Tenth Annual Conference on
Carbon Capture & Sequestration

Policy

Biomass with CCS
Global Potential and Carbon Market Issues

Tim Dixon (IEAGHG), Joris Koornneef, Pieter van Breevoort, Carlo Hamelinck, Chris Hendriks, Monique Hoogwijk, Klaas Koop and Michèle Koper, Heleen Groenenberg (ECOFYS), Ameena Camps (IEAGHG)

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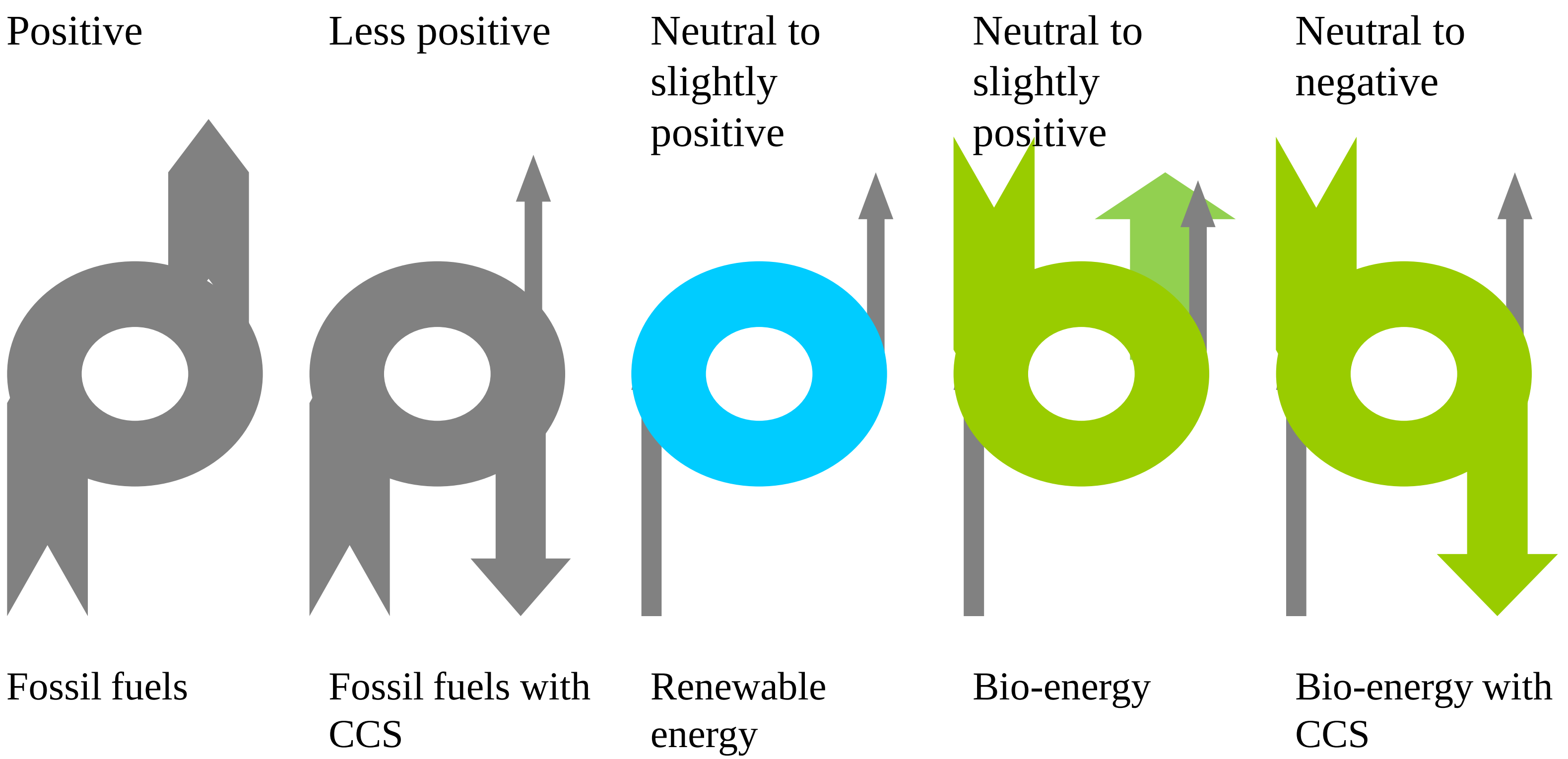
Why Biomass and CCS - the net carbon balance



Koornneef, ECOFYS 2010

Potential for Biomass and Carbon Dioxide Capture and Storage

- ECOFYS - Joris Koornneef et al

- To provide global and regional techno-economic assessment of potential for BE-CCS

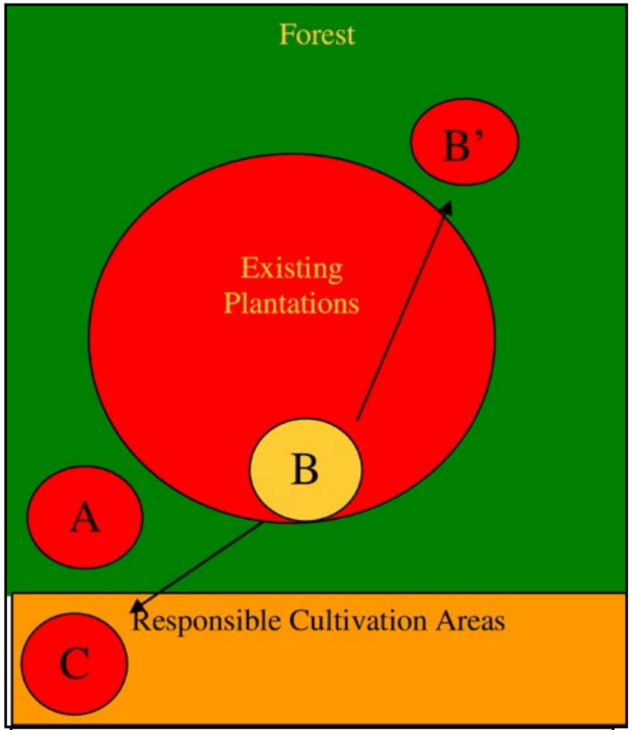
- Identify the main potential types of biomass and technologies applicable for energy conversion/process

Methodology

- First order assessment of potential for BE-CCS technologies at up to 2030 and 2050:
- Considering various levels of potential:
  - Technical Potential: Potential that is technically feasible and not restricted by economic limitations
  - Realisable Potential: Technically feasible and takes future energy demand and scenarios for capital stock turnover into account.
  - Economic Potential: Potential at competitive cost compared to alternatives.
- **Combining existing studies on biomass potentials and CO_2 storage potentials**
- Six technology options selected for detailed analysis from two major sectors: large-scale electricity generation and biofuel production:
  - PC-CCS co-firing; CFB-CCS dedicated; IGCC-CCS co-firing; BIGCC-CCS dedicated; Bio-ethanol advanced generation; FT biodiesel.

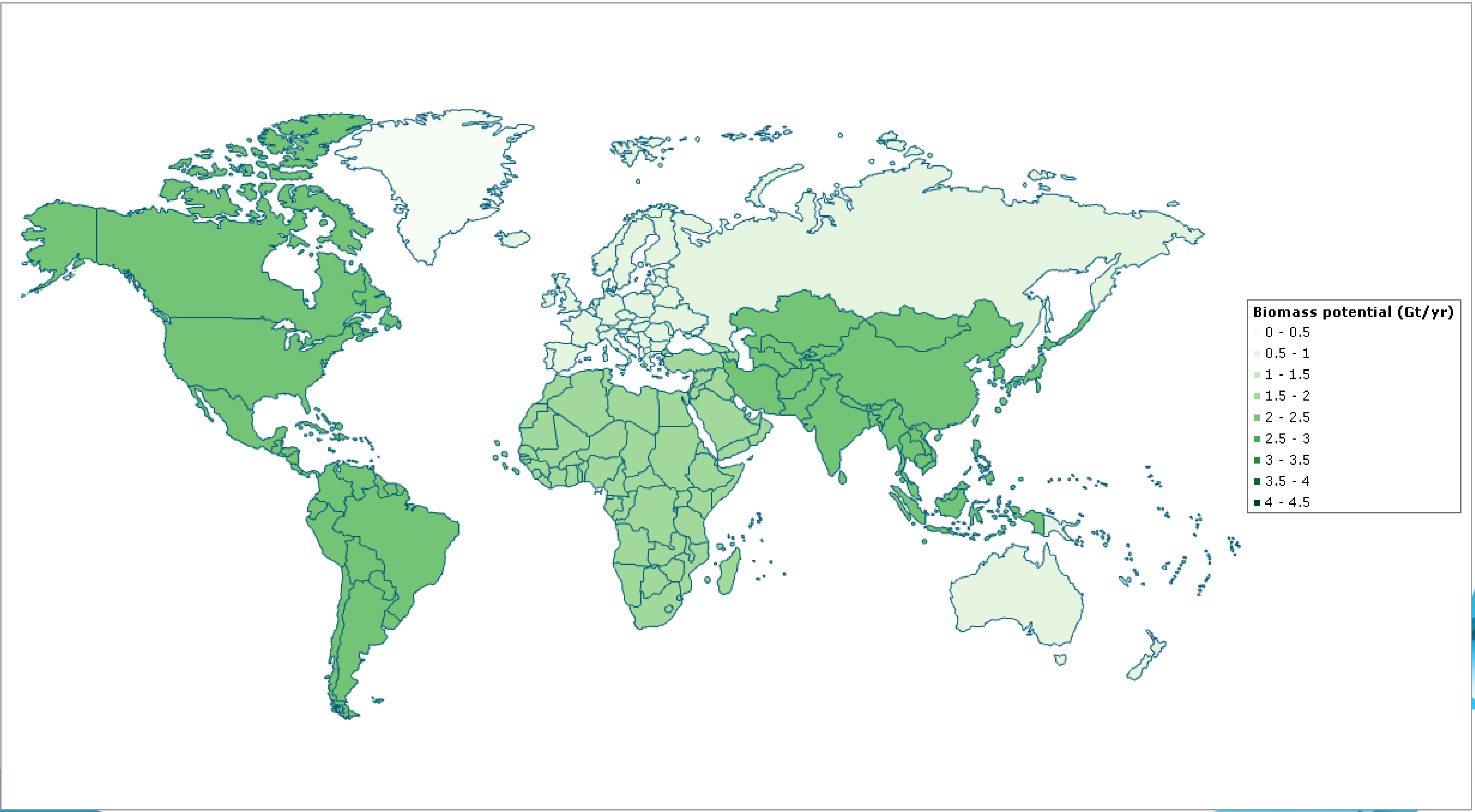
Sustainability Criteria

- Sustainability criteria 'strict' used is deemed appropriate, more detailed assessment of this criteria and factors which may limit sustainable supply will be important for future research.
- Factors classifying sustainable supply include:
    - Labour conditions
    - Protection of areas with high ecological, historical or cultural value
    - Food prices and security
    - Avoidance of indirect land use change (ILUC), and LUC.
    - Water supply and quality
    - Land rights of local communities
- Competition for land (and food prices) as well as ILUC and LUC are key areas of debate.



Adapted from Dehue 2006.

Regional Biomass Potential



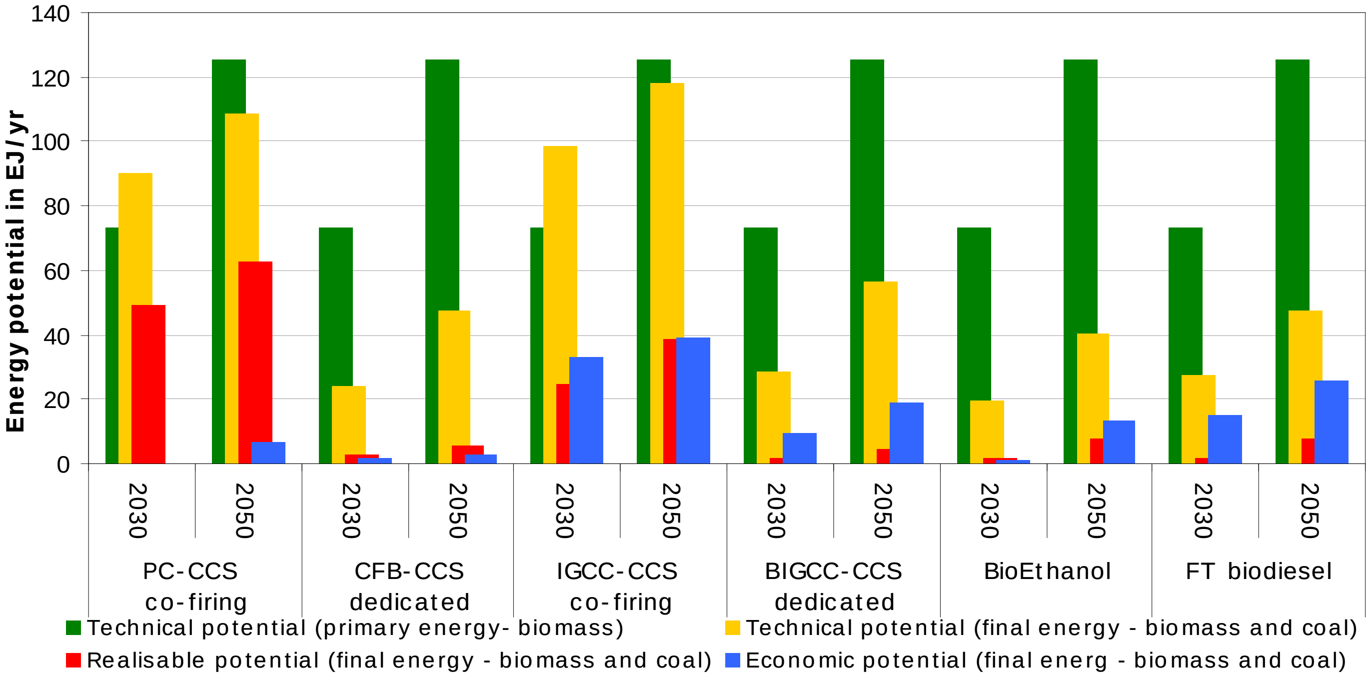
Methodology

- **Determining Technical Potential**
  - Regional and global technical potential - in terms of primary energy converted, final energy and net greenhouse gas emissions determined by the net energy conversion efficiency (including the energy penalty) and the carbon removal efficiency of the BE-CCS route, **combining existing studies on biomass potentials, and CO_2 storage potentials.**
  - Seven regions: Africa and Middle East (AFME), Asia (ASIA), Oceania (OCEA), Latin America (LAAM), Non-OECD Europe and the Former Soviet Union (NOEU), North America (NOAM) and, OECD Europe (OEU).
  - Three categories of biomass analysed:
    - energy crops; forestry residues; agricultural residues;
    - sustainable biomass potential is estimated based on data from previous studies

Methodology

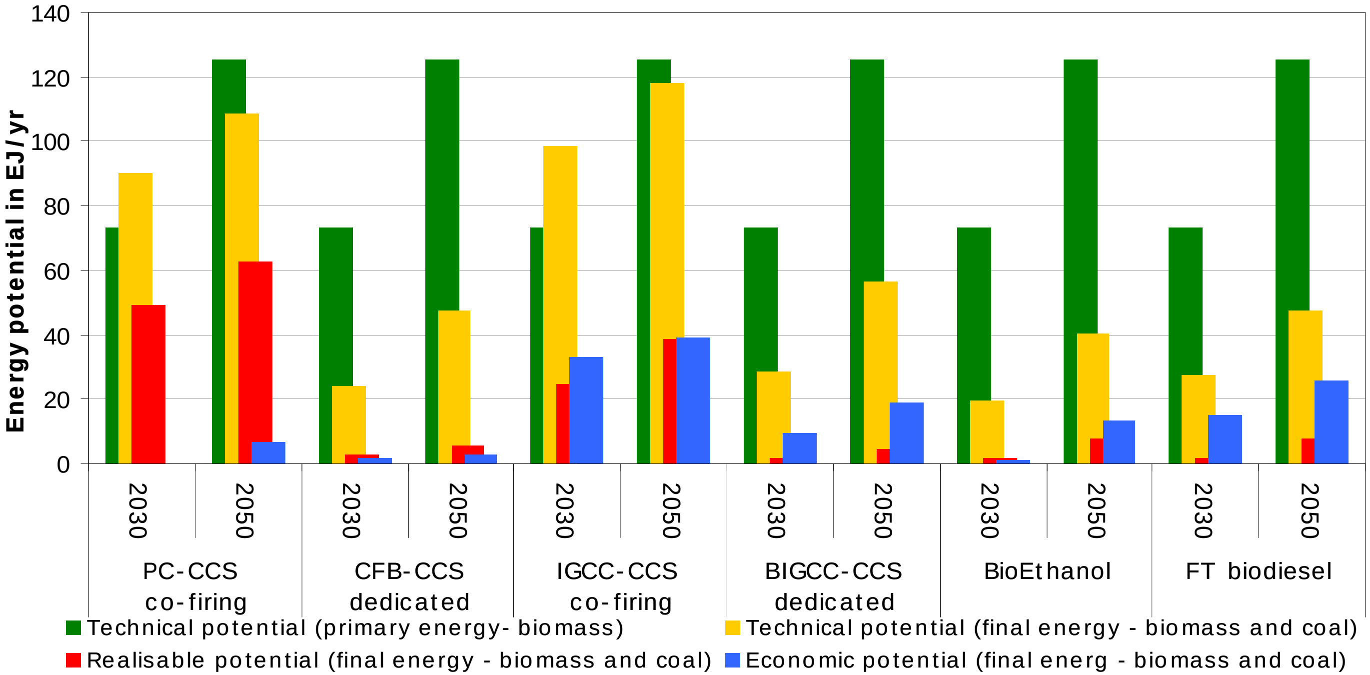
- **Determining Realisable Potential**
  - Adds limitations by including energy demand, capital stock turnover and possible deployment rate. Estimates for electricity supply and transport fuels BE-CCS routes based on the reference scenario in the IEA World Energy Outlook (IEA, 2009), adapted to include the view year of 2050.
- **Determining Economic Potential**
  - Combining the price of biomass resources with costs for biomass conversion and CCS for selected BE-CCS routes. The cost of producing electricity and biofuels (with and without CCS) are assessed, considering the CO_2 price, yielding supply curves for the BE-CCS routes and reference technologies.
  - Biomass pre-treatment and transport is a significant part of the biomass supply chain cost, and is assumed to be an average cost adding approximately 1.3 €/$GJ_{primary}$

Results: Technical Potential



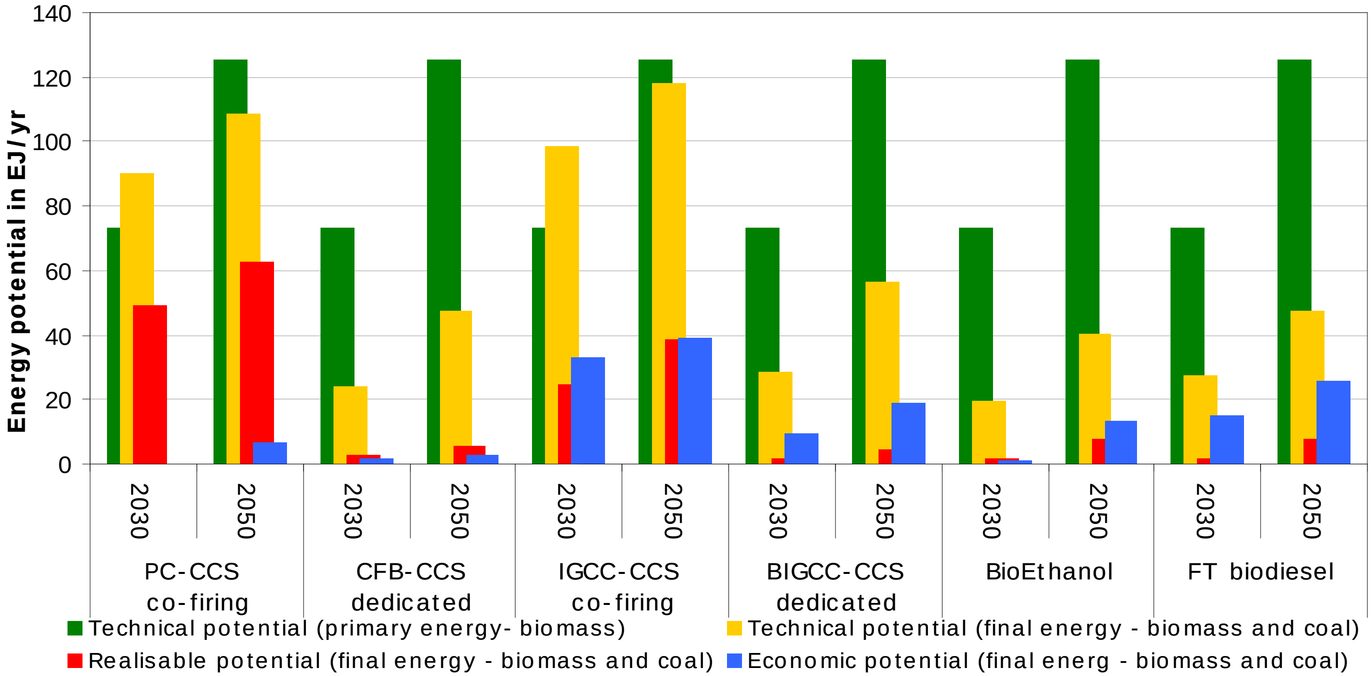
- Deploying the full technical potential equates to up to 16 PWh (59 EJ) of bio-electricity or 1.1 Gtoe (47 EJ) of biofuels.
- The amount of sustainable biomass greatly influences the technical potential for BE-CCS technologies.
- Technical potential greatest in Asia and Latin America, lowest in Oceania, Non-OECD Europe, the Former Soviet Union and, OECD Europe.
- Availability of sustainable biomass is the limiting factor.

Results: Realisable Potential



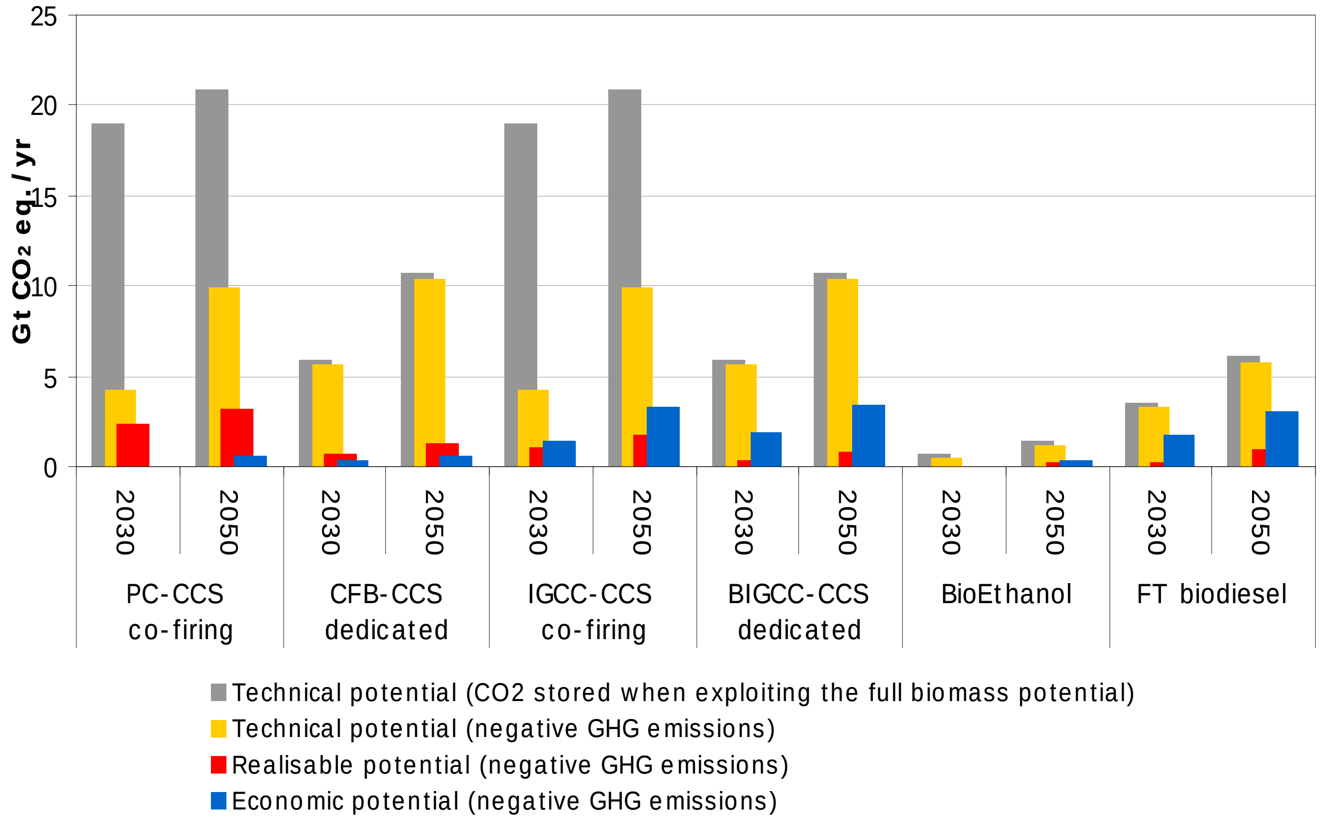
- In short term, realisable potential is estimated to be very small, limited by early deployment opportunities, increasing to 2 - 15 EJ/yr in 2030 (1-4 PWh) and 4 - 20 EJ/yr (1-6 PWh) in 2050 for producing electricity routes; for biofuels routes: 2 EJ/yr in 2030 and 8 EJ/yr (191 Mtoe) in 2050 - cumulative potential of 123 EJ up to 2050.
- The largest realisable potential for the medium and long-term is found for the PC-CCS co-firing route.

Results: Economic Potential



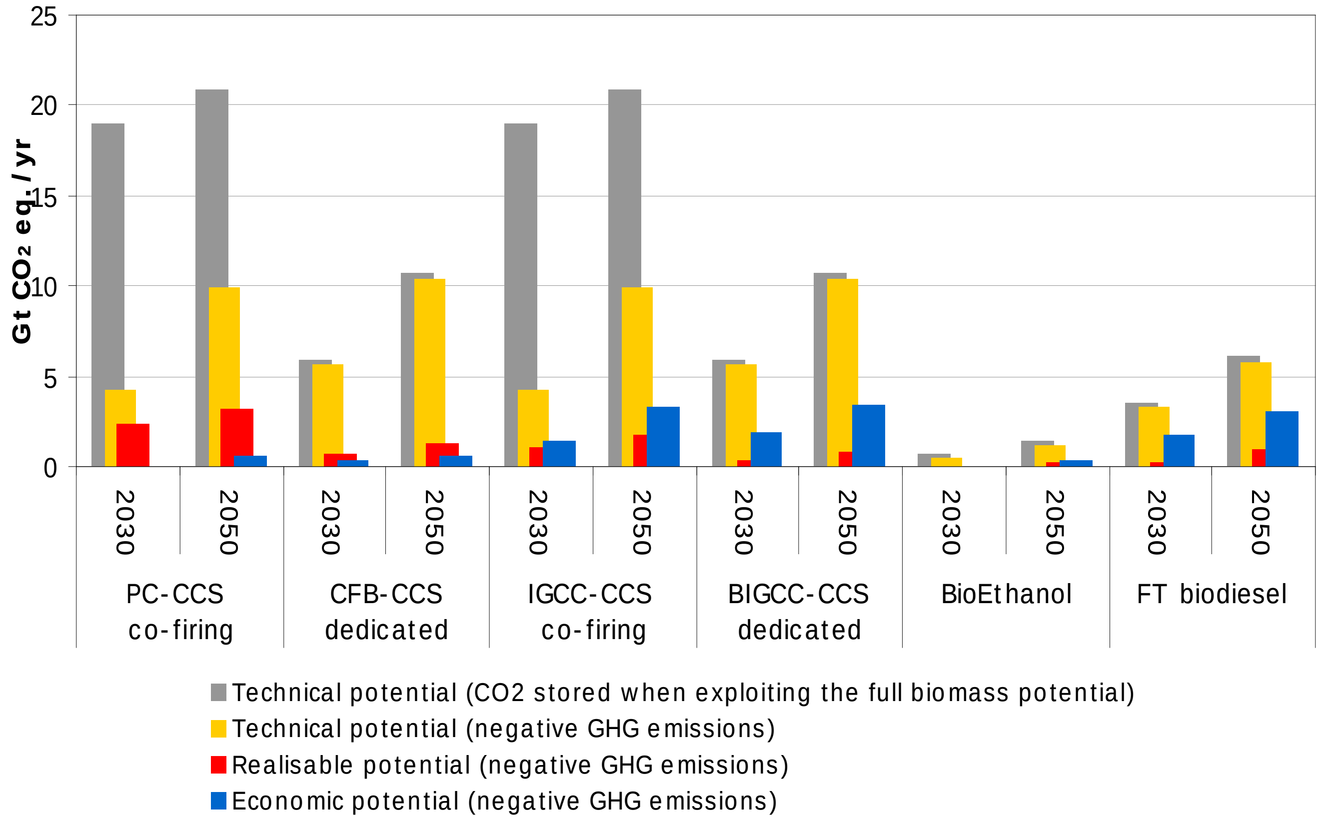
- With CO_2 price of 50 €/tonne, economic potential for BE-CCS up to 20 EJ (5 PWh) for bio-electricity routes, or up to 610 Mtoe (26 EJ) for biofuel routes.
- Greatest potential in gasification based routes, with economic potential of 39 EJ/yr in 2050 for IGCC and, 19 EJ/yr for BIGCC in 2050. Smallest potential appears to be in the PC and CFB routes of about 1 EJ/yr in 2030.
- Conversion cost for power production for all routes, except CFB, is lower overall when equipped with CCS.

Results: GHG Balance - 1



- Global technical potential: up to c. 10 Gt CO_2 eq/yr , greatest potential for negative emissions for BIGCC-CCS and CFB-CCS.
- 1/3rd of technical potential economically attractive, yielding technology economic potential up to 3.5 Gt/yr of negative greenhouse gas emissions.

Results: GHG Balance - 2



- Greatest economic potential: gasification based routes - GHG emissions balance of -3.3 Gt per year in 2050 for IGCC and, GHG -3.5 Gt per year for BIGCC in 2050. Biofuels, highest potential in FT-biodiesel: -3 Gt GHG emissions per year in 2050.

Market Drivers & Barriers

- **<u>CO_2 value</u>**: Under the EU ETS, storing CO_2 from biomass will not 'create' sellable allowances, so no economic value to 'negative emissions'.
  - Stricter climate policy needed to increase the CO_2 policy, and inclusion of BE-CCS in the Clean Development Mechanism (CDM) would be another key driver for all BE-CCS routes.

- **<u>Secure supply of low cost sustainable biomass</u>** is a key driver for BE-CCS, and factors such as land use scenarios and biomass price fluctuations will influence this cost.

Recommendations

CO_2 stored from biomass should have an economic value

Further research on assessing BE-CCS potential per region through regional specific cost supply curves

Further research on biomass supply options not included in this study, such as aquatic biomass from algae and seaweed

The effect of (co-)firing biomass on the performance of CO_2 capture options in pilot/demonstration plants

Map early opportunities of co-utilisation of biomass and coal in existing and new Fischer Tropsch facilities

Early opportunities for bio-ethanol BE-CCS exist in Brazil and the U.S.A. – the largest producers of bio-ethanol. Future research should focus on potential in these regions.

Incentives using Carbon Markets

IEAGHG and Heleen Groenenberg (Ecofys)

- EU ETS – EUAs
- JI – ERUs
- CDM – CERs
- IPCC GHG Guidelines - AAUs

EU ETS

- EU ETS Directive 2009

- Art 10a – free allocation can be given to biomass CCS, but not to any electricity production
- Industrial operations OK? use of benchmarks
- Annex 1.1 – 100% biomass combustion not covered by Directive
- Article 24a – EUAs can be given to activities reducing GHGs outside ETS, given not in respect of emissions. Needs host govn to apply.

- Creates uncertainty, needs clarification

Joint Implementation

- JI-ERUs
- Bilateral offset projects in co-operation with host govn – allocates from AAUs and converts AAUs to ERUs for project – can work for biomass CCS
- Domestic offsets??

Clean Development Mechanism

- CDM – CERs
- CERs allocated for emissions reductions below baseline – can work for biomass CCS, BUT CCS not yet recognised for CDM.
- Copenhagen CMP5 – invites new methodologies for net reduction technologies
- Sustainable development

National GHG Inventories

- IPCC GHG Guidelines (2006)
- CCS Chapter 5.3 – "Negative emissions may arise......if CO2 generated by biomass combustion is captured. This is a correct procedure and negative emissions should be reported as such."
- However in practice – limitations, uncertainty, lack of being tested

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