



The influence of carbon storage and biomass potentials in the future development of Bioenergy with carbon capture and storage

Sandrine Selosse

MINES ParisTech, PSL Research University,
Centre for Applied Mathematics

July 9th, 2018

EURO 2018 - Valencia

TIAM-FR: *French version of the TIMES Integrated Assessment Model*

Optimization, linear programming

Minimization of the total discounted cost of the system

Bottom-up

Long term: **2010-2100**

Multi-regional: 15 regions (+T-ALyC)

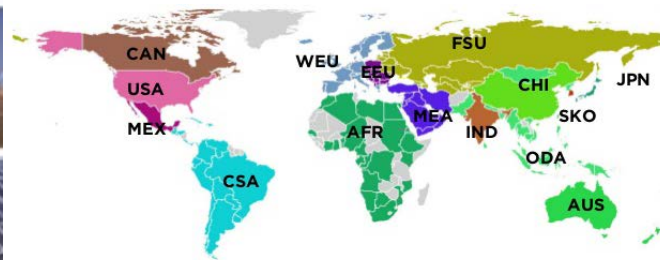
Multi-sectors: 6 sectors

42 demands

585 729 data

11 646 commodities (about 770/region)

39 817 technologies (about 2 500/region)



$$NPV = \sum_{r=1}^R \sum_{y \in YEARS} (1 + d_{r,y})^{REFYR-y} * ANNCOST(r,y)$$

Where

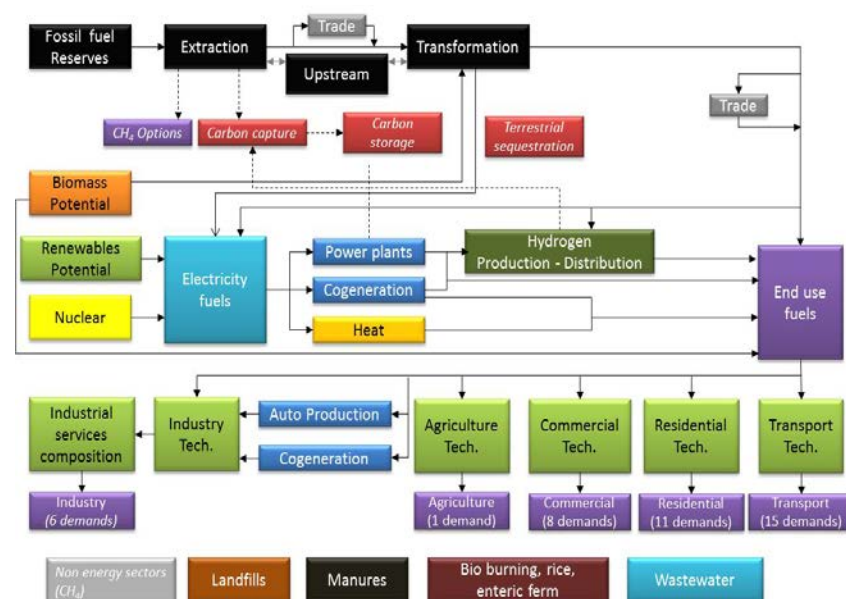
NPV is the net present value of the total cost for all regions over the projected period;

ANNCOST (r,y) is the total annual cost in region r and year y;

d_{r,y} is the discount rate;

REFYR is the reference year for discounting;

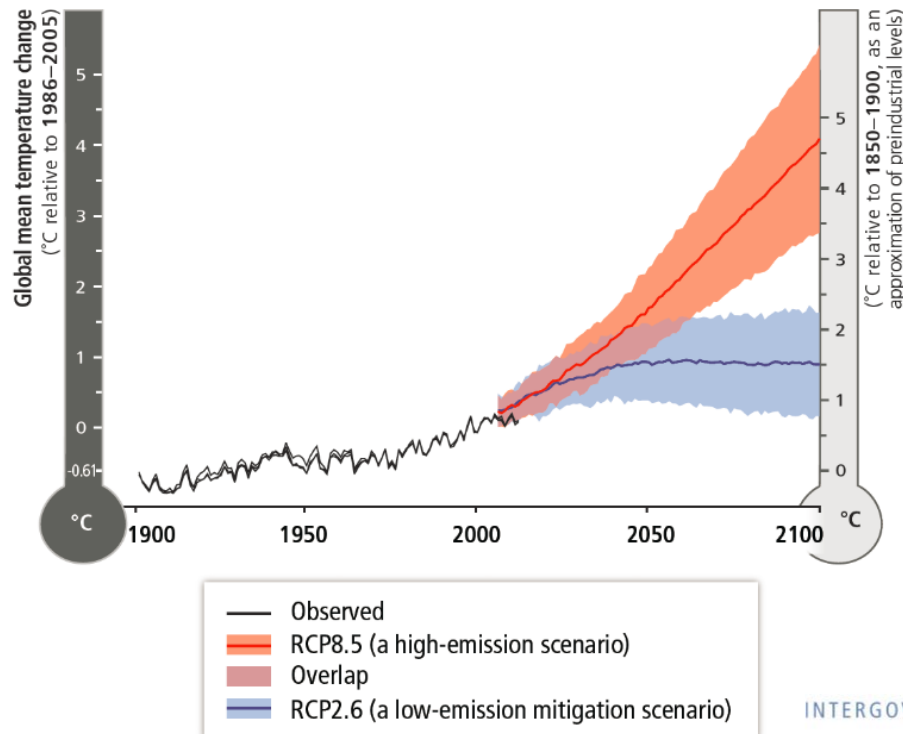
YEARS is the set of years and R is the set of regions (15 regions)



Long-term possible low carbon futures of the energy system

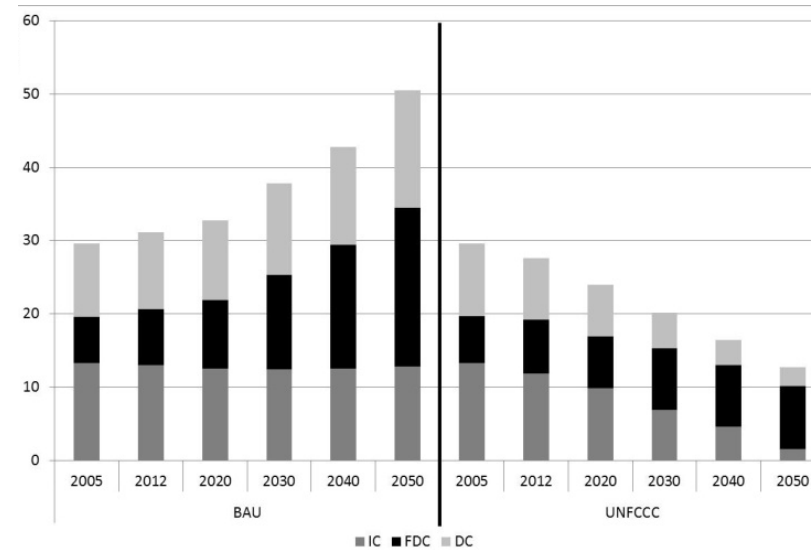
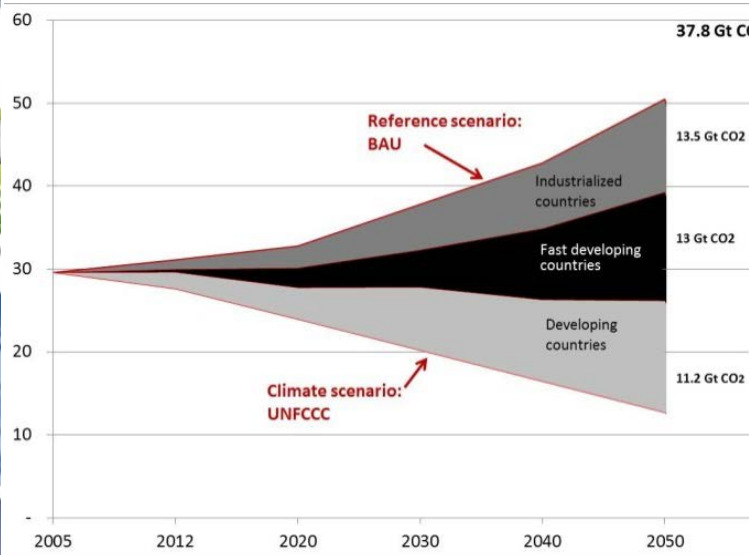
• Climate constraints

- 2°C objectives (emissions targets [Gt CO₂], radiative forcing [W/m²], atmospheric concentration [ppm])
- Paris Agreement (NDCs)



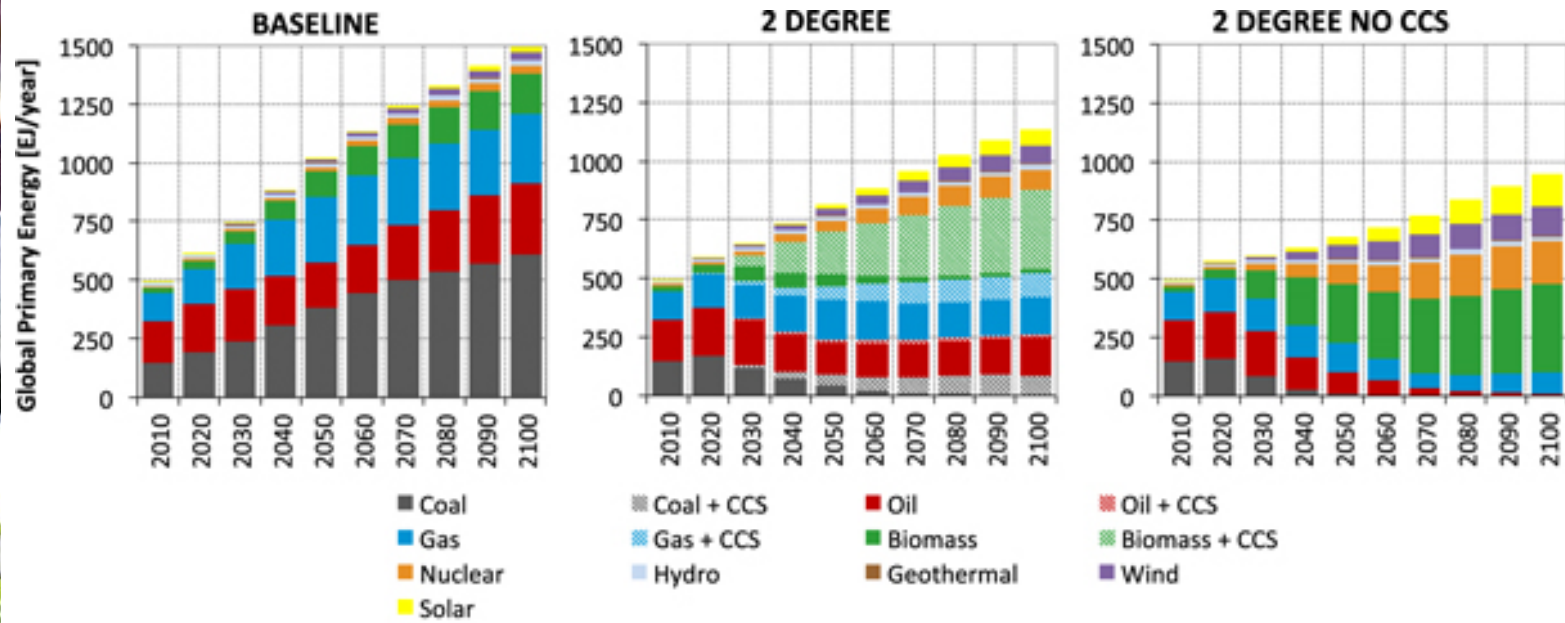
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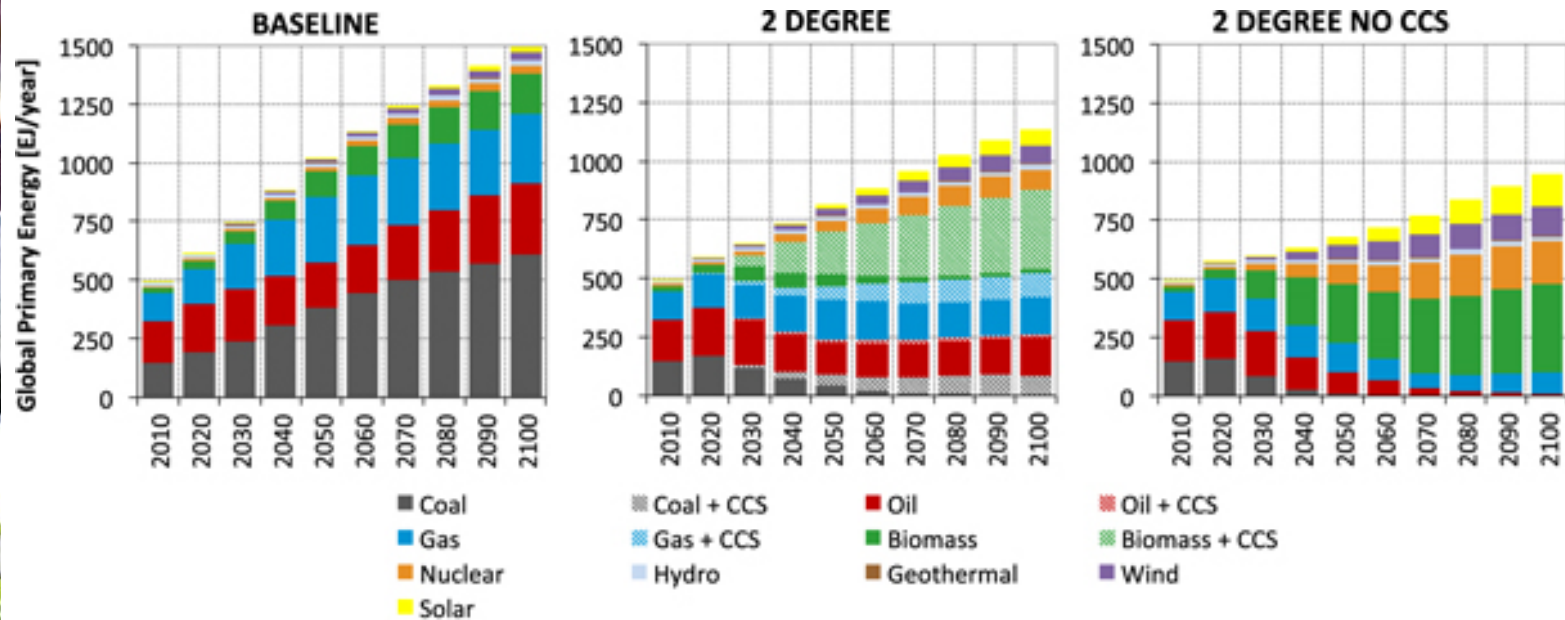
Regional contribution to the mitigation effort

Technologic choices to a climate stabilization



Muratori et al. (2016) - <http://iopscience.iop.org/article/10.1088/1748-9326/11/9/095004>

Technologic choices to a climate stabilization

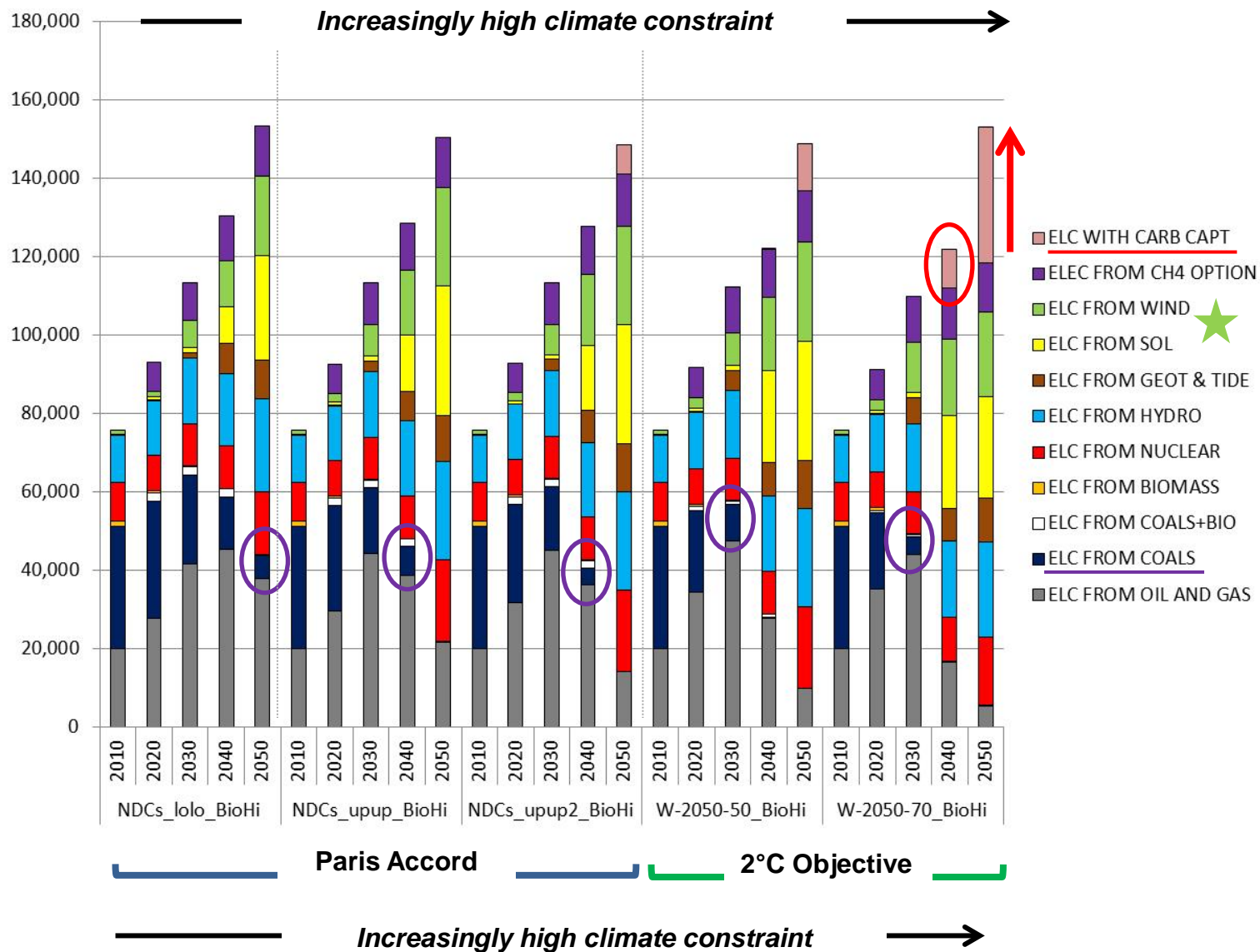


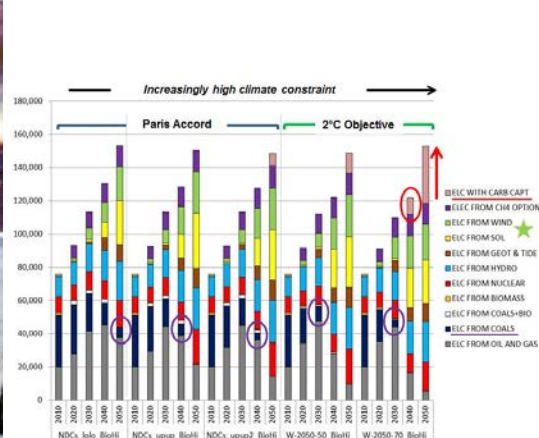
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AR5 : 101 of the 116 scenarios with a limited atmospheric concentration at 430-480 ppm rely on BECCS

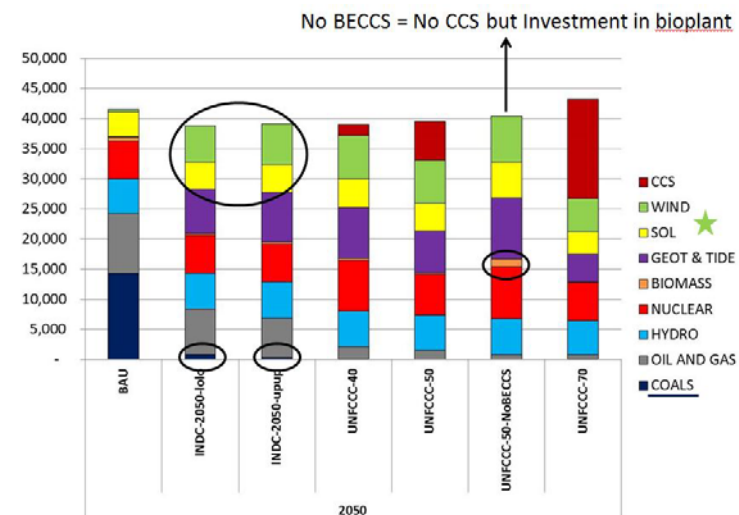
About 67% of these have a BECCS share in primary energy exceeding 20% in 2100

(Fuss et al. (2014), *Nature Climate Change*)





Industrialized countries

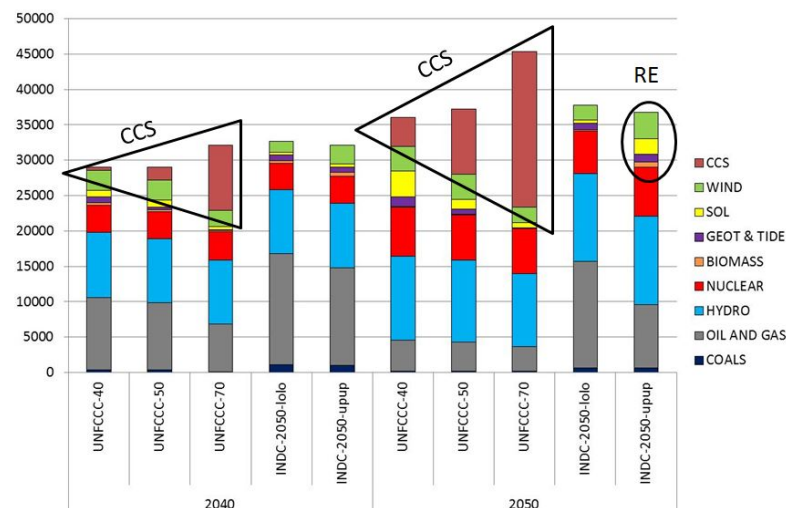
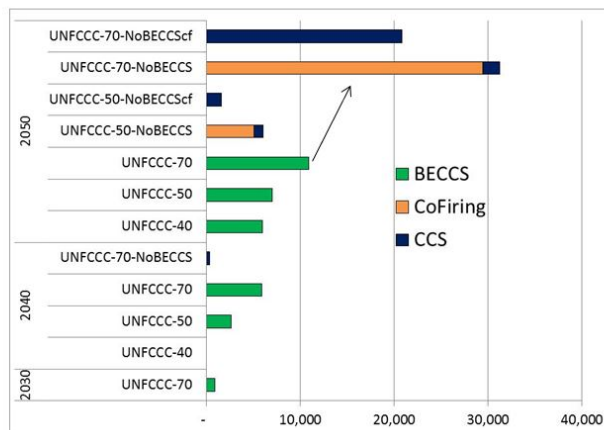


Fast developing countries

Developing countries

INDCs Scenarios: no CCS but electricity from bioplant is more important

UNFCCC-70-NoBECCS: decarbonized electricity system (solar)



What low carbon and sustainable energy future?

- **Ambitious climate targets achieved if:**

- Contribution of developing countries
- Ambitious contribution of emerging countries
- Almost total decarbonization of the industrialized countries
- Major deployment of the CCS
- Use of negative emissions with BECCS



What low carbon and sustainable energy future?

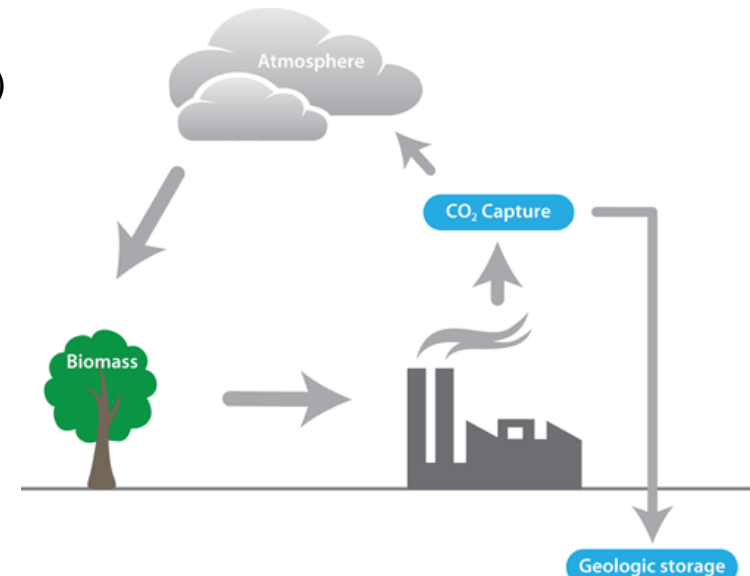
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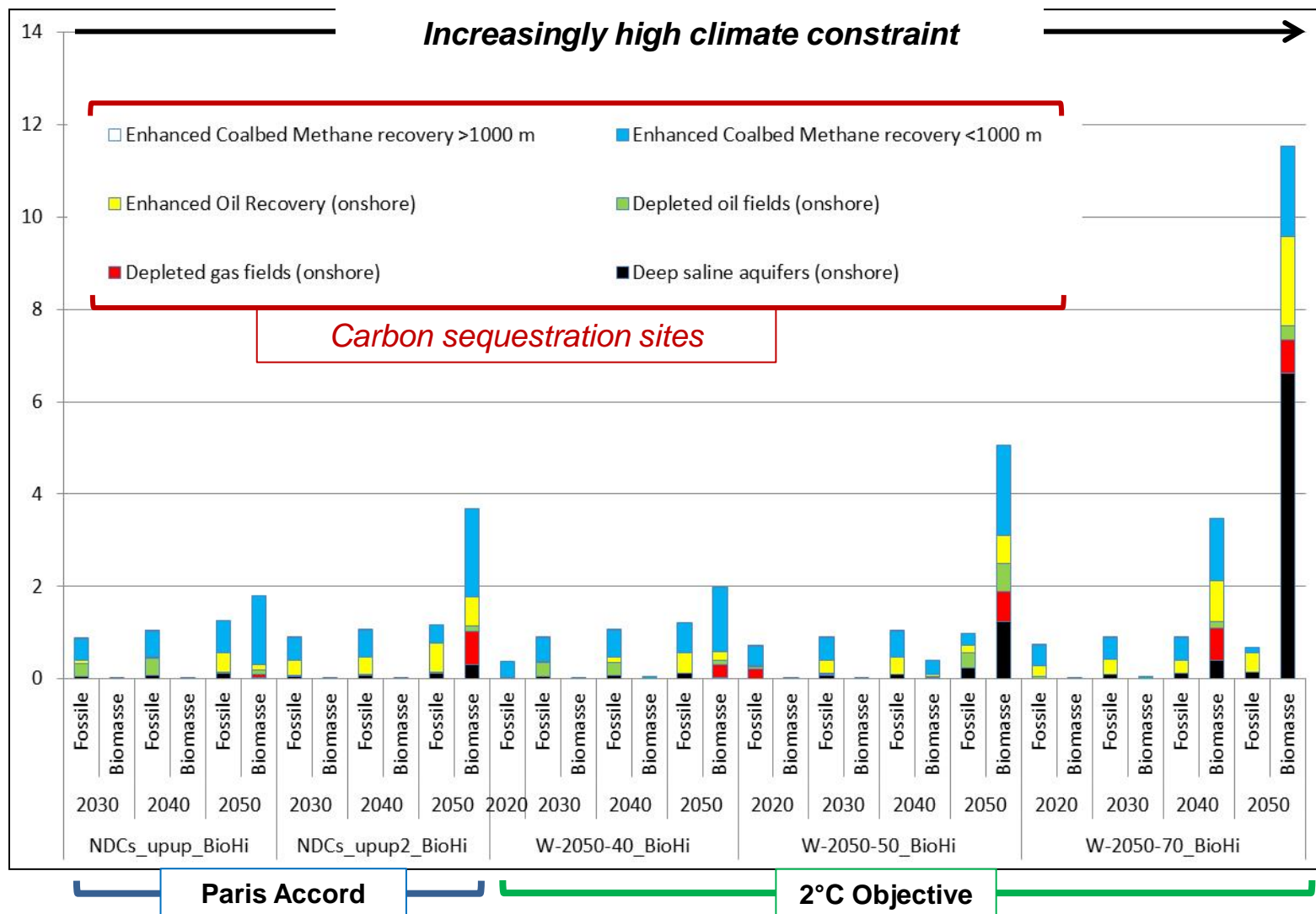
• Technological and resource constraints

- Availability of technology
 - Carbon capture and storage (CCS)
 - Availability of onshore storage
- Resource potential
 - Carbon storage
 - Biomass resources

Role of CCS and BECCS



The question of carbon storage.... (Gt)

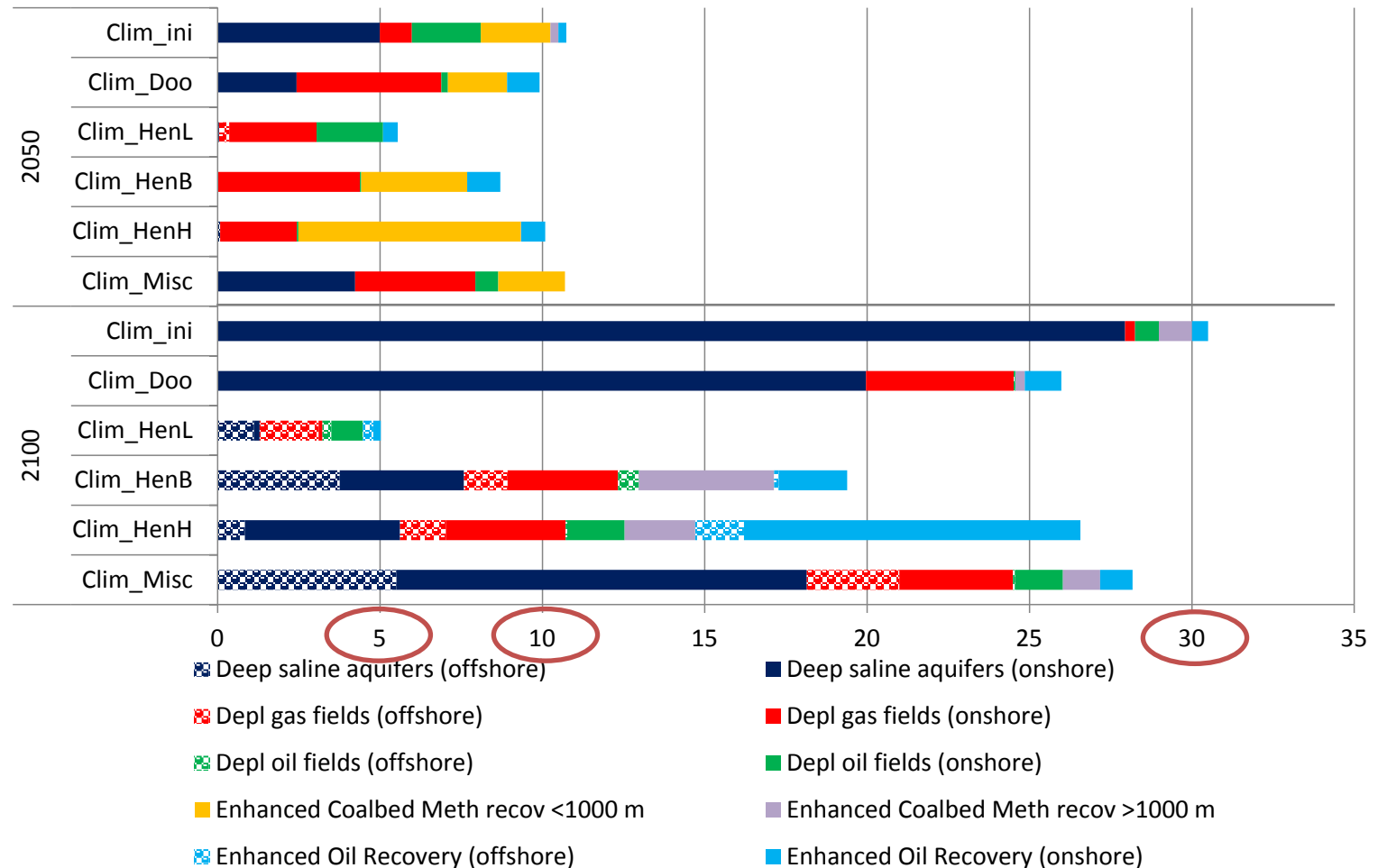


- **Scenario analysis** (under climate constraints)
 - Carbon storage potentials
 - Initial TIAM – 9,392 Gt
 - Collection of various database, reports, etc. – 10,142 Gt
 - Ref. Dooley – 10,655 Gt
 - Ref. Hendriks – 572 Gt / 1,706 Gt / 5,864 Gt
 - Onshore/offshore determination



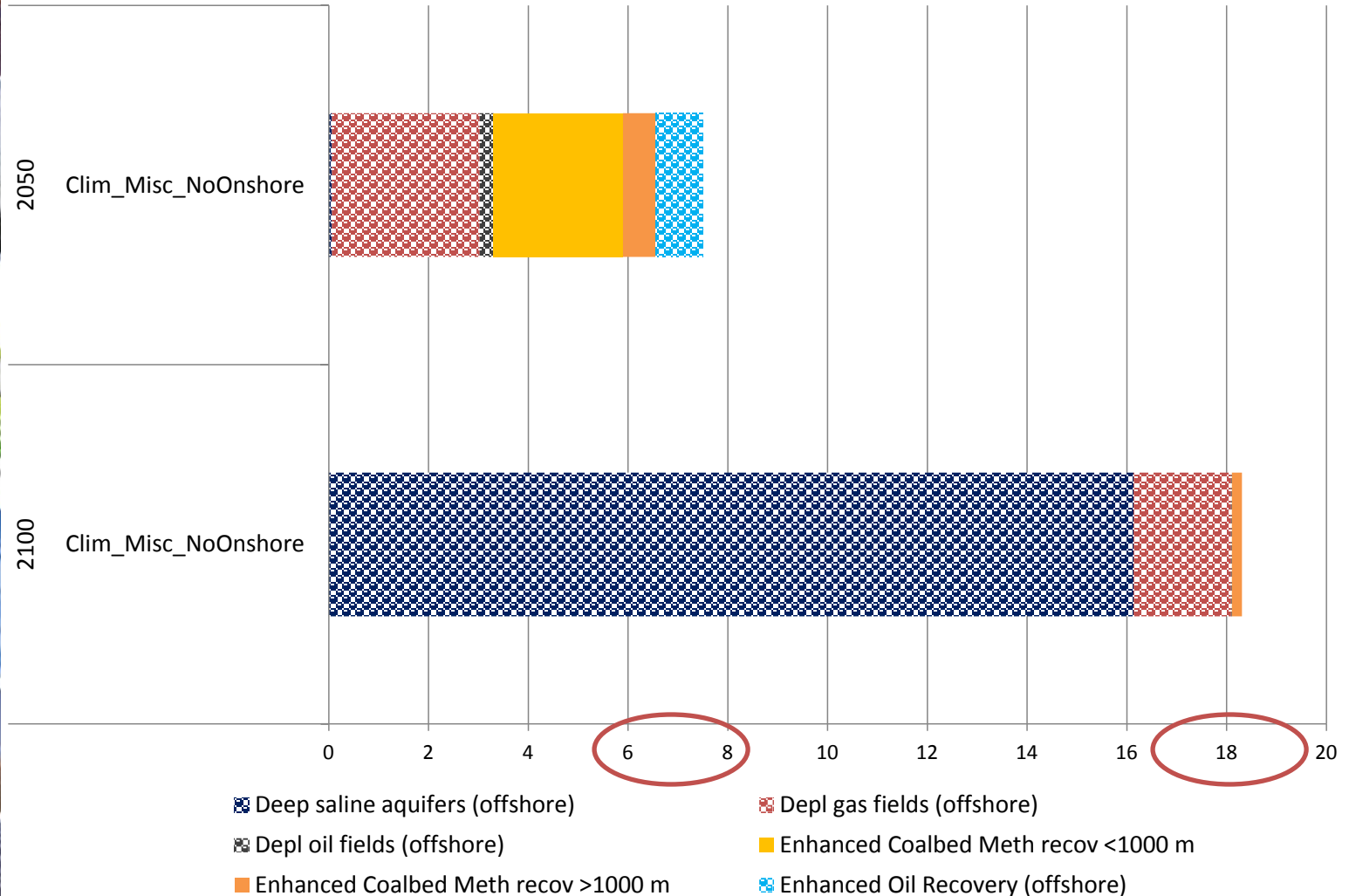
Carbon storage by year to achieve the 2° C objective (radiative forcing at 2,6 W/m² by 2100)

Sensitivity analyses on carbon storage by site and scenario (Gt CO₂)

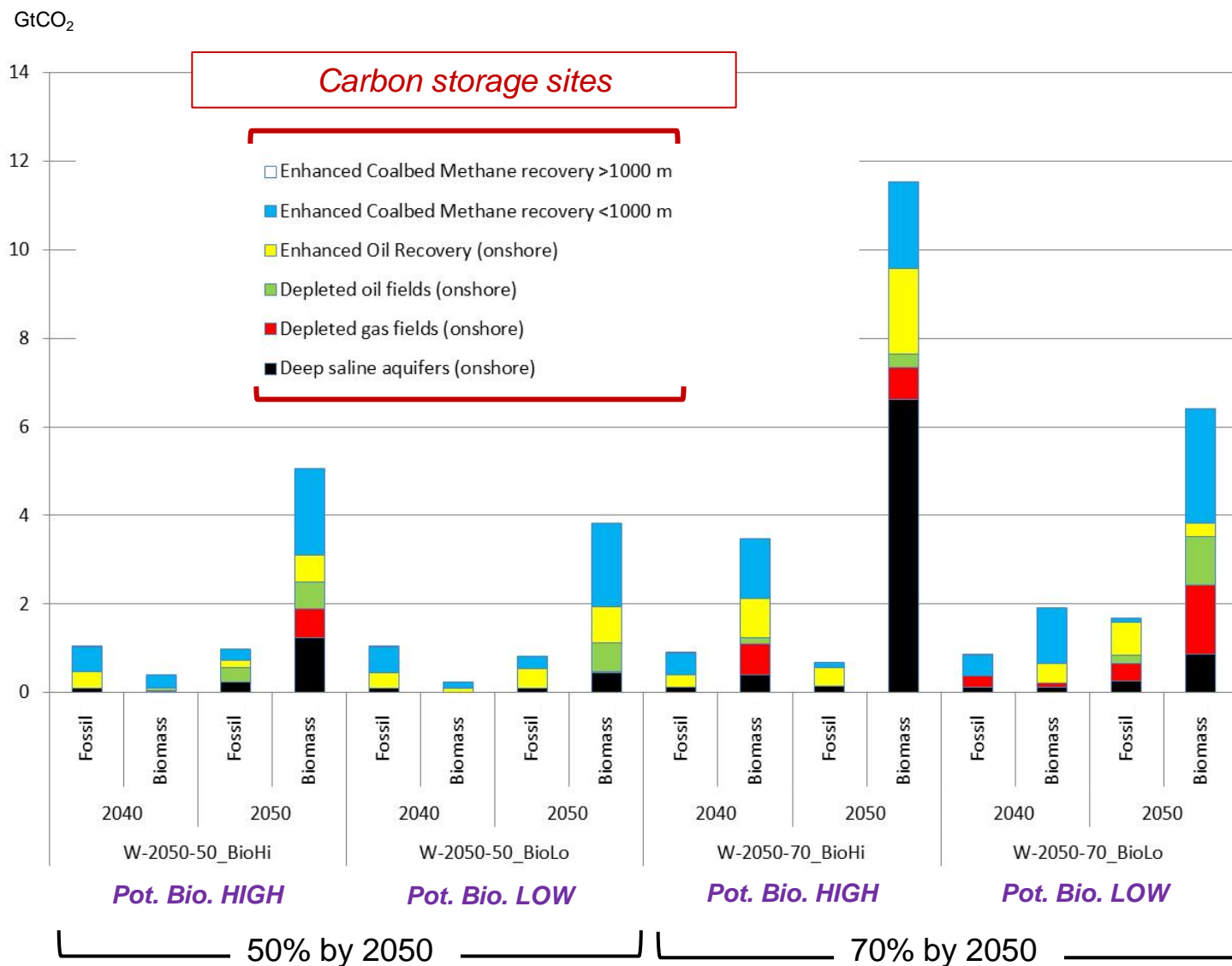


Impact of an onshore storage ban on carbon storage an CCS deployment

Carbon storage by site (Gt CO₂)



Sensitivity analysis on biomass potential and impact on storage carbon



Influence of carbon storage and biomass potentials in the future development of BECCS



Share of CCS in the world production of electricity in 2050				
Ambitious climate scenario		Biomass potential		
		High	Medium	Low
Carbon storage potential	High	45%	39%	27%
	Medium	45%	39%	27%
	Low	33%	28%	15%

Gt of sequestered CO2 in 2050				
Ambitious climate scenario		Biomass potential		
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	Medium	33	29	20
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Thank you for your attention!

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