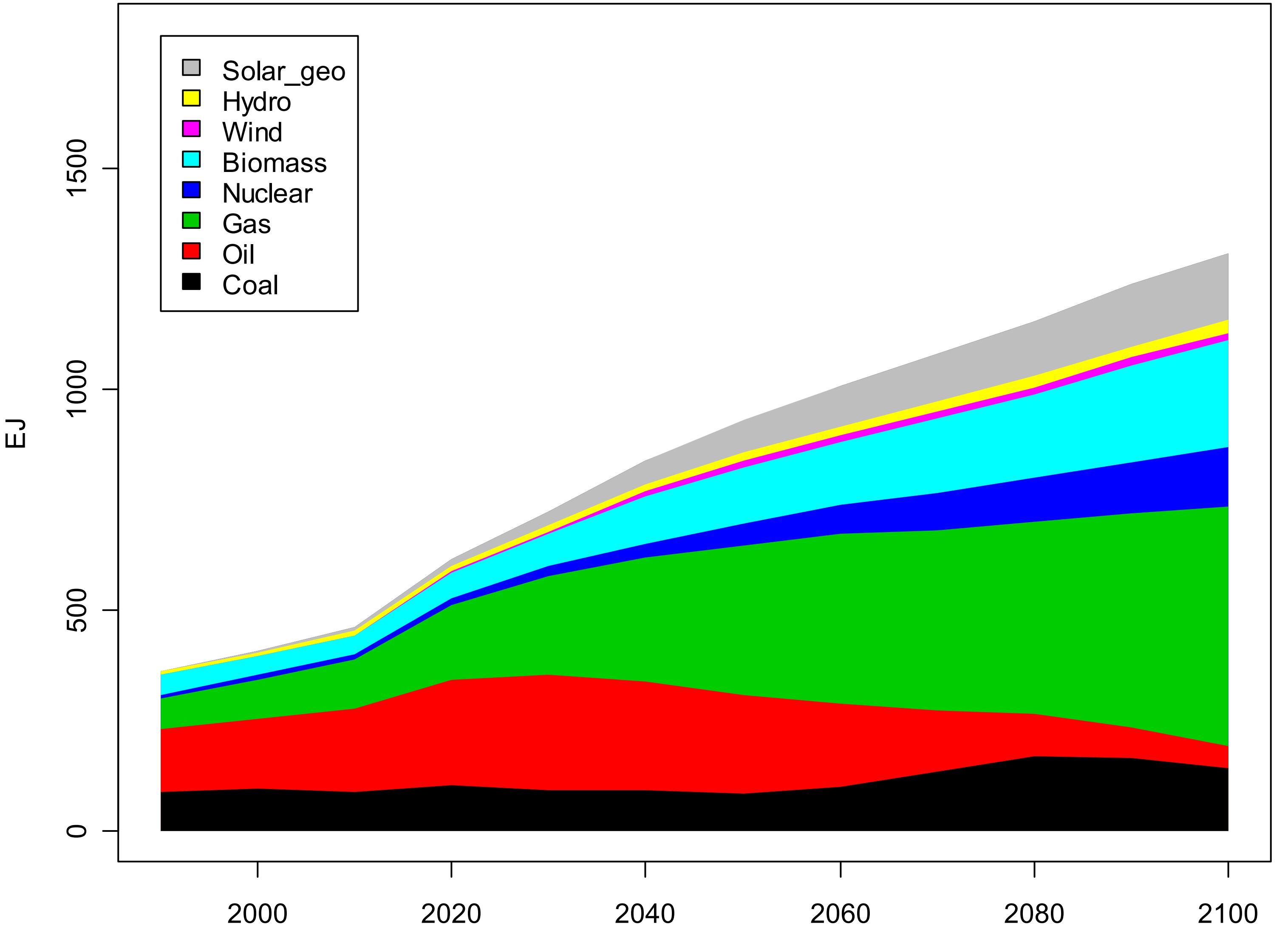
Methane Hydrates Assumptions

- available after 2030
- well-head costs: 10 – 100 $/boe
  [MacDonald 1990; Rogner 1997]
- hydrates occurrences (in place): 0 – 800 ZJ
  (800 ZJ ~ 19000 Gtoe, 20000 tcm, 10 EgC)
  e.g. [Dickens 1997; Rogner 1997]
- 25% of natural gas used for production
  (+ emissions)

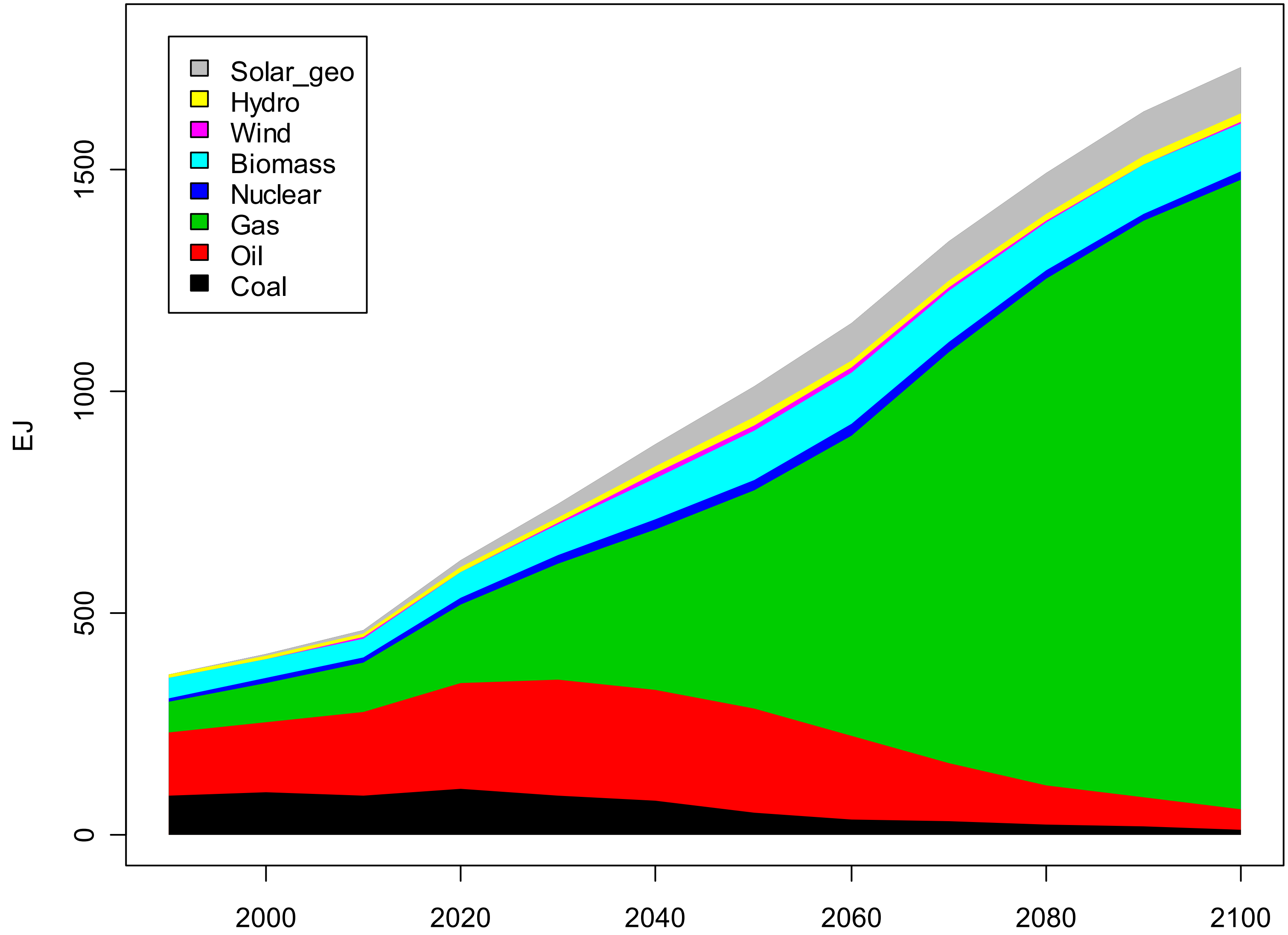
TPES: no hydrates



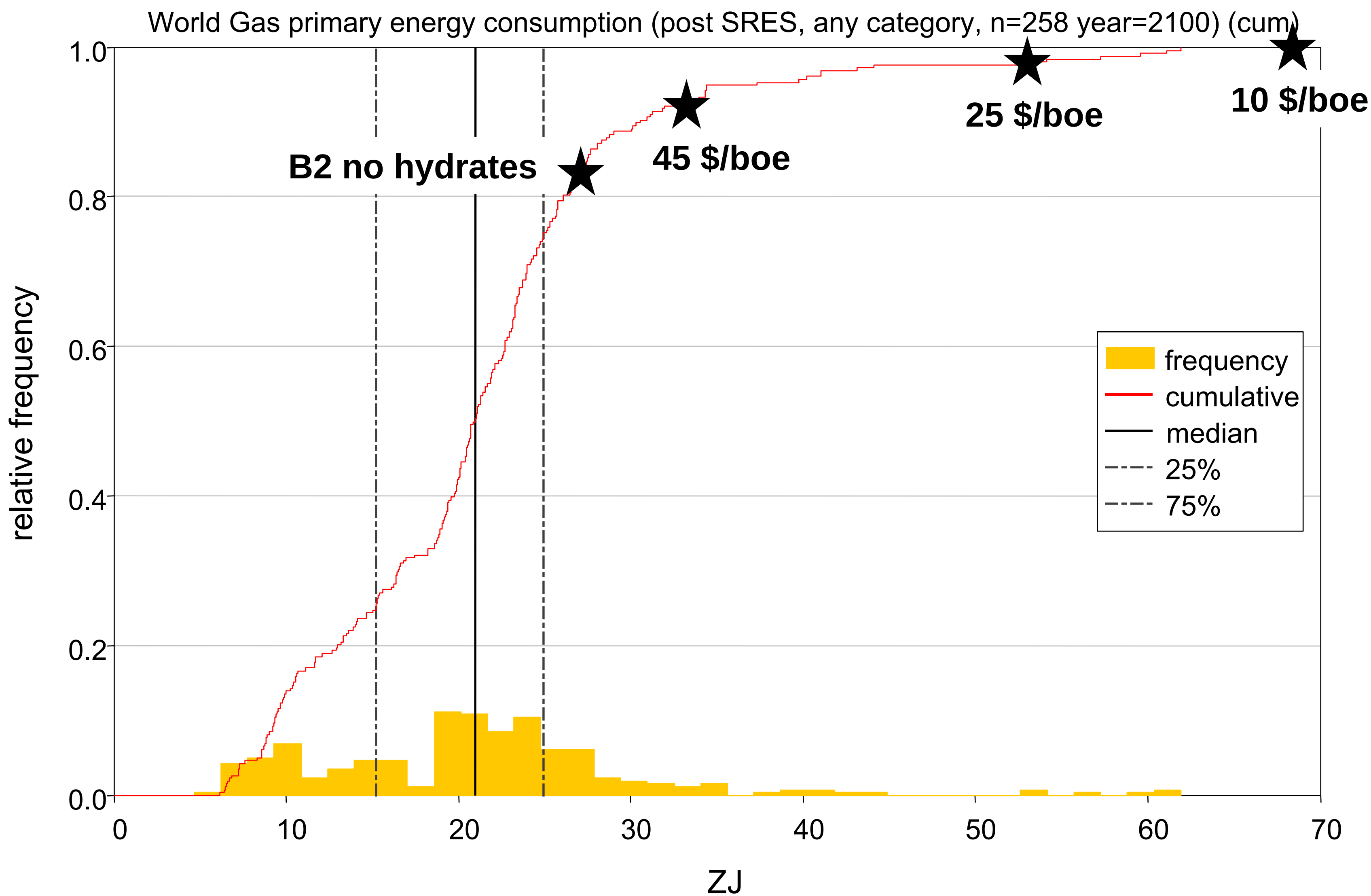
TPES: hydrates @ 45 $/boe



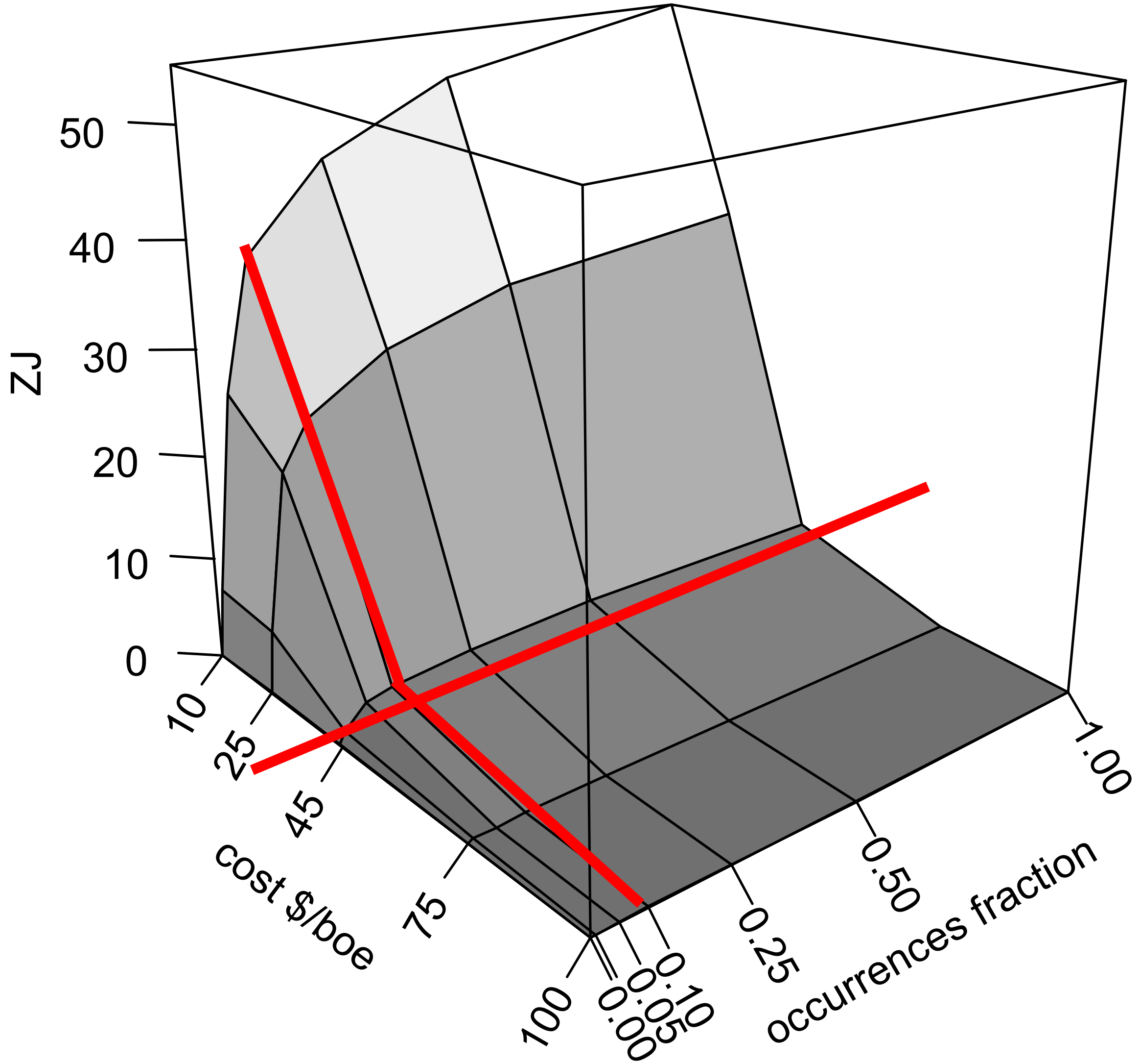
TPES: hydrates @ 10 $/boe



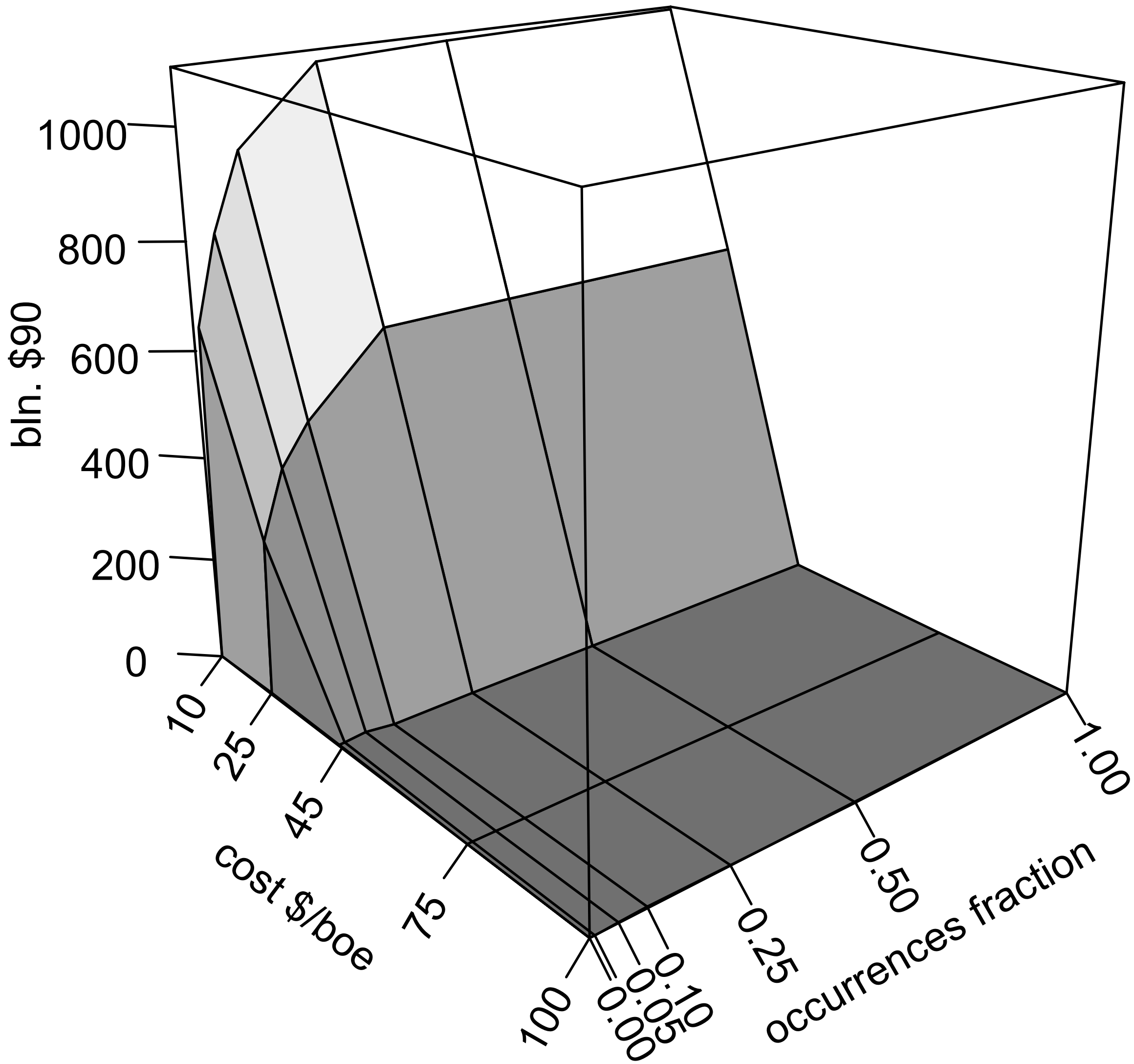
TPES Gas – Scenario Literature



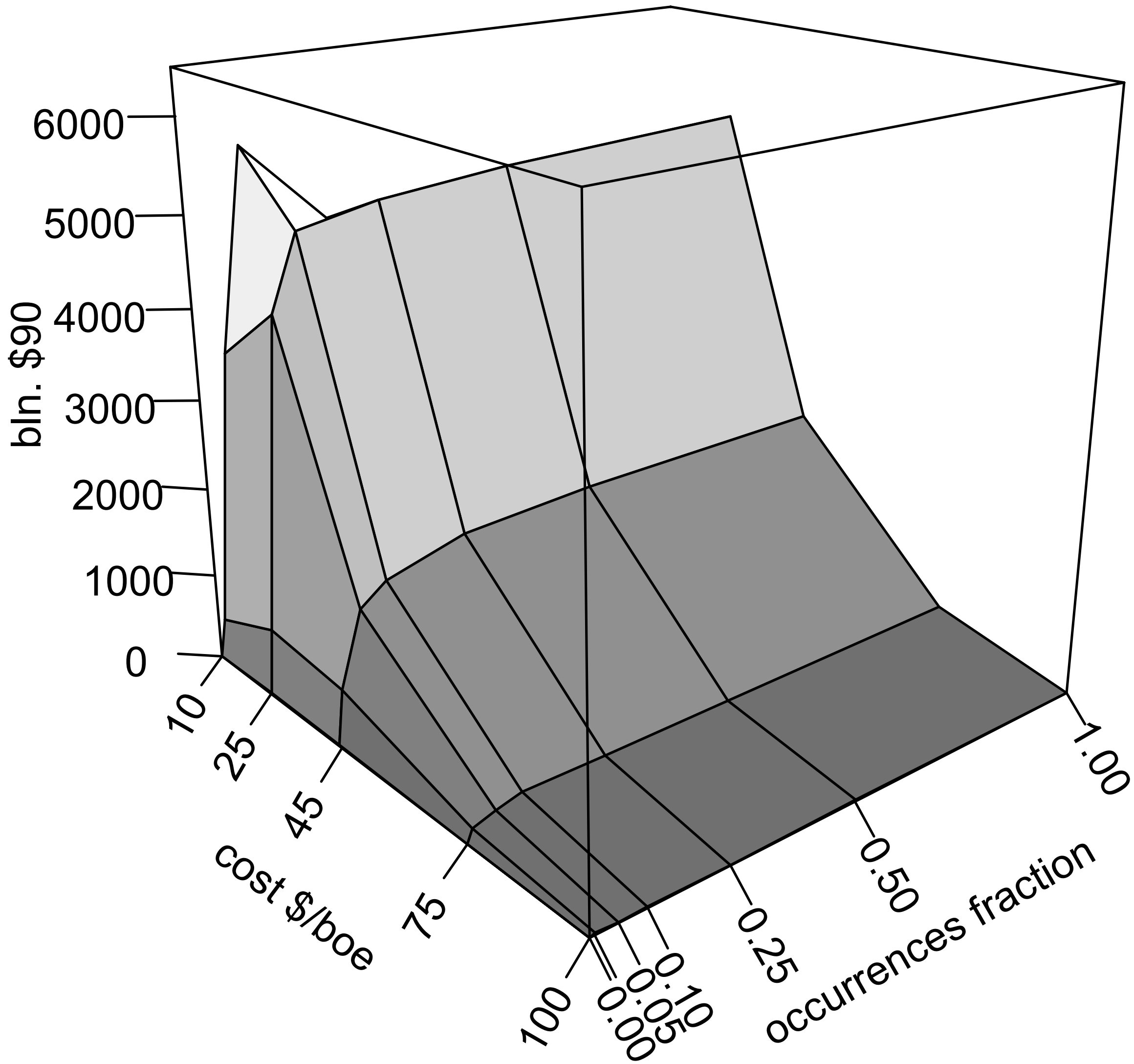
Cumulative Hydrates Extraction



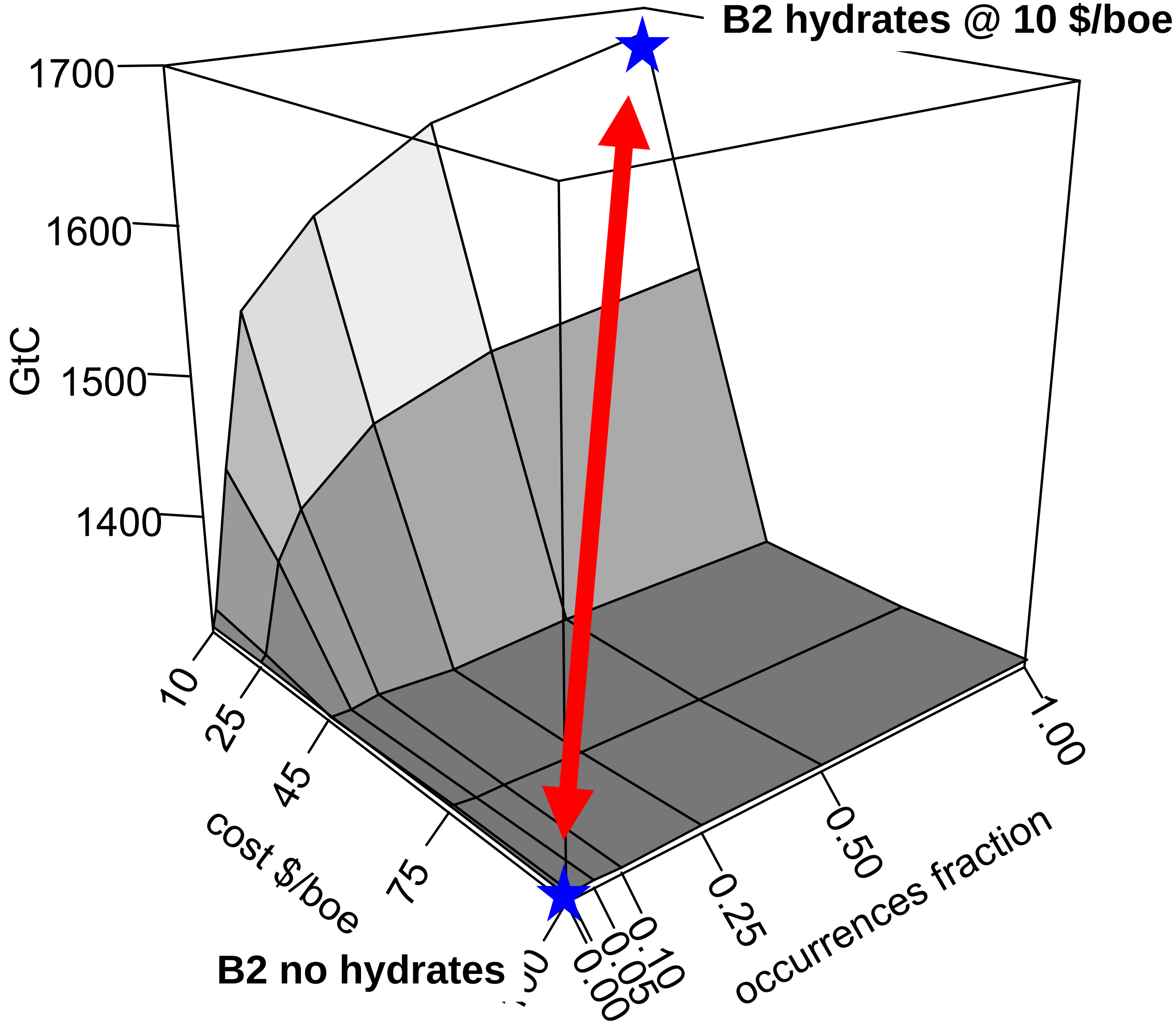
Market Size in 2050



Market Size in 2100



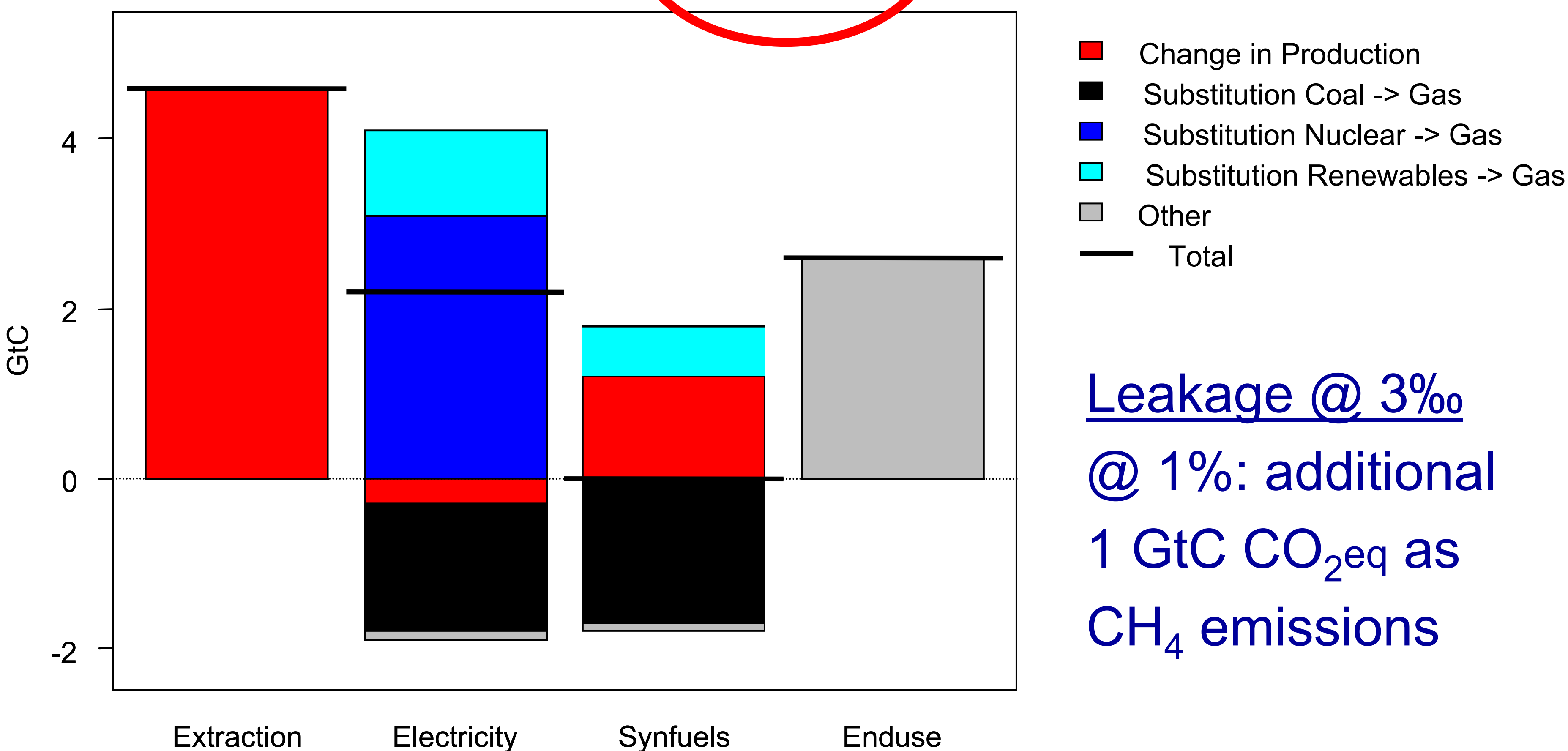
Cumulative CO_2 Emissions



Change of GHG Emissions by 2100 (B2 orginal vs. B2 hydrates @ 10$/boe)

B2 original: 13.4 GtC

B2 hydrates @ 10 $/boe: 22.7 GtC

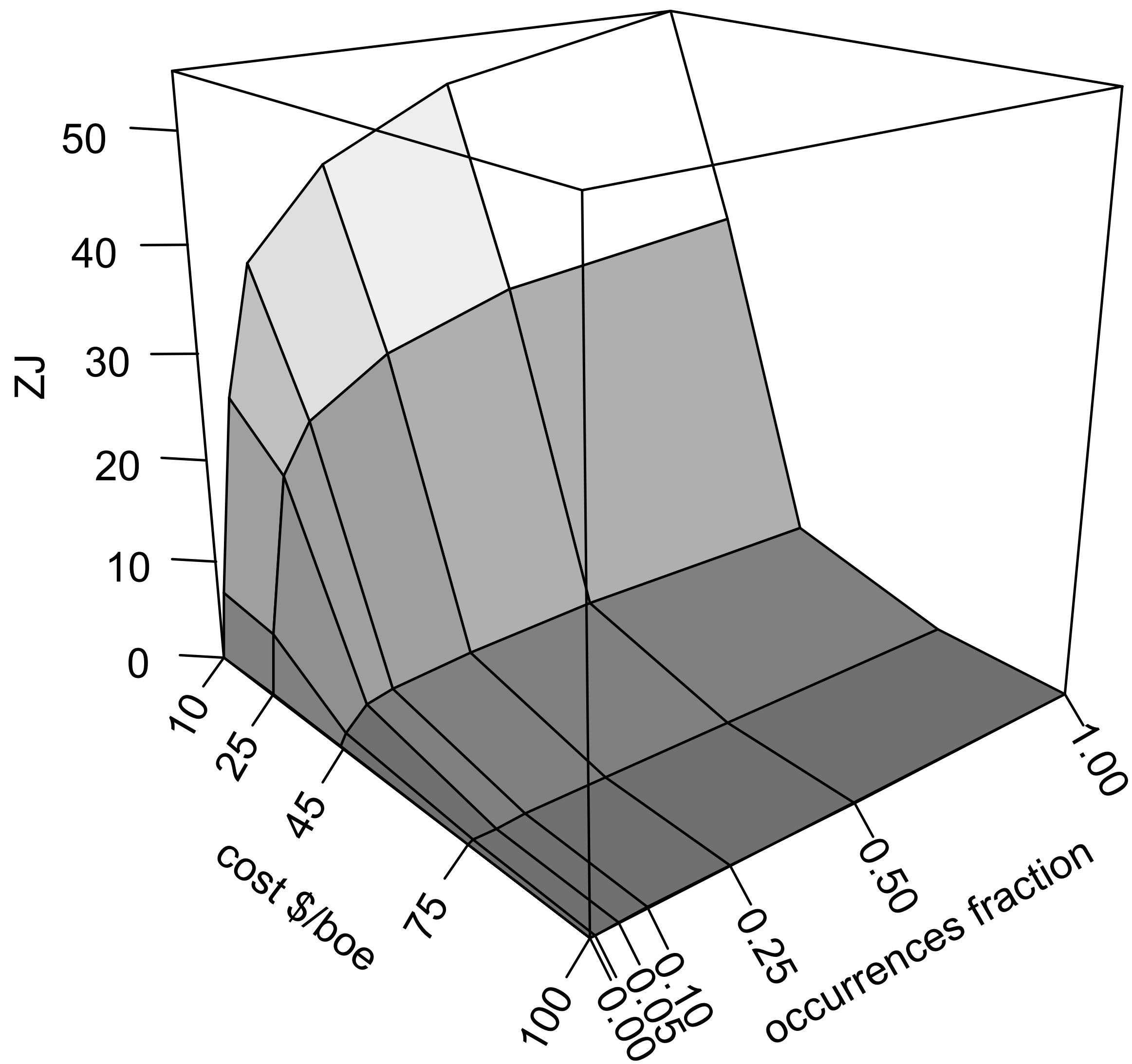


Leakage @ 3‰

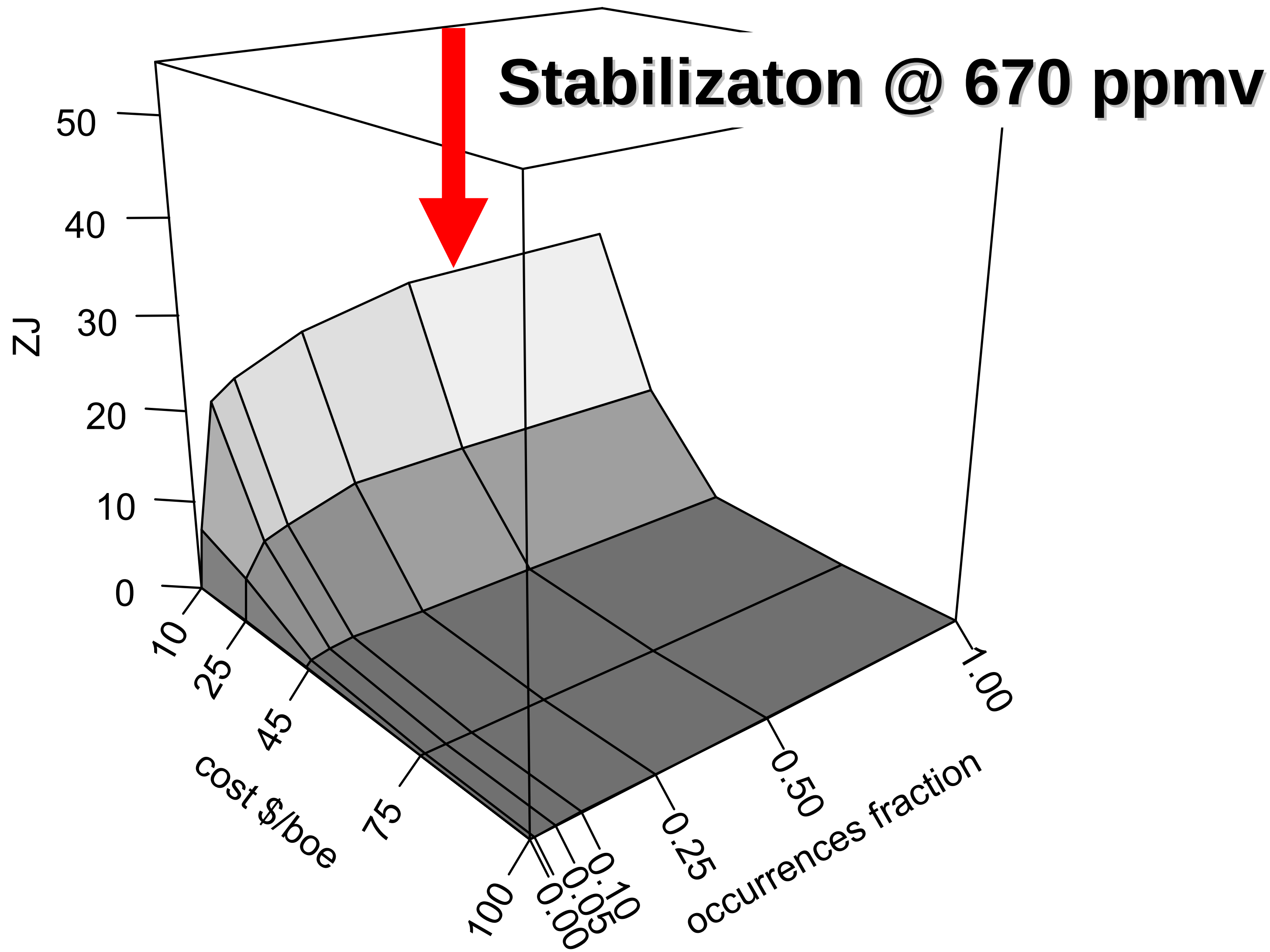
@ 1%: additional 1 GtC CO_{2eq} as CH_4 emissions

Hydrates and Mitigation: Stabilization @ 670ppmv

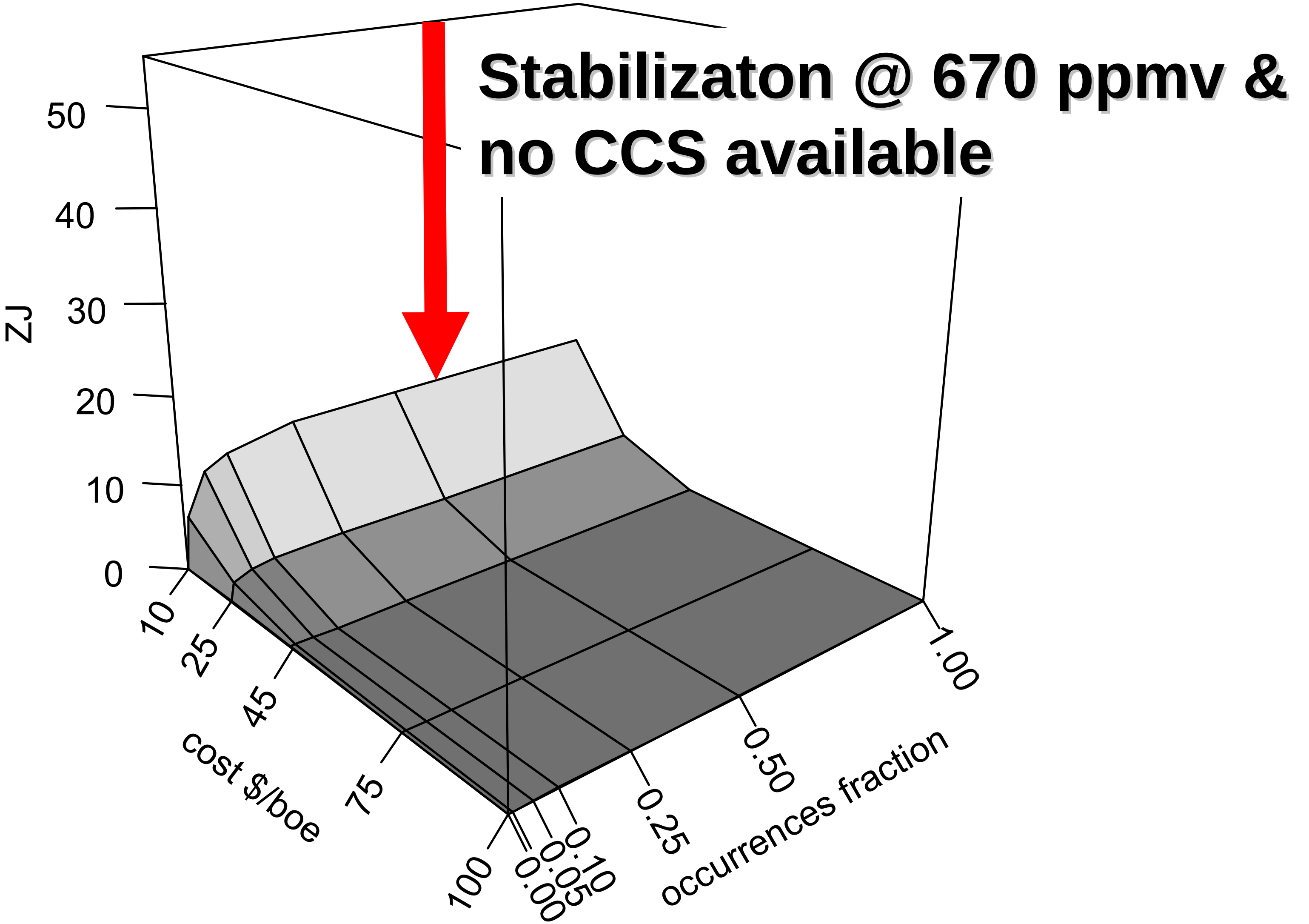
Cumulative Hydrates Extraction



Cumulative Hydrates Extraction



Cumulative Hydrates Extraction



Summary & Conclusions

- Main thresholds:
  - interesting @ well-head costs <50 \$/boe (5-55 ZJ cumulative extraction)
  - Huge market impacts <25 \$/boe (up to 1 trillion \$ in 2050 and up to 6 trillion \$ in 2100)
  - Maximum use of 7% of total assumed occurrences
  - regional distribution matters (vicinity to markets)
- GHG emissions:
  - energy intensity of hydrates production dominates
  - substitution effects (dependent on baseline) cannot compensate for upstream emissions penalty
  - Leakage important
  - CCS important in stabilization scenarios

Thank you!