温室効果ガスの削減目標と画期的技術開発の必要性
(Target of GHGs Emission Reduction and necessary Technology Innovations)

Vital Spark セミナー　—エネルギー技術革新に基づく新しい気候変動政策—

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エネルギー経済研究所（IEEJ)
常務理事
黒木　昭弘

温暖化議論のメインストリーム

結論1：**<u>産業革命以前</u>**からの温度上昇を**<u>2℃</u>**に抑える必要がある
Conclusion 1: Keep temperature below 2 degree above preindustrial levels

↓

結論2：2℃に押さえるためには**<u>温室効果ガス</u>**の濃度を**<u>450ppm</u>**以下に安定させる必要
Conclusion 2: Keep GHG concentration below 450ppm

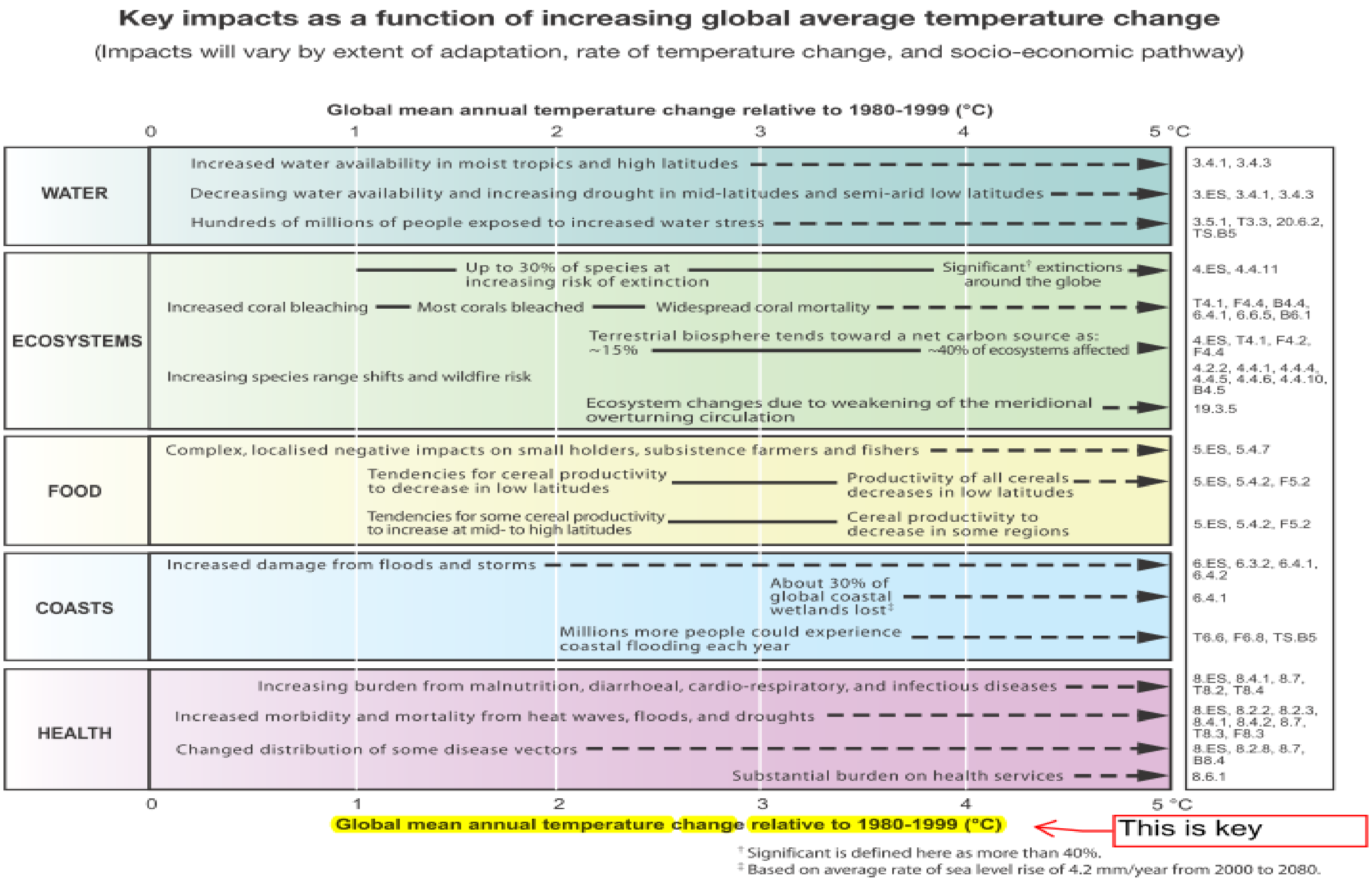
↓

結論3：2100年に温室効果ガスを450ppm以下に安定させるためには**<u>2050年</u>**に温室効果ガスの排出量を最低でも**<u>50%</u>**（**先進国は80%**）削減する必要がある
Conclusion 3: Goal of long-term emission reduction by at least 50% by 2050

結論1への疑問

- IPCCのどの報告書にも2℃以下に抑える必要性の記述は何処にも無い。
- そもそもIPCC WG2での温度上昇とその影響評価は工業化以前からの温度上昇でなく、1980-1999年の平均値からの温度上昇を評価

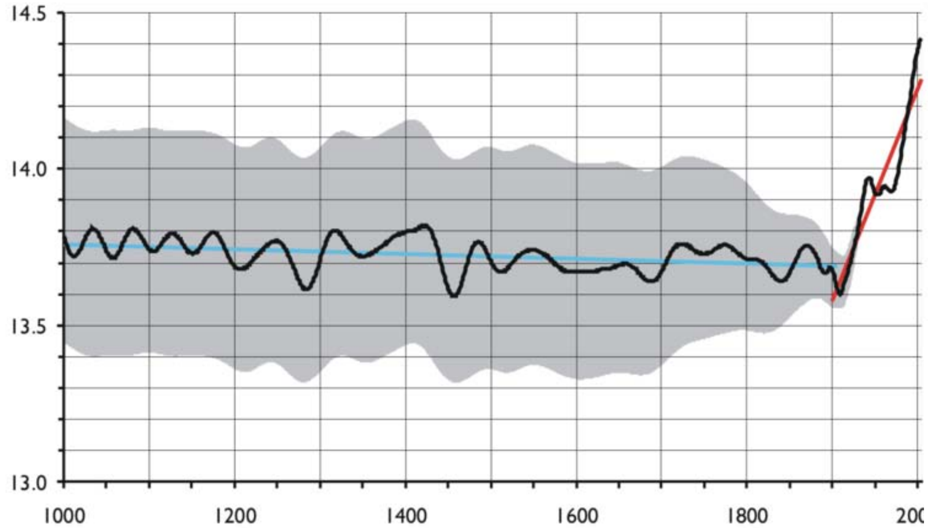
IPCC 4次報告での気温上昇の影響評価は産業革命以降ではない

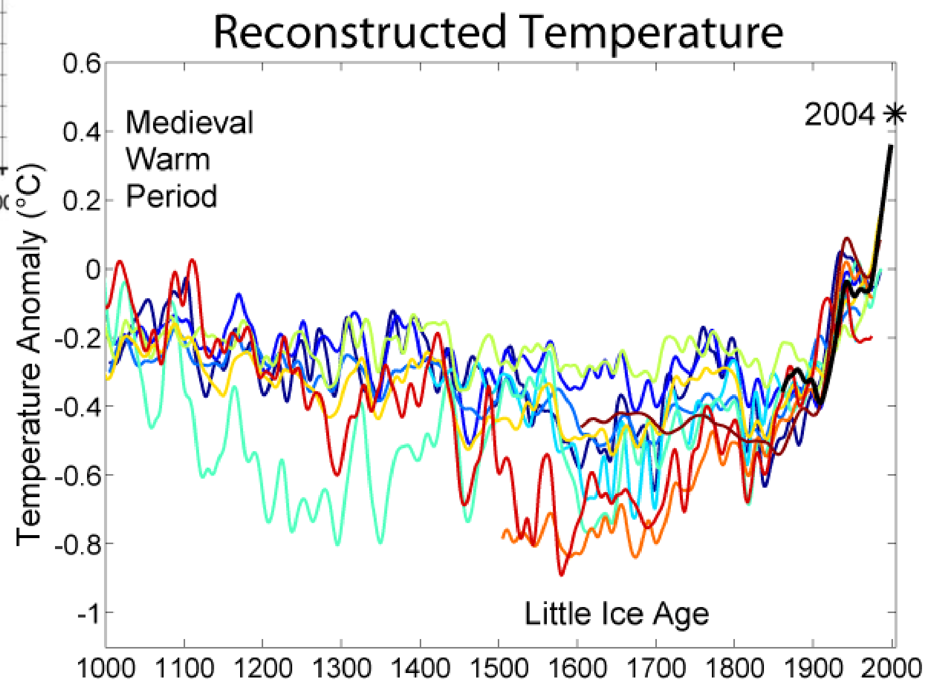


IPCC AR4では2℃への言及は無い

change will be mixed across regions. For increases in global mean temperature of less than 1-3°C above 1990 levels, some impacts are projected to produce benefits in some places and some sectors, and produce costs in other places and other sectors. It is, however, projected that some low-latitude and polar regions will experience net costs even for small increases in temperature. It is very likely that all regions will experience either declines in net benefits or increases in net costs for increases in temperature greater than about 2-3°C [9.ES, 9.5, 10.6, T10.9, 15.3, 15.ES]. These

ホッケースティク曲線信じない限り安定した「工業化以前の気温」は存在しない





結論2への疑問

- 温度上昇と温室効果ガス濃度との関係は不確実性が非常に高い

気候感度（温室効果ガスが2倍の濃度になった時の気温上昇） 1.5℃～4.5℃←3倍の差

（Climate Sensitivity　1.5～4.5℃）

- そもそも現在の温室効果ガスの濃度はIPCCのどの報告書でも無い

温室効果ガス濃度と気温上昇の不確実性

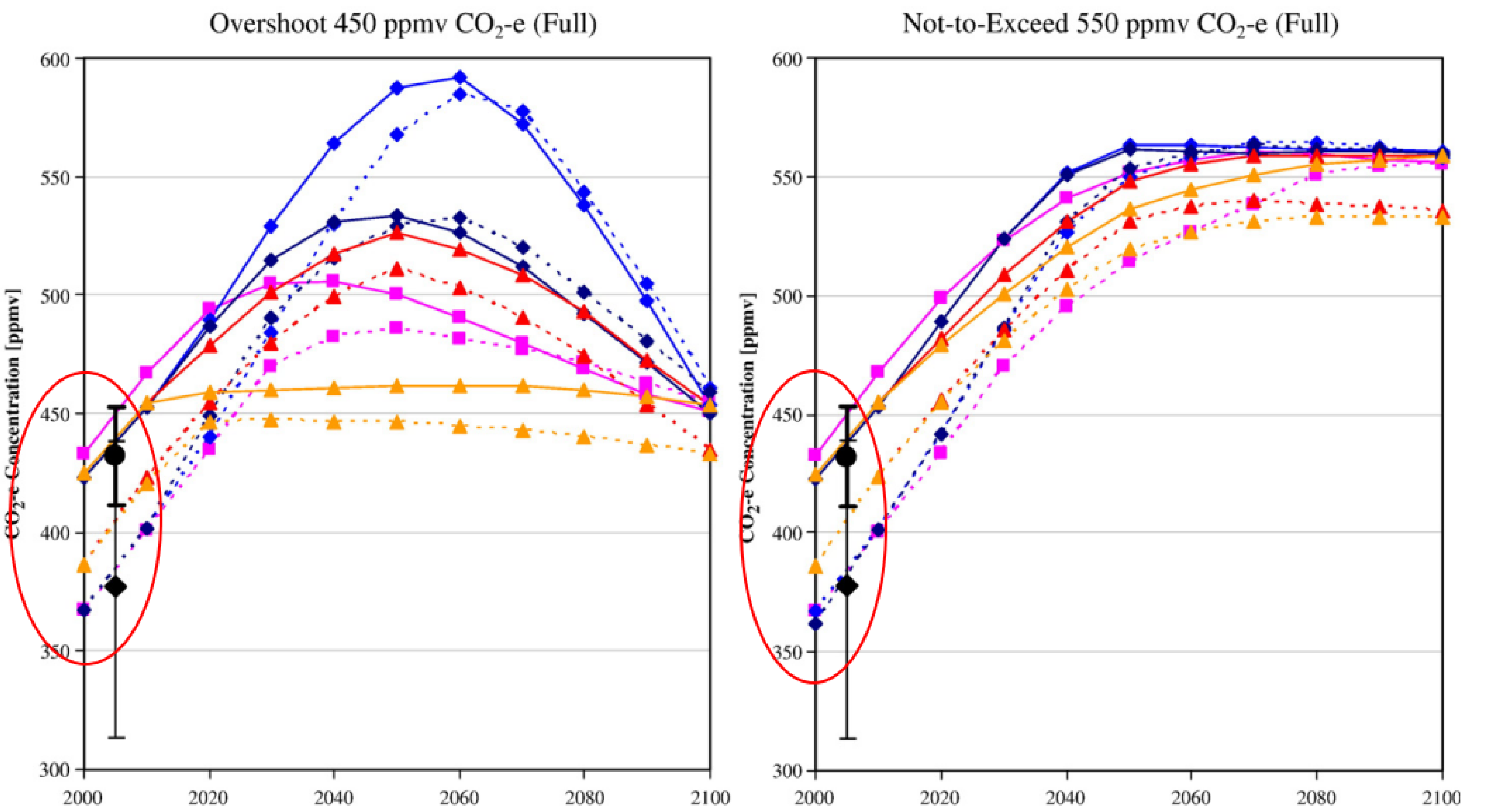
Projections of Temperature Change

Global mean temperatures will continue to rise over the 21st century if greenhouse gas emissions continue unabated. Under the assumptions of the concentration-driven RCPs, global-mean surface temperatures for 2081–2100, relative to 1986–2005 will *likely*[1] be in the 5–95% range of the CMIP5 models; 0.3°C–1.7°C (RCP2.6), 1.1°C–2.6°C (RCP4.5), 1.4°C–3.1°C (RCP6.0), 2.6°C–4.8°C (RCP8.5). With respect to preindustrial conditions, global temperatures averaged in the period 2081–2100 are projected to *likely* exceed 1.5°C above preindustrial for RCP4.5, RCP6.0 and RCP8.5 (*high confidence*) and are *likely* to exceed 2°C above preindustrial for RCP6.0 and RCP8.5 (*high confidence*). Temperature change above 2°C under RCP2.6 is *unlikely* (*medium confidence*). Warming above 4°C by 2081–2100 is *unlikely* in all RCPs (*high confidence*) except for RCP8.5 where it is *as likely as not* (*medium confidence*). [12.4.1, Tables 12.2, 12.3, Figures 12.5, 12.8]

同じ放射強度でも、気候感度の取り方によって温度上昇は大きな違い。気候感度に関してはコンセンサスが無い。

[16] No best estimate for equilibrium climate sensitivity can now be given because of a lack of agreement on values across assessed lines of evidence and studies.

現在のGHGsの濃度に関してはコンセンサスは無い

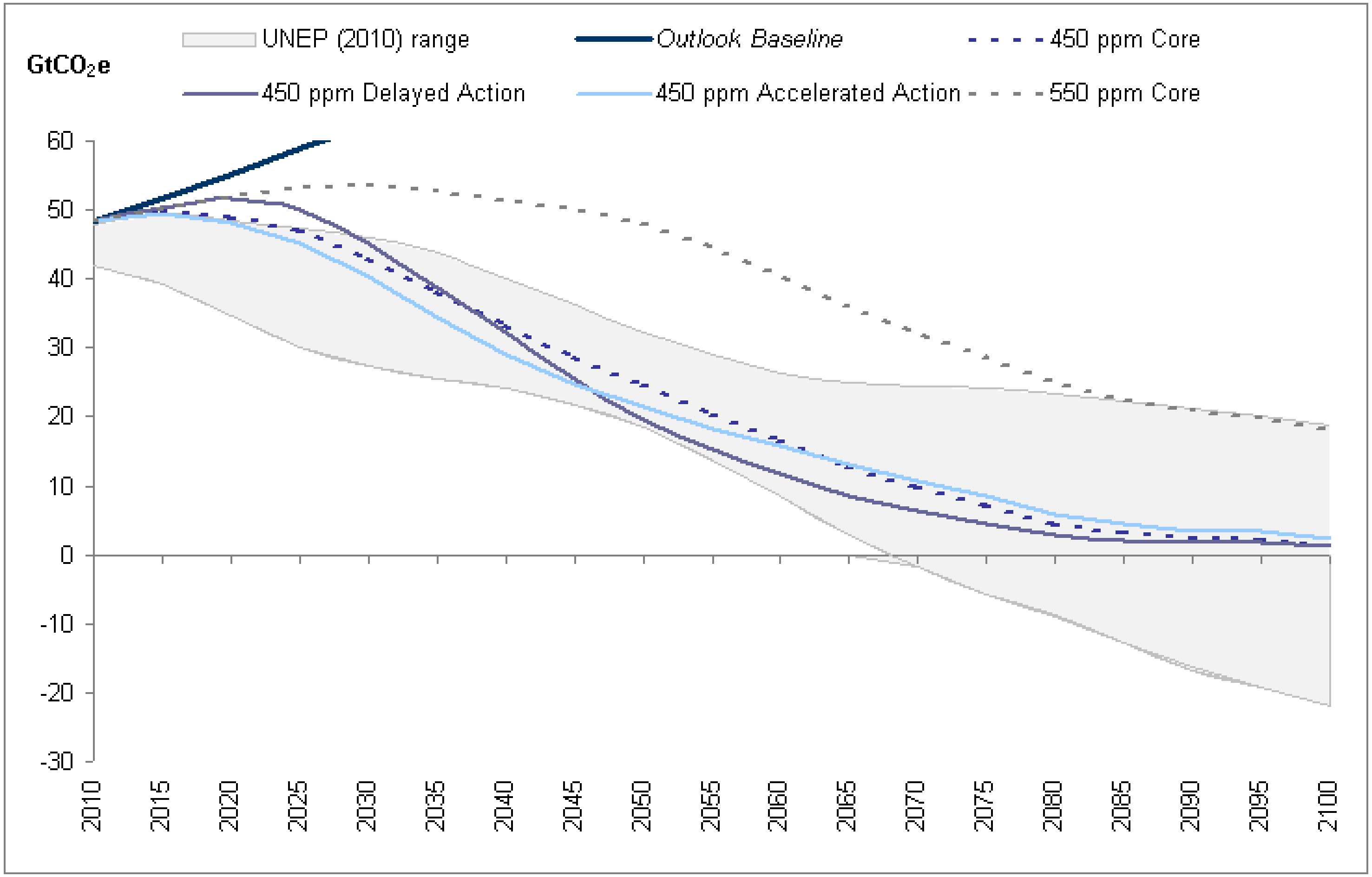


出典：EMF22

結論3への疑問

- 450ppmを目標とするとオーバーシュートシナリオとマイナスエミッションが必要
- マイナスエミッションを考えるのであればといわゆる「CO2バジェット」の考え方は成り立たない
- 2010年、450ppm（あるいは550ppm）シナリオは幾つかのパスがあり、2030年や2050年断面はリジッドではない。

450ppmを実現するパスは大きな幅がある



何をしなければ行けないか？

- 現実的には450ppm オーバーシュートか550ppmシナリオにならざるを得ない。（650ppmでも2℃以下になる可能性は十分ある）

- 画期的な削減技術が必要

①大部分の化石燃料を代替できる「新エネルギー」＋「系統安定化技術」

②ゼロもしくはマイナス排出の技術

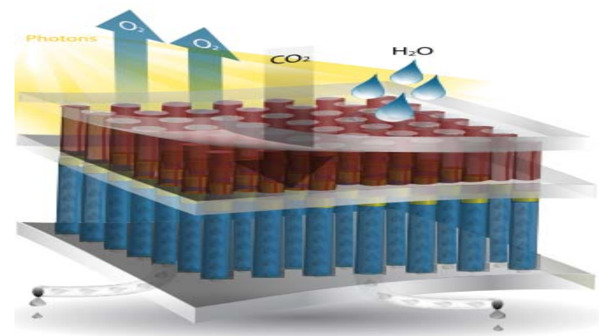
人工光合成等

画期的技術開発の必要性

１. 化石燃料＋CCS　　ゼロエミッション
　 バイオ燃料＋CCS　マイナスエミッション

２. 人工光合成・燃料　　ゼロエミッション
　 人工光合成・原材料　マイナスエミッション

３. その他のマイナスエミッション技術
　 ①Artificial Trees
　 ②Soda Lime
　 ③Biochar



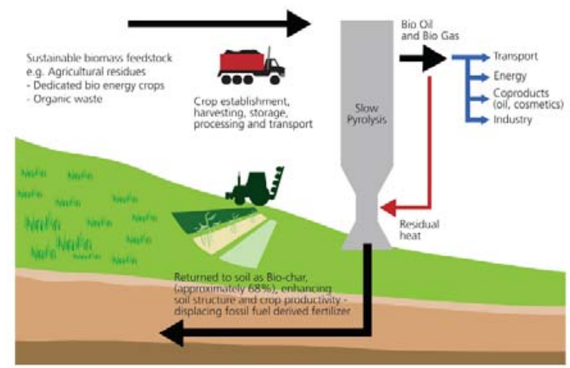


Figure 4. Concept diagram of biochar sequestration process from feedstock production to low-temperature (slow) pyrolysis and

ネガティブエミッション技術のコスト

Type of air Capture	Cost Competitiveness*	Rollout Limitations	Technical Challenges & Environmental Impacts
Artificial Trees	**~95 $/t$CO_2$e**	• Significant electricity demand of technology • Carbon transport and storage network development	• Novel sorbent technologies need to be developed to reduce energy input and water requirements • Improving thermodynamic efficiency • Linking a geographically distributed set of sites to a viable CO_2 transport and storage network
Soda/Lime process	**~155 $/t$CO_2$e**	• Substantial energy requirement • Carbon transport and storage network development	• Novel sorbent technologies need to be developed to reduce energy input • Need to reduce size of scrubbing towers • Improving thermodynamic efficiency • Linking a geographically distributed set of sites to a viable CO_2 transport and storage network
Augmented Ocean Disposal	**~90 $/t$CO_2$e**	• Availability of required shipping capacity • Conflict with international protocols on ocean disposal	• Improving calcination processes • Building suitable transport infrastructure to integrate the sub-processes • Unknown consequences for the marine environment
Biochar	**~135 $/t$CO_2$e**	• Availability of biomass for energy and competition with other uses • Poor understanding of carbon stability (Mean Residence Time)	• Scale up of slow pyrolysis technology • Need for better understanding of Mean Residence Time across feedstock streams and different soil conditions • Potential bioenergy related environmental impacts
BECCS	**~59-111 $/t$CO_2$e**	• Availability of biomass for energy and completion with other uses • CCS development requirements	• Realisation of CCS technology development at scale including a viable CO_2 transport and storage network • Integration of biomass combustion with CCS technology • Potential bioenergy related environmental impacts

Table 9. Summary table of costs, rollout limitations, technical challenges and environmental impacts for all technologies.

出典：Negative Emission Technologies, Imperial College London 2012