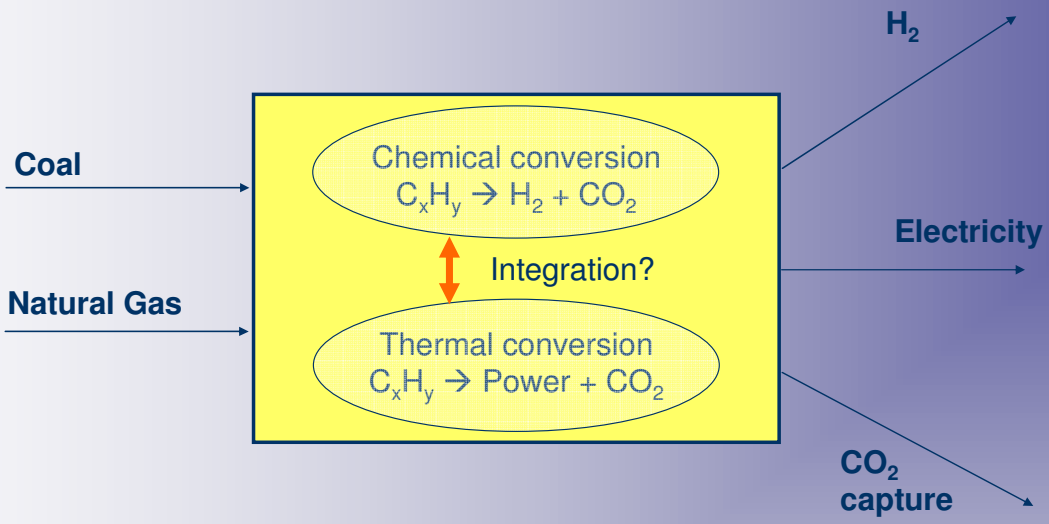

Dynamis SP2: Power plant & capture technologies

Castor-Encap-Cachet-Dynamis workshop

Lyon, 22nd-23rd January 2008

Dr. Petter E. Røkke, SP2 leader

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Layout

- Objective
- Partners – work structure
- Evaluation of concepts
- Recommendation

Objectives

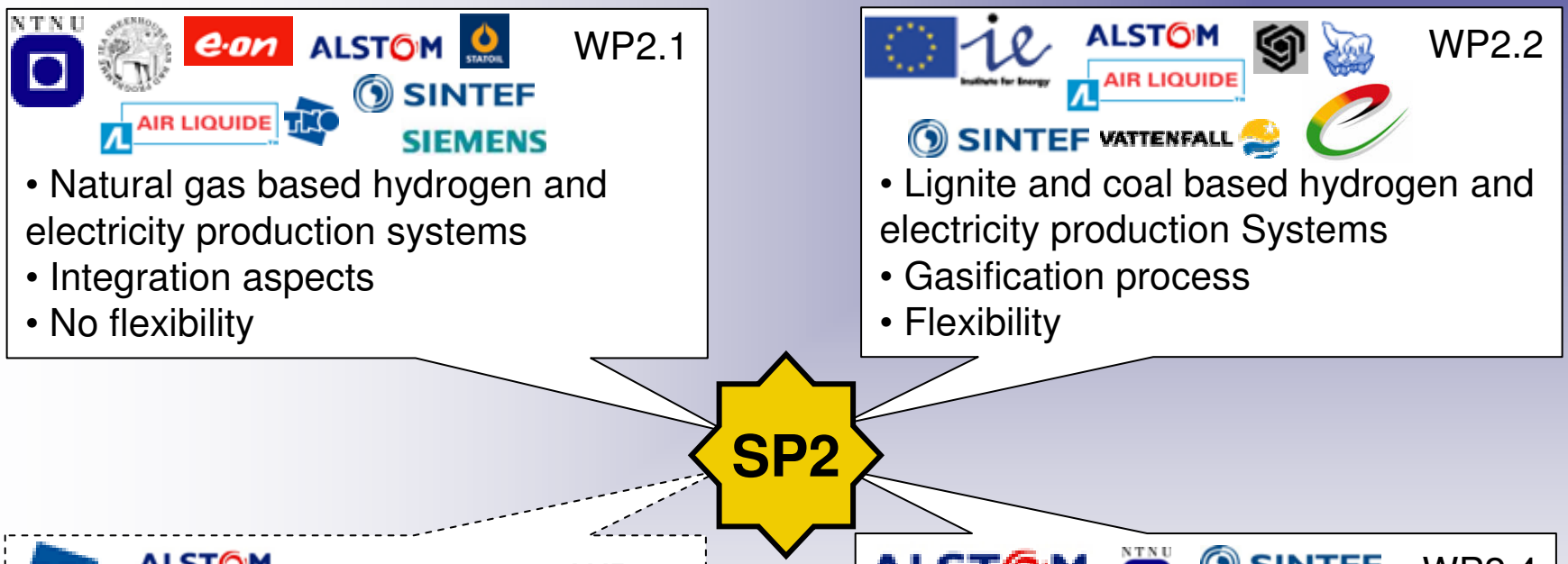
Dynamis overall objective;

Investigate viable routes for large-scale cost-effective combined H_2 and electricity production with integrated CO_2 capture and storage, probably combined with EOR

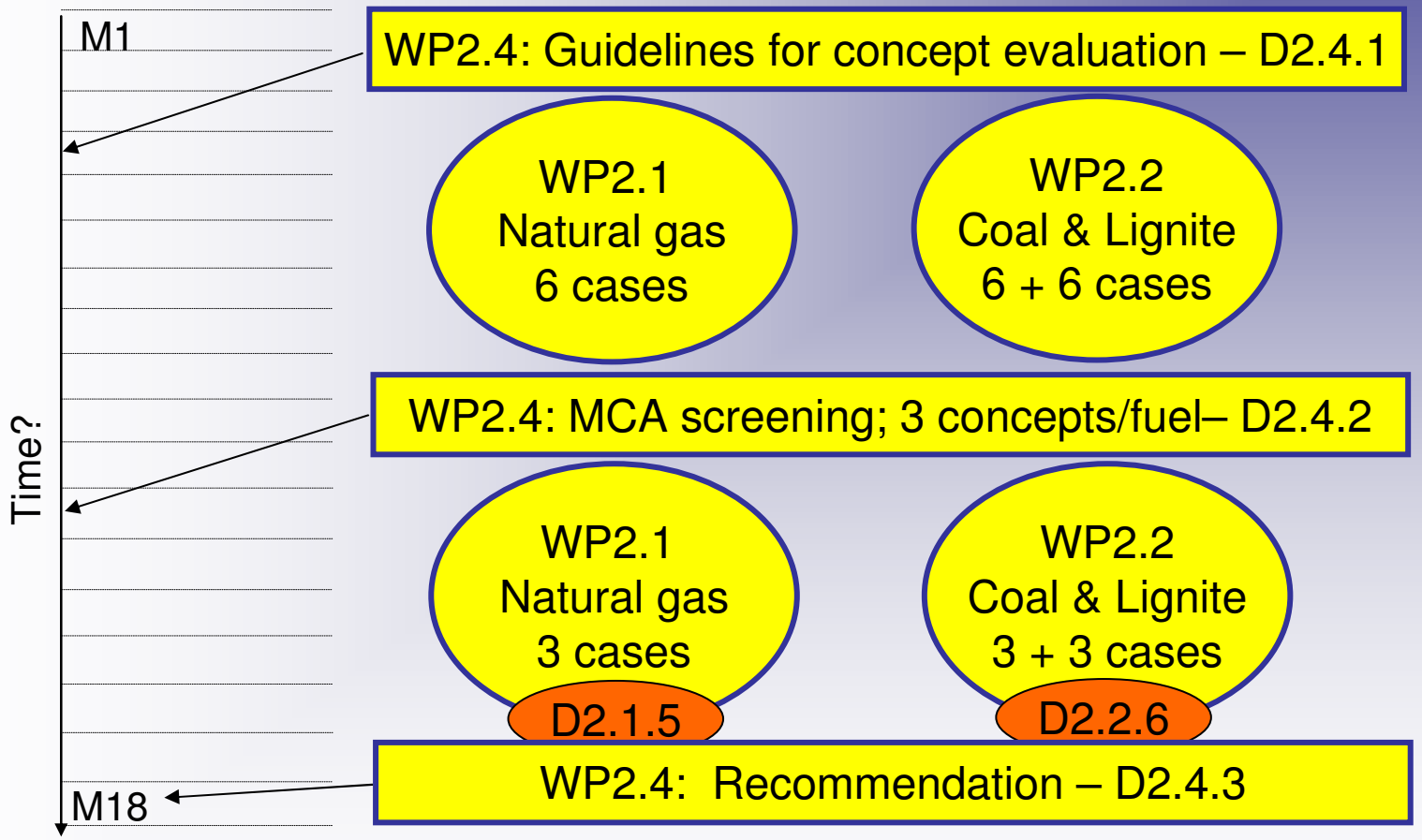
SP2 objective;

- Determine the overall configuration of plants that employ
  1. gasification technologies for the decarbonisation of coal and lignite (via a synthesis gas), and
  2. reforming technologies for natural gas,
- to be used for a combined production of hydrogen and electric power generation.

SP2: Work breakdown structure



SP2: Layout of working plan



SP2 – Main results

Guidelines for concept evaluation

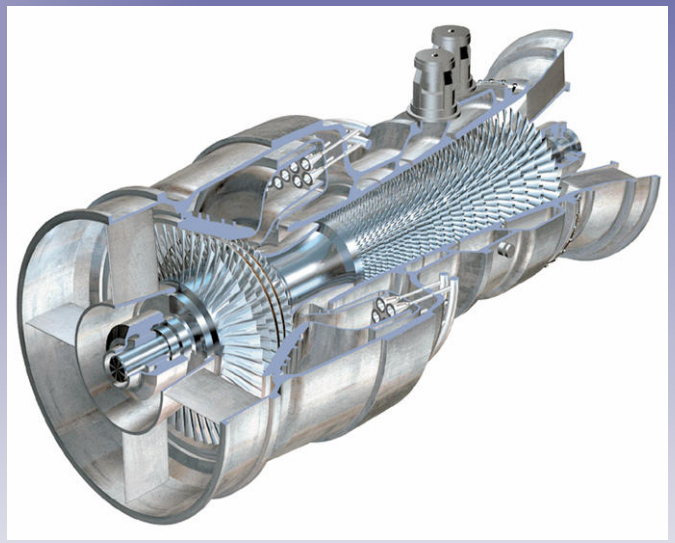
Specifications on:

- Gas turbines to be used in the simulations,
- Ambient conditions,
- Fuels (Bit. coal, lignite and natural gas),
- Emission limits,
- Oxygen purity,
- Hydrogen composition,
- CO_2 composition,
- Economic assumptions

SP2 – Main results

Important issues in SP2

- Capture technology
  - Dynamis – a pre-combustion project?
  - For coal/lignite – yes!
  - For natural gas – no! NGCC with post-combustion capture of CO_2 CAN and WILL be evaluated



- Gas turbine
  - Commercial technology in 2010
  - Agreed in the project: Use E-class GT with H_2 rich fuel used for integrated cases
  - For NGCC with post-combustion CO_2 capture and parallel production of H_2 – Use F-class GT fuelled with NG

  → Difference in efficiency due to GT

SP2 – Main results

Multicriteria Assessment (MCA)

Evaluation of;

- 6 coal-based concepts
  - 3 gasifiers
  - 3 AGR processes
  - 2 GTs
- 6 natural gas-based concepts
  - Degree of integration
  - Parallel option
  - GT; E or F-class
- Recommendation
  - 3 concepts for coal, lignite and natural gas

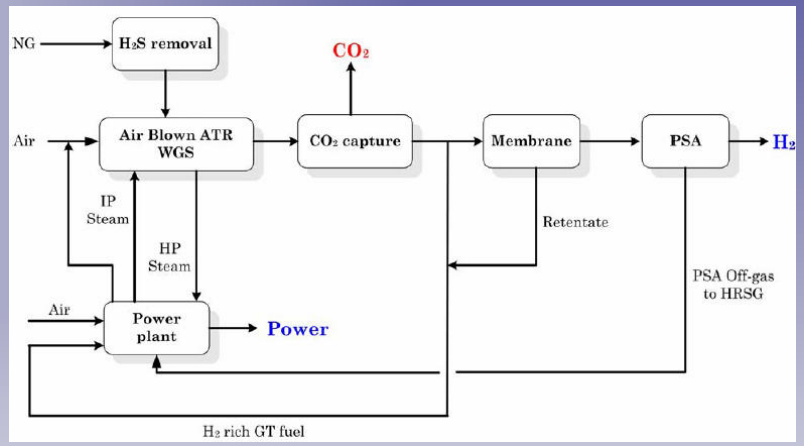
Criteria;

- *efficiency, reliability, availability, planned maintenance, cost, operability, output ratio flexibility, safety, environment , carbon capture efficiency, CO_2 product quality, H_2 product quality, bankability, technical risk*

SP2 – Main results

Description of concepts – Natural gas

1. Parallell
   - SMR, Post- and Pre-C capture, NGCC with F-class GT
2. Integrated
   - O_2-blown ATR, Pre-C capture, IRCC with E-class GT
3. Integrated
   - Air-blown ATR, Pre-C capture, IRCC with E-class GT



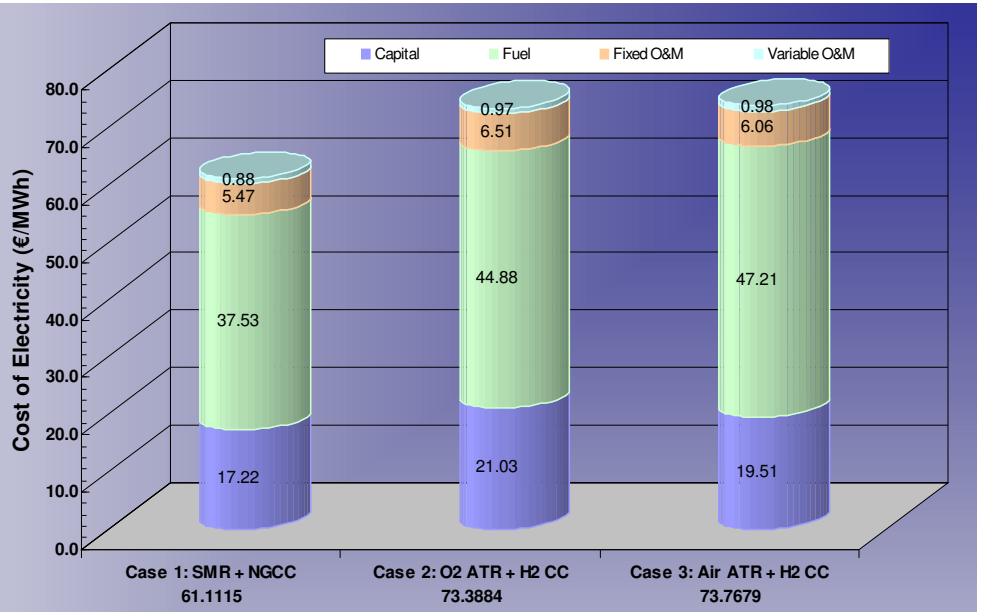
SP2 – Main results

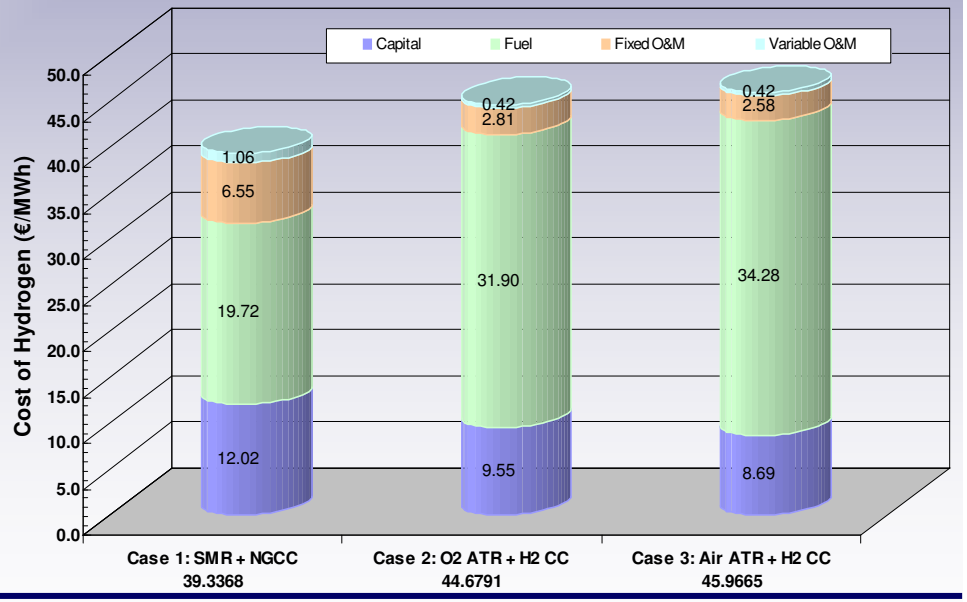
NG costs

- Case 1, Parallel production of H_2 and electricity, is the least expensive option

Case 1: 1 F-class GT

Case 2 and 3: 2 E-class GTs





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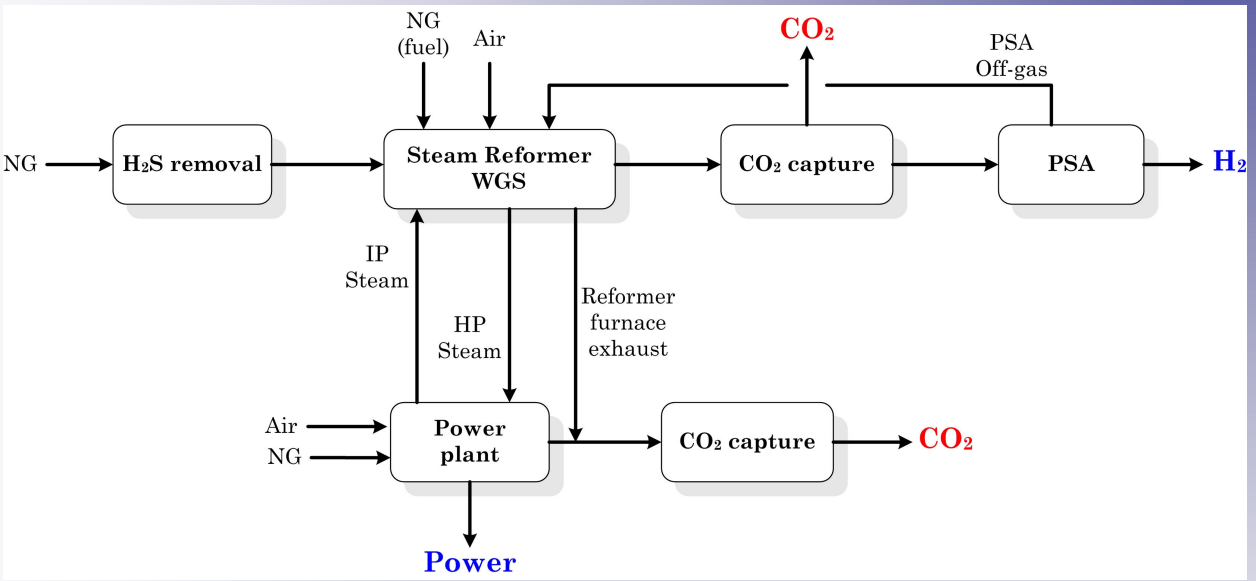
SP2 – Main results

Natural gas - recommendation

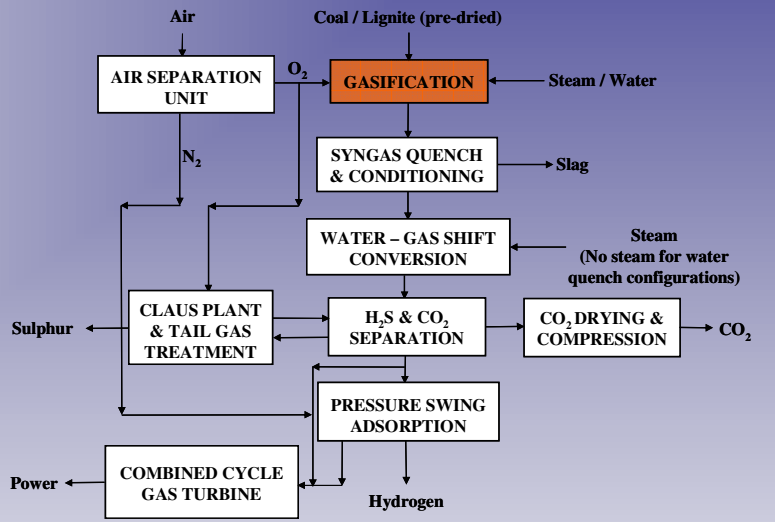


- Higher efficiency (F-class GT, SMR, MEA for CO_2 capture)
  - A ”thought H_2-fired F-class GT” would not close the gap in efficiency
- Less integration → lower complexity

SP2 – Main results

Description of concepts – Coal

1. Shell gasifier
2. Siemens gasifier
3. GE gasifier

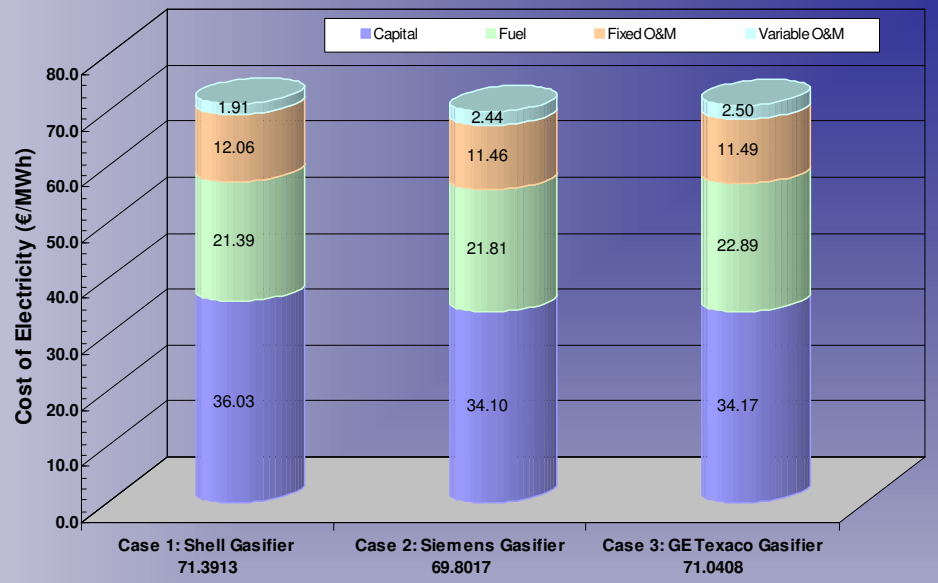


All:

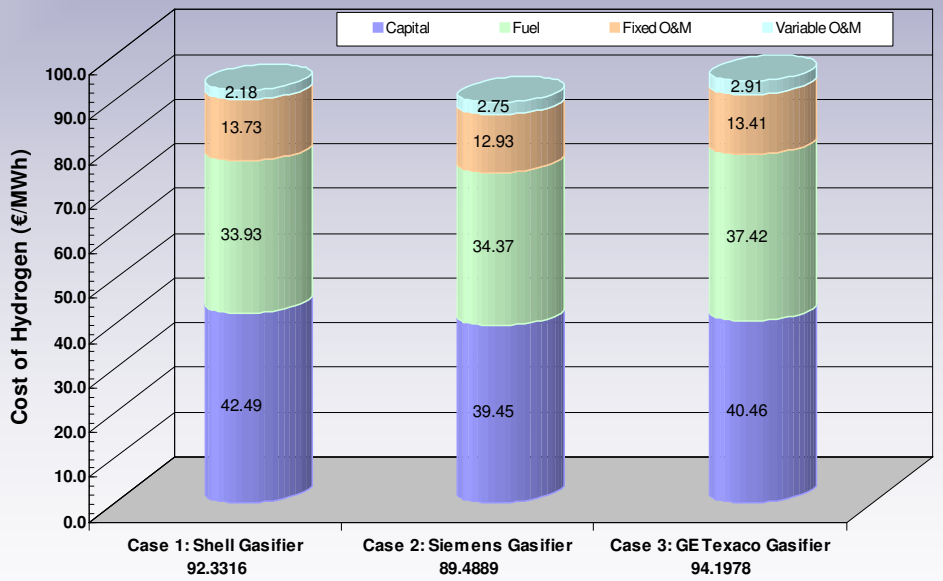
- Entrained flow gasifiers
- Selexol® AGR process
- E-class GT

SP2 – Main results

Coal concepts comparison



Gasification Technology	Unit	Shell	Siemens	General Electric
Power plant config. (GT/HRSG/ST)	GT/HRSG/ST	2/2/1	2/2/1	2/2/1
Coal flow (a.r.)	t/h	199.7	202.3	220.24
Gross power output	MW_e	594.91	592.27	630.38
Ancillary power demand	MW_e	132.69	134.19	155.53
Cooling water consumption	t/h	48826	49840	60873
Net power output	MW_e	462.22	458.08	474.85
Gross efficiency	%	42.6	41.86	40.93
Net efficiency	%	33.1	32.38	30.83
Carbon capture rate	%	90.26	90.02	90.28
CO_2 specific emissions	kg/MWh	102.93	107.83	110.27



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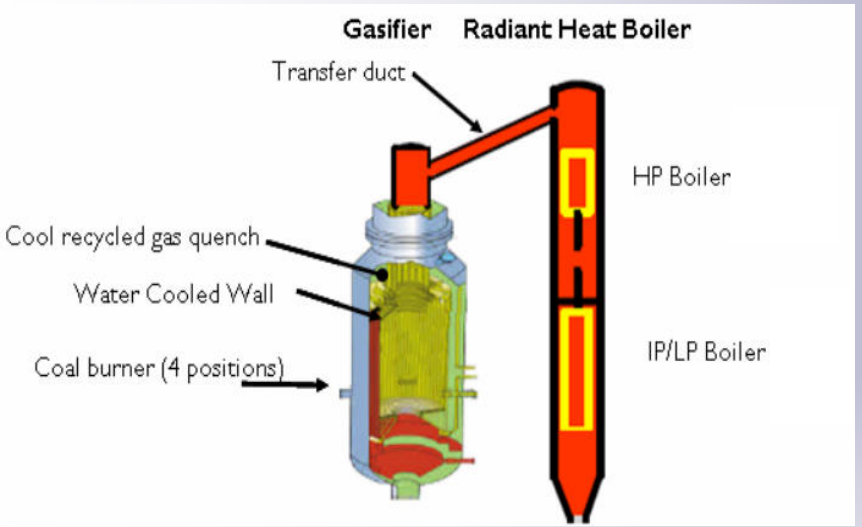
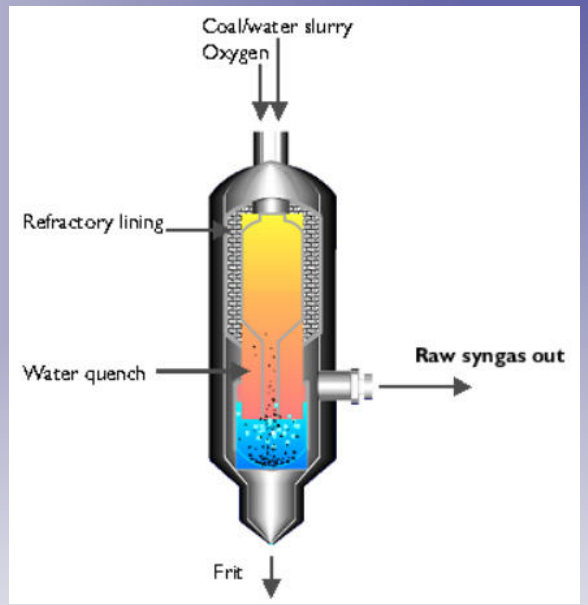
SP2 – Main results

Coal - recommendation



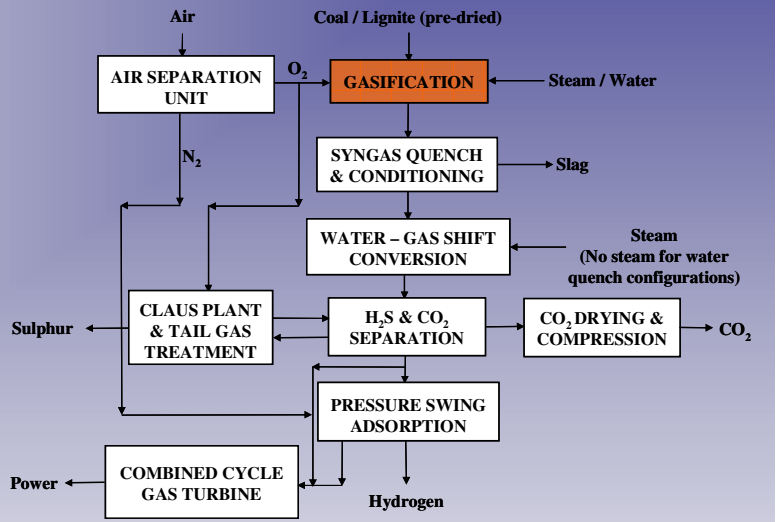


- Shell gasifier concept
  - Entrained flow
  - High efficiency, but drawback in costs, complexity and reliability
- GE gasifier concept
  - Good reliability, low CAPEX and technical risk
  - Drawback in efficiency

SP2 – Main results

Description of concepts – Lignite

1. Siemens entrained flow gasifier
2. HTW fluidized bed gasifier
3. BGL moving bed gasifier



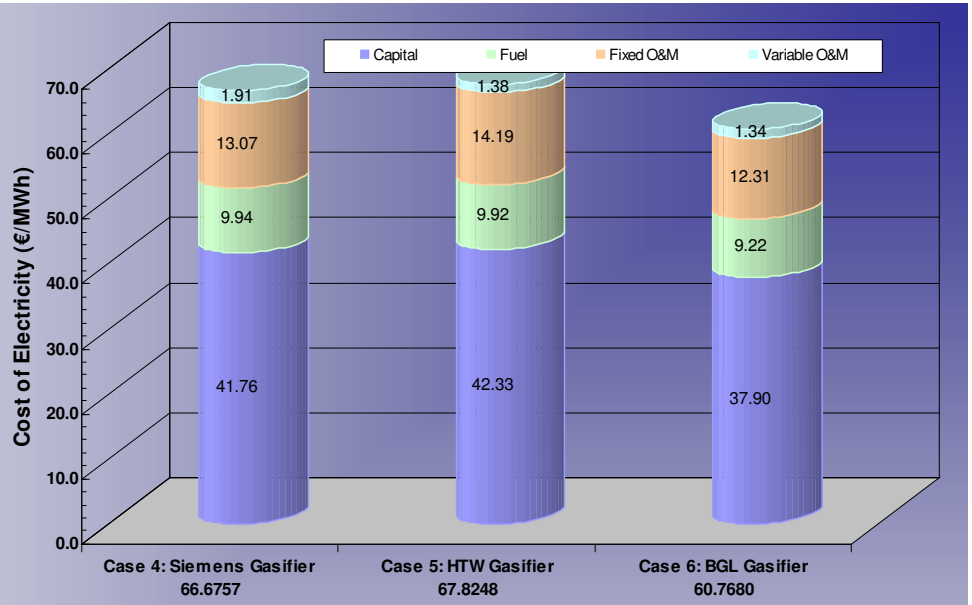
All:

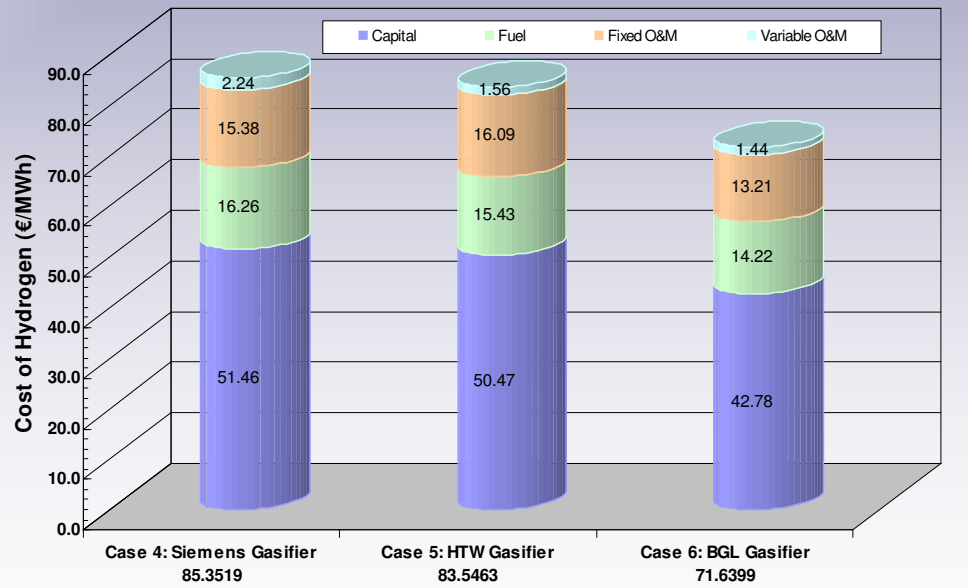
- Selexol® AGR process
- E-class GT

SP2 – Main results

Lignite concepts comparison

Gasification Technology	Unit	Siemens	High Temperature Winkler *	British Gas Lurgi
Power plant config. (GT/HRSG/ST)	GT/HRSG/ST	2/2/1	2/2/1	2/2/1
Lignite flow (a.r.)	t/h	510.2	484	446
Gross power output	MW_e	596.62	560.94	543.94
Ancillary power demand	MW_e	161.5	144.15	131.63
Cooling water consumption	t/h	52516	42842	38615
Net power output	MW_e	435.12	416.79	412.31
Gross efficiency	%	48.11	47.68	50.17
Net efficiency	%	35.08	35.42	38.03
Carbon capture rate	%	90.41	83.00	80.3
CO_2 specific emissions	Kg/MWh	111.47	186.88	211.6





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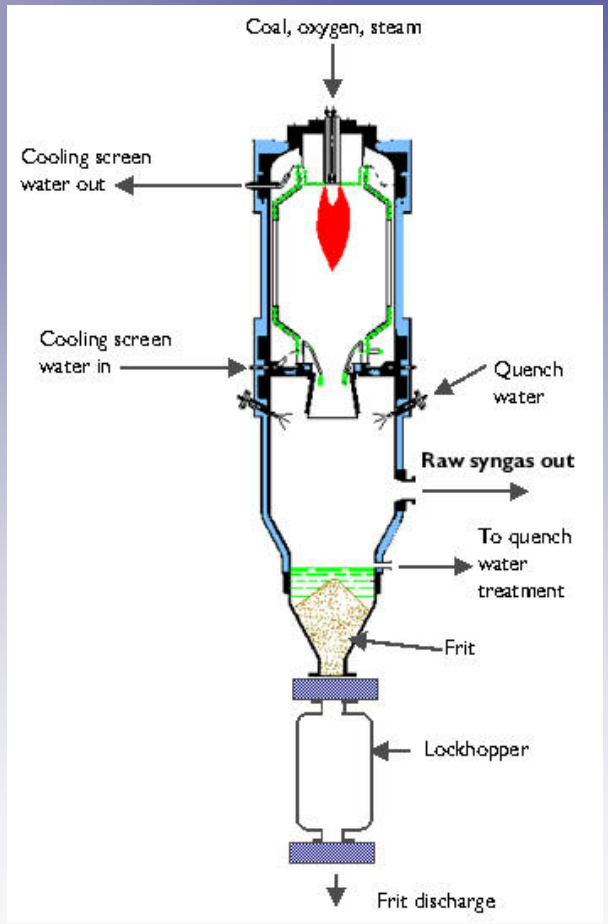
SP2 – Main results

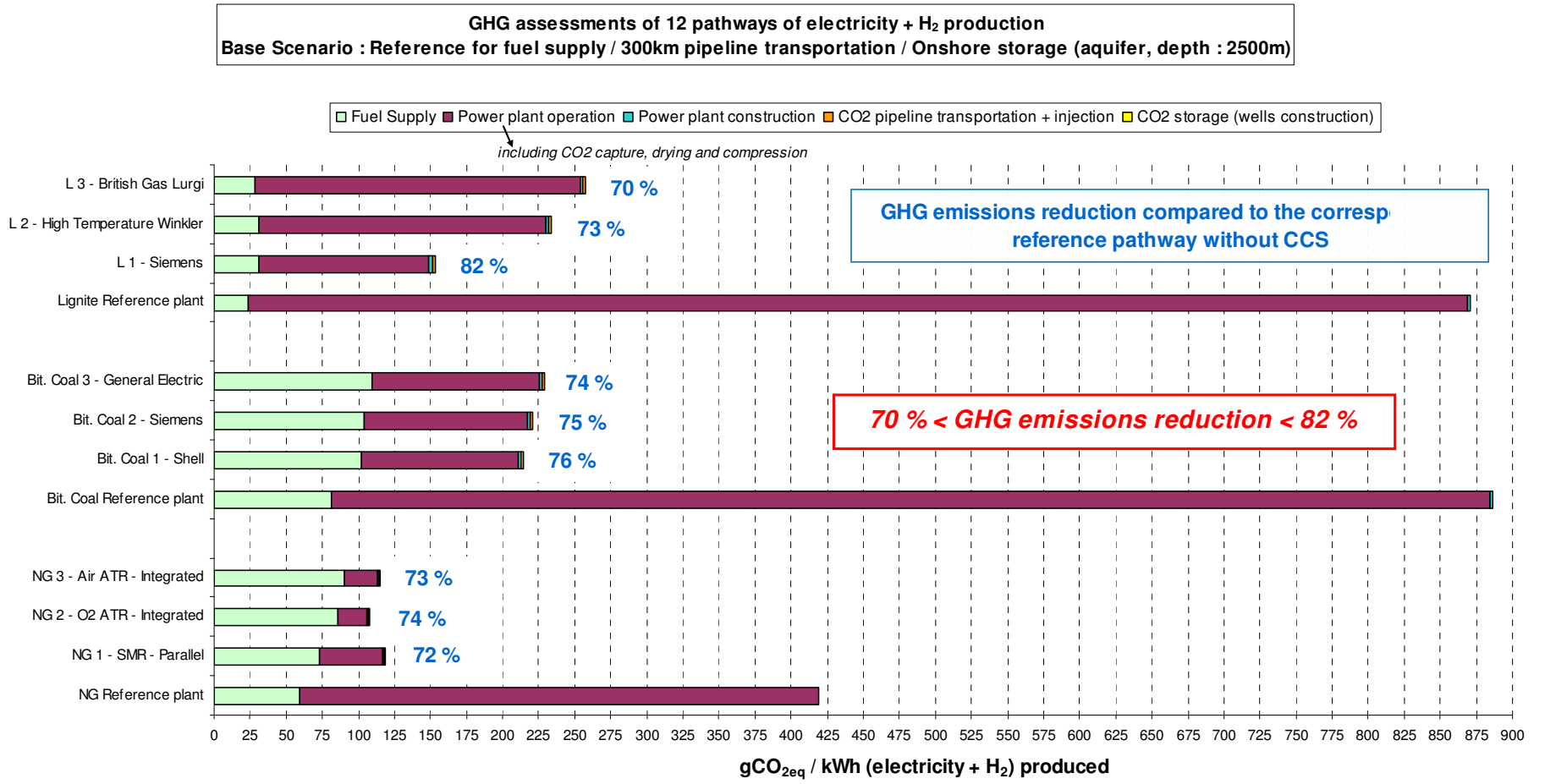
Lignite - recommendation

- Siemens gasifier concept
  - Entrained flow
  - CO_2 capture rate
  - Better techno-economic performance



SP2 – Main results

Life Cycle Analysis (LCA)



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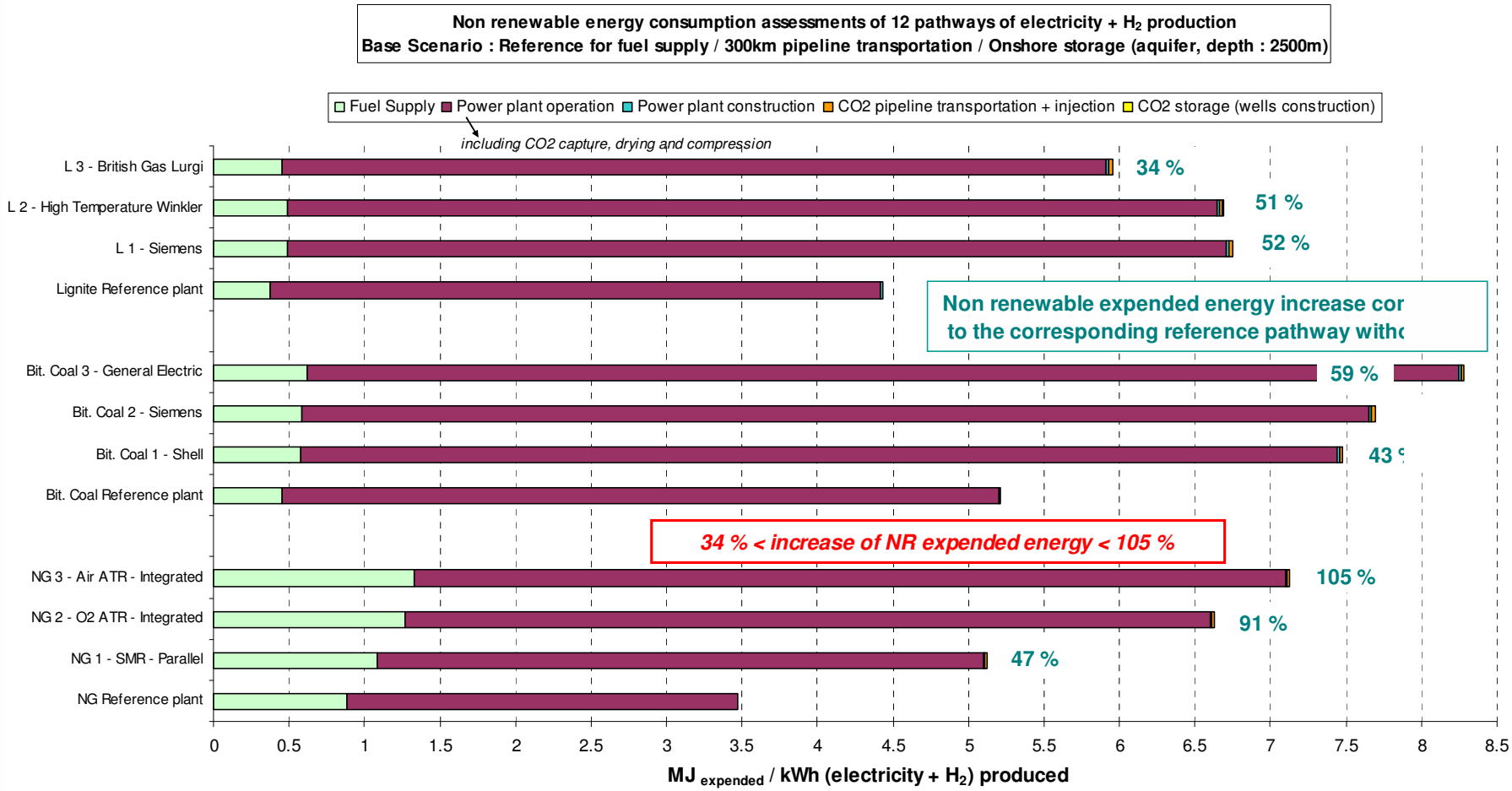
SP2 – Main results

Life Cycle Analysis (LCA)



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SP2 – WP2.3

New technologies…

- Exhaust gas recirculation with post-combustion capture of CO_2
  - Process simulations → promising results

- Supercritical Water Gasification + antisublimation process for H_2/CO_2 separation
  - Experiments @ TNO:
    - SWG – viable option – but more on a long-term perspective
  - Experiments @ Armines (subcontract of APE-FR):
    - Antisublimation – Feasible option for CO_2 capture from a pre-combustion process with SWG

Summary of results and recommendations in SP2

- A number of concepts have been studied for natural gas, coal and lignite within SP2 and a recommendation has been given with respect to further studies in SP5.

- Basis for recommendation;
  - Technical evaluation
    - WP2.1 and WP2.2
  - Economical evaluation
  - LCA
  - MCA

That's all from Dynamis SP2…

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