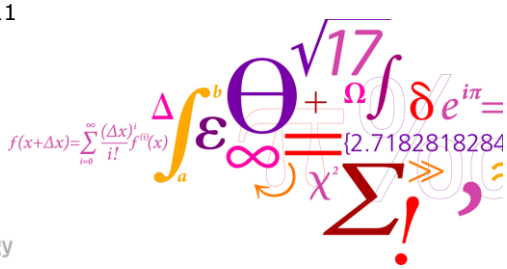
The role of biomass and CCS in China in a climate mitigation perspective

Kenneth Karlsson[1], Mikael Lüthje[2], Jay Gregg[1], Tullik Helene Ystanes Føyn[1], and Olexandr Balyk[1]

[1] DTU Climate Centre, Risø DTU, Denmark
[2] DONG Energy, Denmark

ETSAP Workshop, Stanford, July 2011



Risø DTU
National Laboratory for Sustainable Energy

Introduction

- 2° C target requires ambitious global efforts and China's participation is essential:
  1. world's #1 population, #2 economy, #1 GHG emitter
  2. China's rapid growth in emissions could offset mitigation efforts in other parts of the world
  3. Due to rapid growth in energy demand, the country is facing a large challenge in expanding supply rapidly enough. Domestic coal is currently the most used and most readily available energy supply source.
- We examine the role of China in global mitigation efforts, and focus on biomass, carbon capture and storage (CCS), and bioenergy CCS (BECCS) using a global energy system optimization model (TIAM)
- Different scenarios are run testing different assumptions for biomass potential, available storage volume for CO_2, and efficiency and costs of CCS technology.

TIAM (TIMES Integrated Assessment Model)

- Energy-economic partial equilibrium model with climate module, inter-temporal optimisation
- Whole energy system (from primary resource extraction to end-use), technology-rich (several thousand technologies)
- 16 regions
- 2005-2100

www.etsap.org/tiam_etsap

Climate scenarios

- 2° C target set by following the GHG emission trajectory from the IPCC RCP3-PD emission scenario.
  - The CO_2 concentration peaks just after 2050 and decreases then to 421 ppm in the year 2100.
  - Only the CO_2 pathway is included as the majority of CH_4 and N_2O emissions reductions are handled exogenously in TIAM.
- The reference scenarios have exogenously defined economic growth rates for the various regions in TIAM and include no climate constraint.

CCS Potential for China (I)

- **A large share of the coal consumed in China is used in the power sector, and thus a large share of carbon emissions could be captured and stored**
- **Large scale implementation of biomass energy with CCS makes it possible to reduce the atmospheric concentration of CO_2**
- In general, it is only possible to capture 85% to 95% of the CO_2 emitted, so power production utilizing CCS on fossil fuels still emit a small amount of CO_2
- In all scenarios, CCS capability is available only to new power plants.

CCS Potential for China (II)

- Potential for geological storage of CO_2 in China is high: **total estimated storage capacity 3,000 Gt CO_2 ≈100 years of current global emissions**
- The vast majority of the storage potential is in saline aquifers, and most large point sources for emissions are in proximity of a storage location.
- Some storage capacity is found in oil and coal basins where there is a potential to combine it with enhanced coalbed methane recovery and enhanced oil recovery (EOR) to drive the cost down
- Costs of capture, transport, and storage are all included in TIAM
- Efficiency loss (6-10%) in power generation is the major cost of CCS

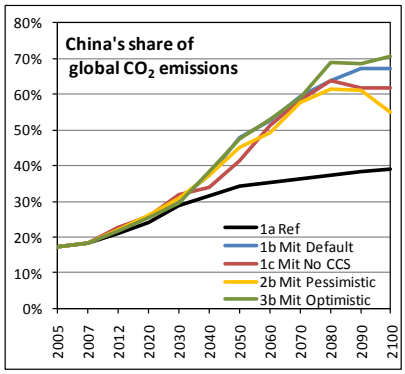
Biomass resources

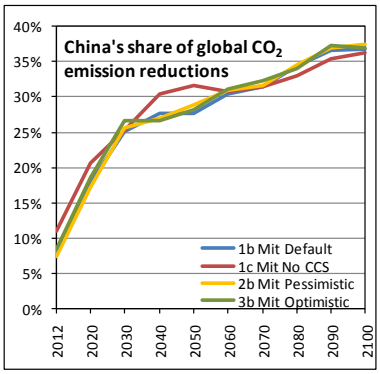
- Six categories of biomass are included: industrial waste, municipal waste, landfill gas, sewage, bioenergy crops, and solid biomass resources (agricultural residues and forestry products)
  - In this TIAM the biomass potential is exogenously defined
  - It is assumed that biomass is not traded between regions
- Bioenergy crops are assumed to be grown on surplus crop land, solid biomass resources estimated from future crop production and land use
- End of century maximum supply in China is estimated to be **6 EJ yr^{-1} for energy crops and another 11.1 EJ yr^{-1} from solid biomass**.
- For sensitivity analysis we vary the default TIAM values by ±25%
- The amount of waste biomass available is held constant in all scenarios analyzed in this paper.

Scenarios

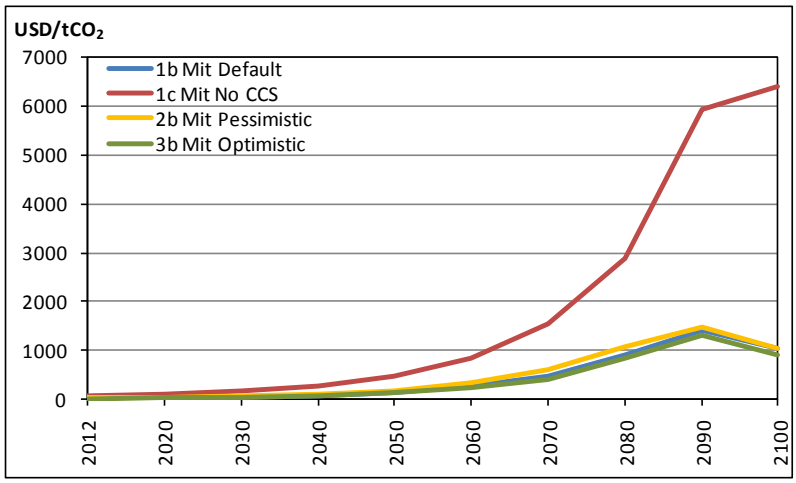
Scenario	Global Climate Constraint	Biomass Resource in China	Efficiency Loss Due to CO_2 Capture	CO_2 Storage Capacity
1a Reference	Reference (None)	Default (100%)	Default	Default (100%)
1b Mitigation Default	RCP3-PD (CO_2 only)	Default (100%)	Default	Default (100%)
1c Mitigation No CCS	RCP3-PD (CO_2 only)	Default (100%)	NA	0%
2a* Reference Pessimistic	Reference (None)	75%	50% higher	50%
2b Mitigation Pessimistic	RCP3-PD (CO_2 only)	75%	50% higher	50%
3a* Reference Optimistic	Reference (None)	125%	50% lower	200%
3b Mitigation Optimistic	RCP3-PD (CO_2 only)	125%	50% lower	200%

China's share of emissions and reductions





Price of CO_2

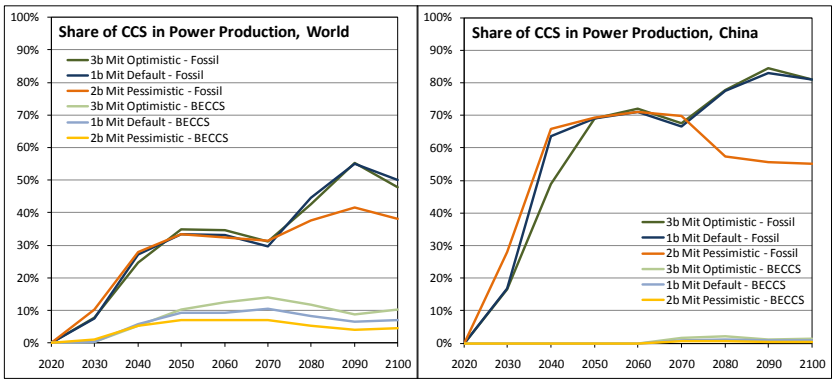


Costs of mitigation

	Mitigation Default: 1a vs. 1b	Mitigation No CCS: 1a vs. 1c	Mitigation cost increase 1b vs. 1c	Mitigation Pessimistic: 2a vs. 2b	Mitigation Optimistic: 3a vs. 3b
China	4%	15%	267%	7%	3%
World	5%	10%	122%	5%	4%

- China's share of total discounted costs of the global energy system ≈ 13% (all scenarios)
- Share of mitigation costs varies between ≈ 11%-16%.

Use of CCS technologies

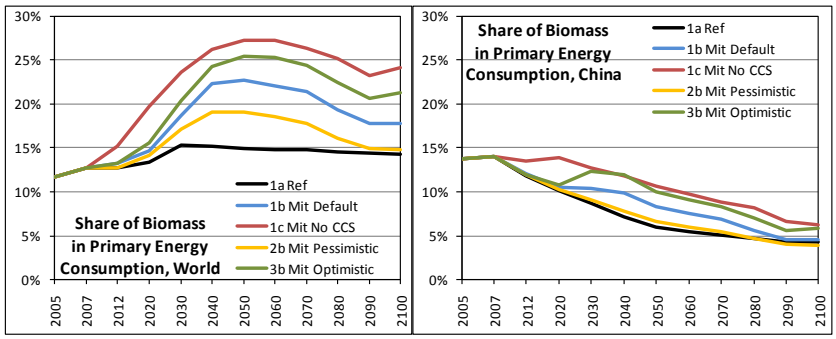


Usage of CO_2 storage potential

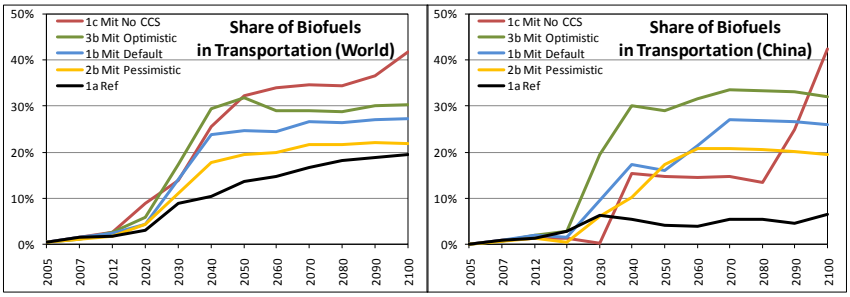
- All regions in the model utilize CCS to some extent
- Scenario 1b (Mitigation Default): almost 2,000 Gt CO_2 is stored worldwide and about half of this in China
- Utilization of CCS is not limited by a lack of storage capacity

CO_2 Storage Capacity Used	Scenario 1b (Mitigation Default)	Scenario 2b (Mitigation Pessimistic)	Scenario 3b (Mitigation Optimistic)
China	31%	53%	15%
World	14%	26%	7%

Biomass in primary energy



Biomass in transportation



Conclusion

- Chinese economic growth causes a dramatic increase in energy demand
  - final energy demand grows 500-600% from 2010 to 2100
- This gives a lot of pressure on domestic renewable resources such as biomass, wind, and solar PV. Even with optimistic assumptions on future biomass availability (scenario 3b), it can only cover around 10% of the Chinese primary energy consumption in 2050 and around 5% in 2100. Most of the available biomass in China is optimally used in the transport sector, thereby favoring CCS over BECCS.
- CCS is a key technology for China in an emissions constrained world
- The CCS storage potential in China is not a limiting factor