Potential for Biomass and Carbon Dioxide Capture and Storage

Preliminary results

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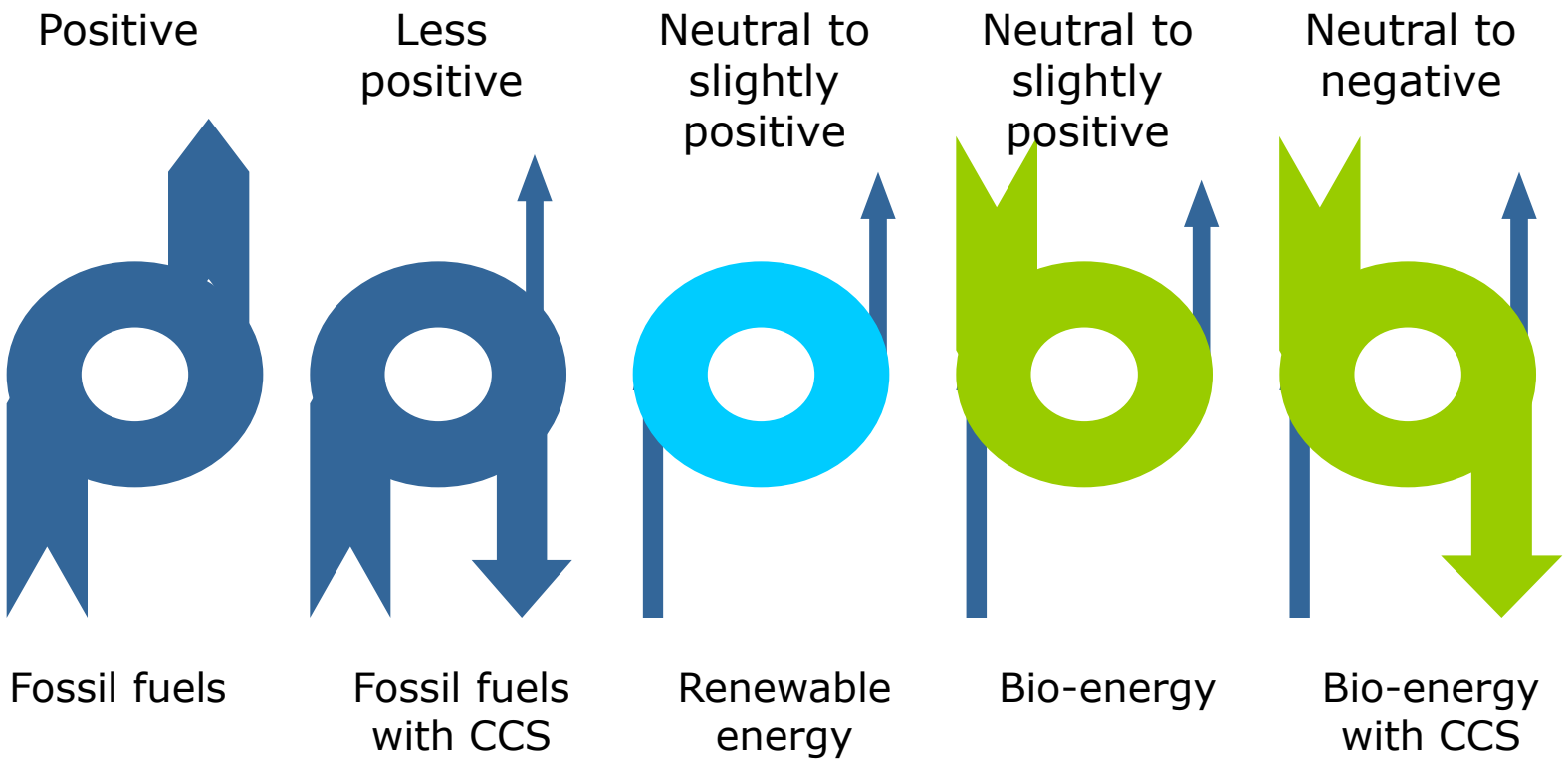
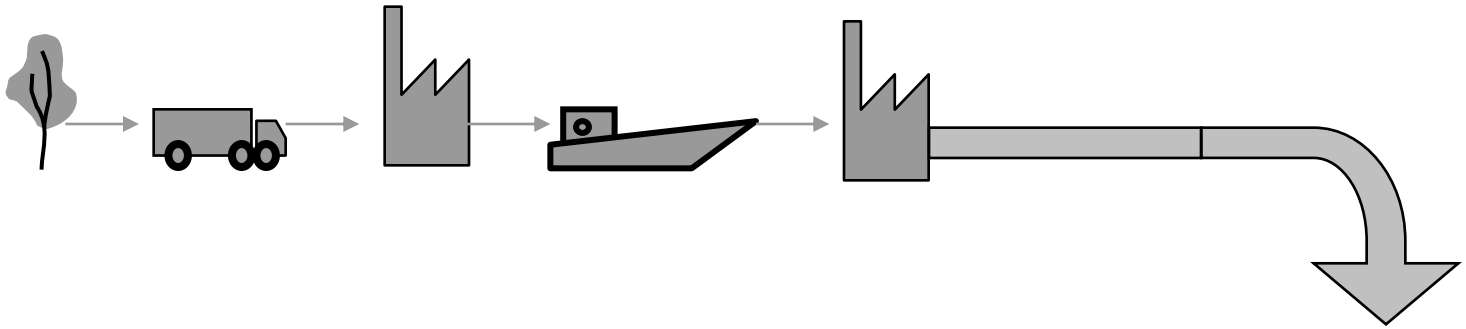
Why Biomass and CCS - the net carbon balance

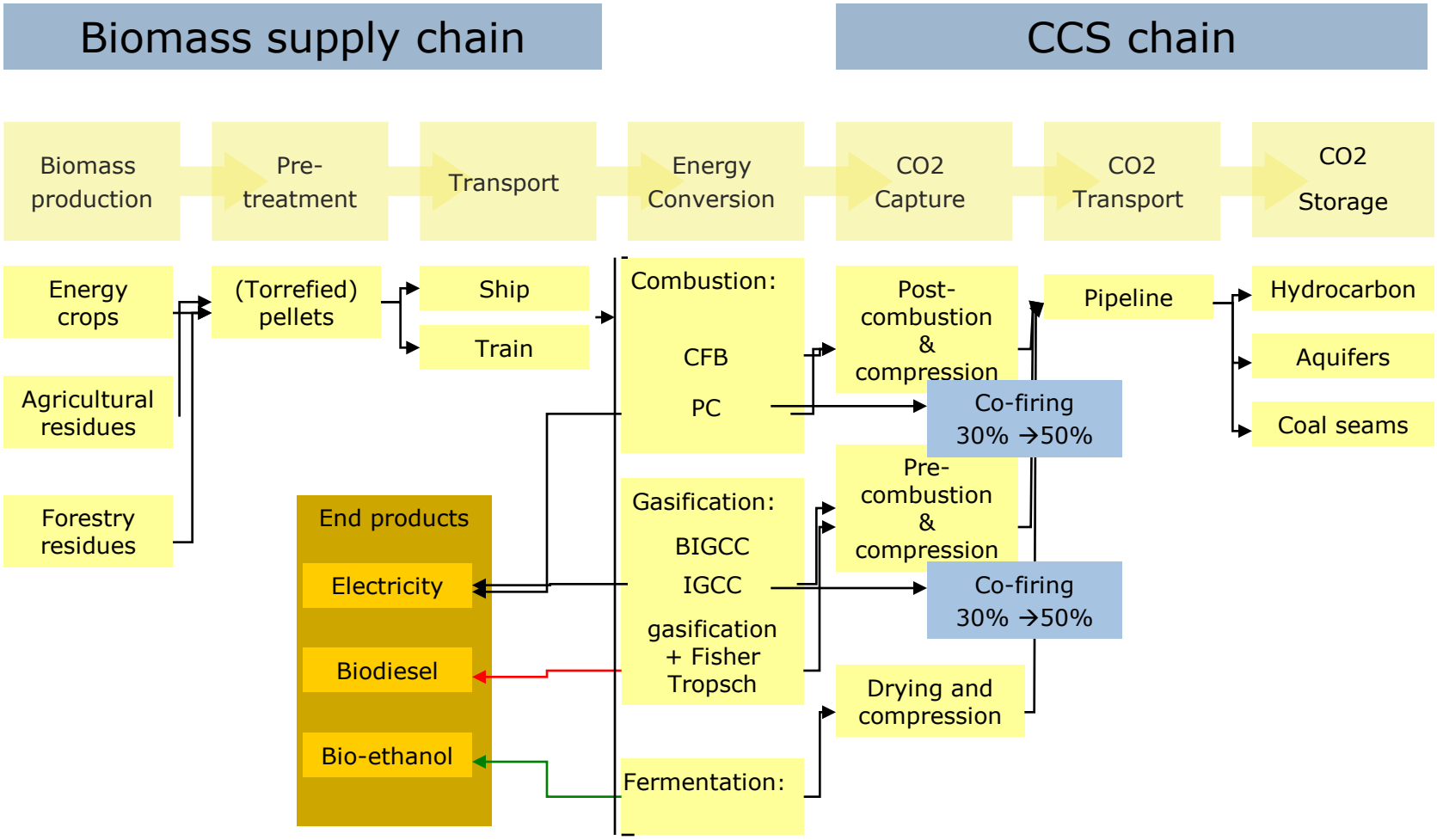


Goal of the study

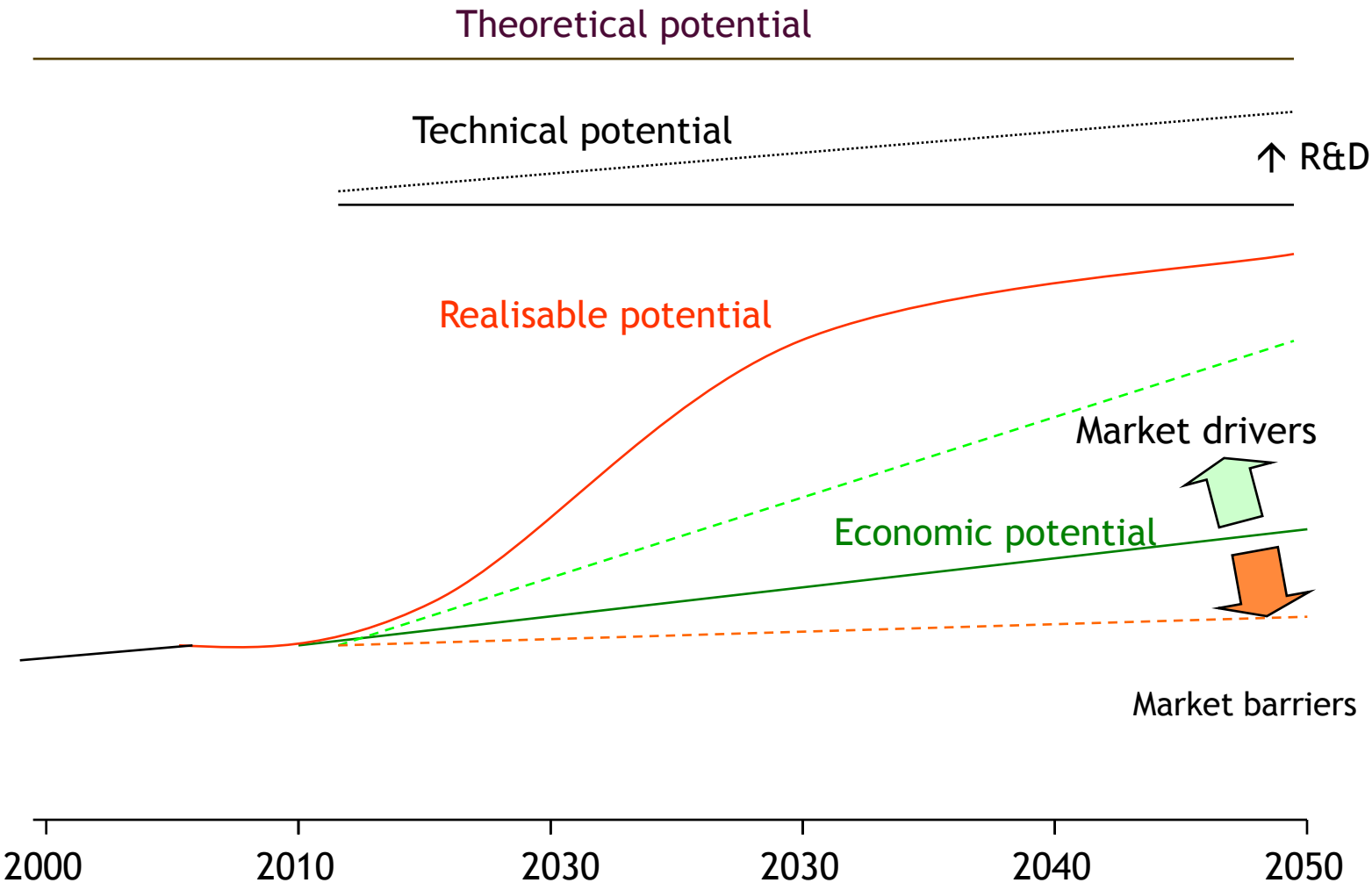
To provide understanding of the global **technical**, **economic** and **realisable** potential for biomass combined with CCS (BE-CCS) for the years 2020/2030 and 2050.



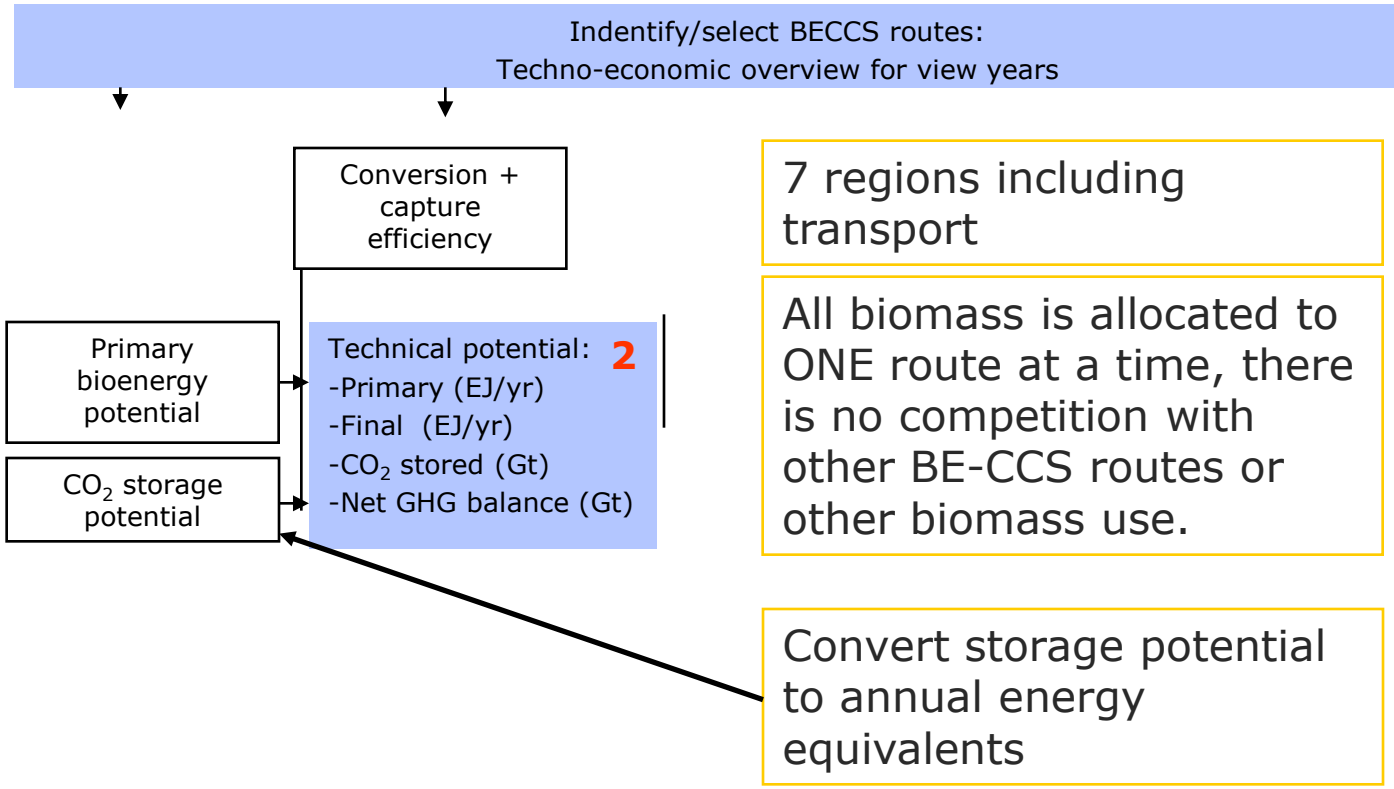
We consider the full BE-CCS chain



Which potentials did we assess?



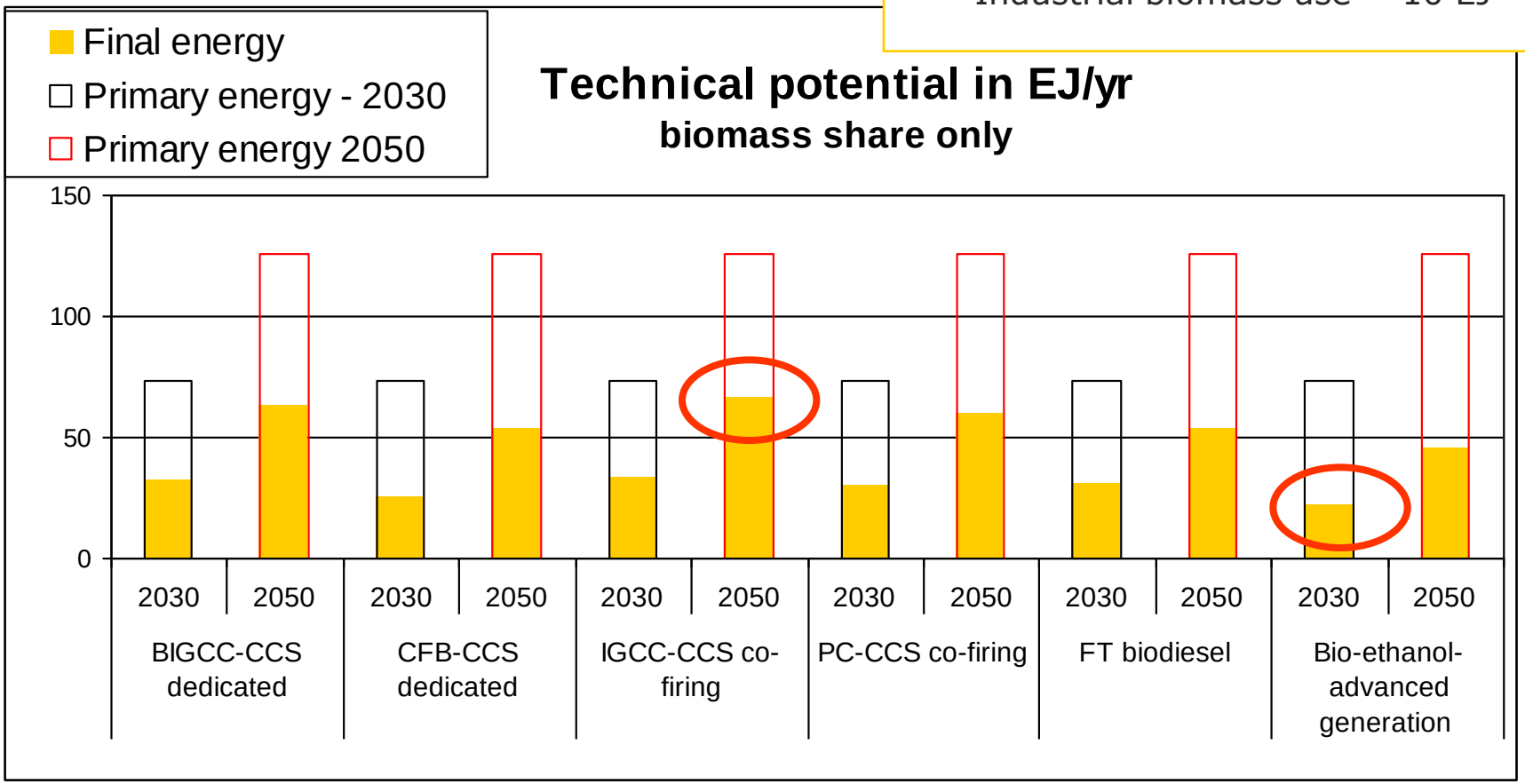
Research steps – technical potential



Results – technical potential

Global prim. energy use 2008 = 514 EJ

Industrial biomass use ~ 10 EJ



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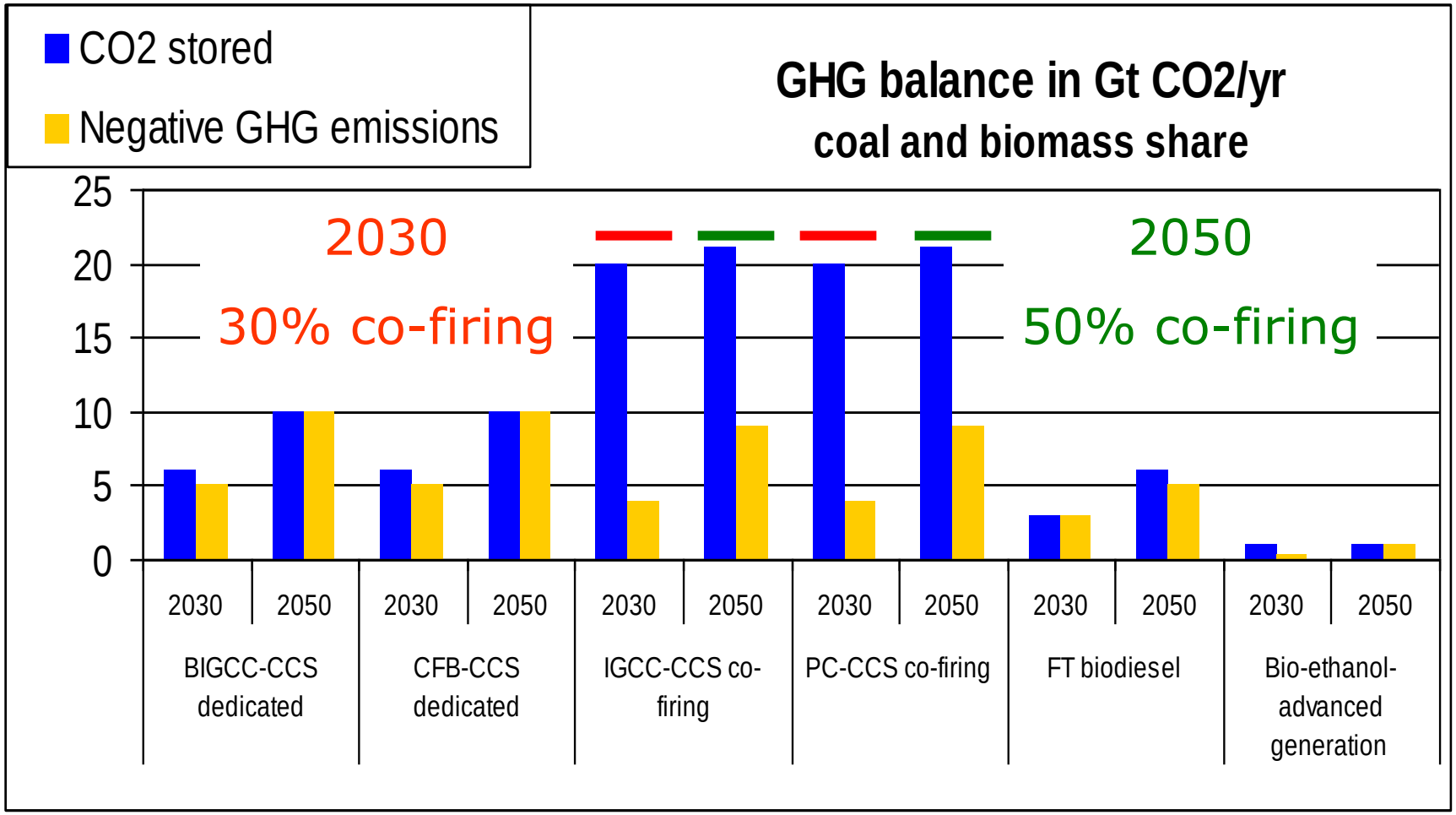
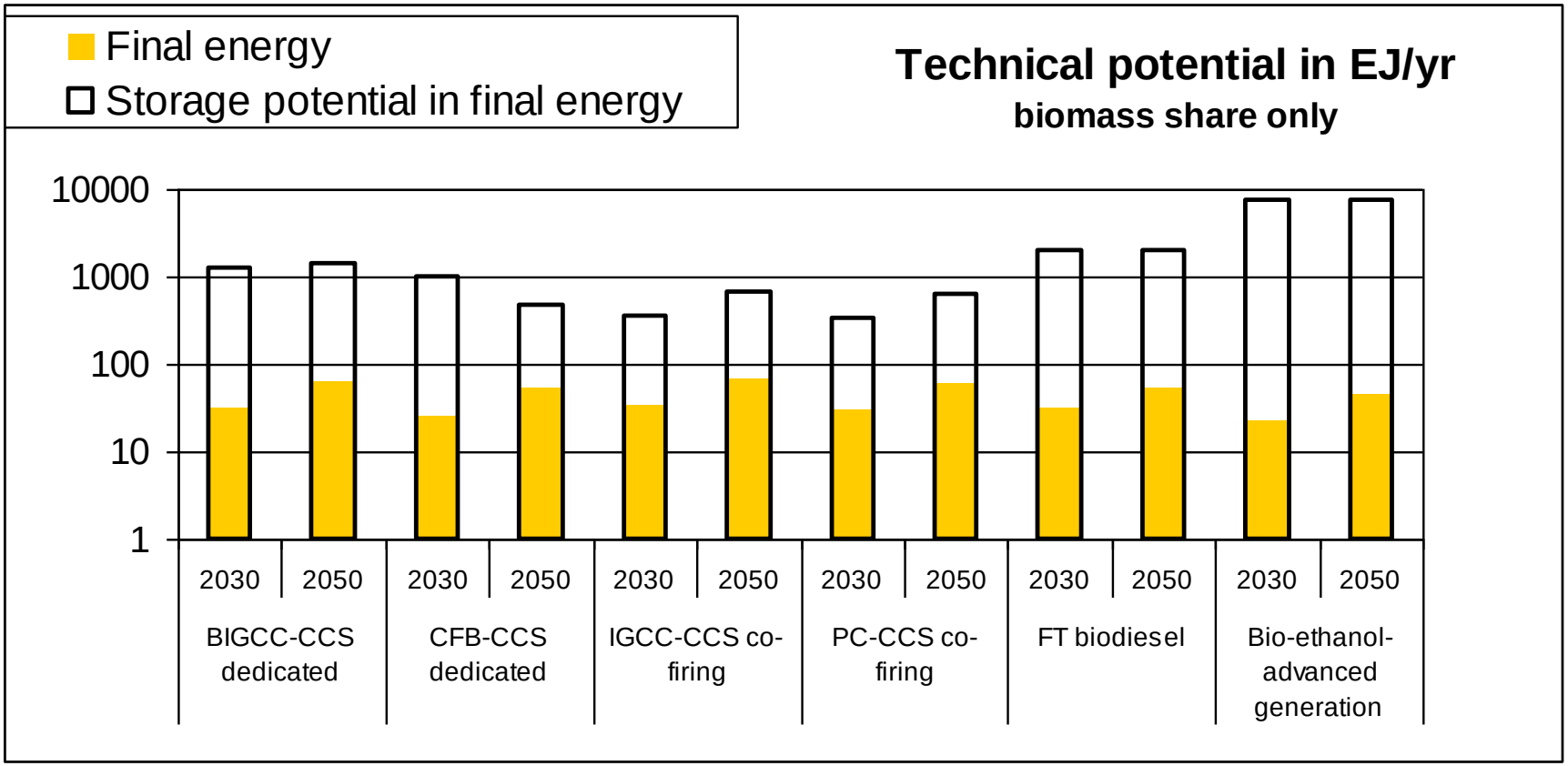
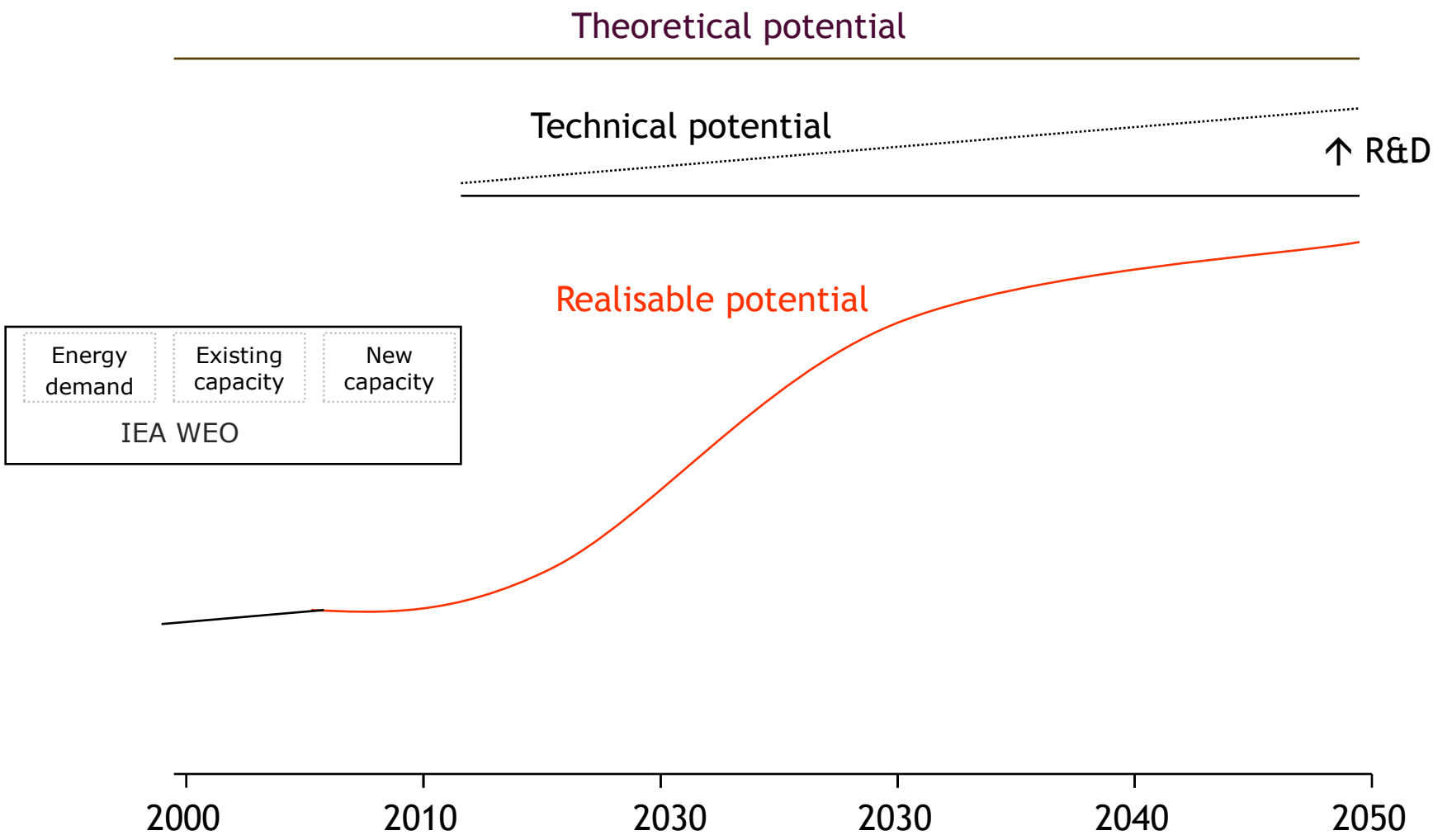


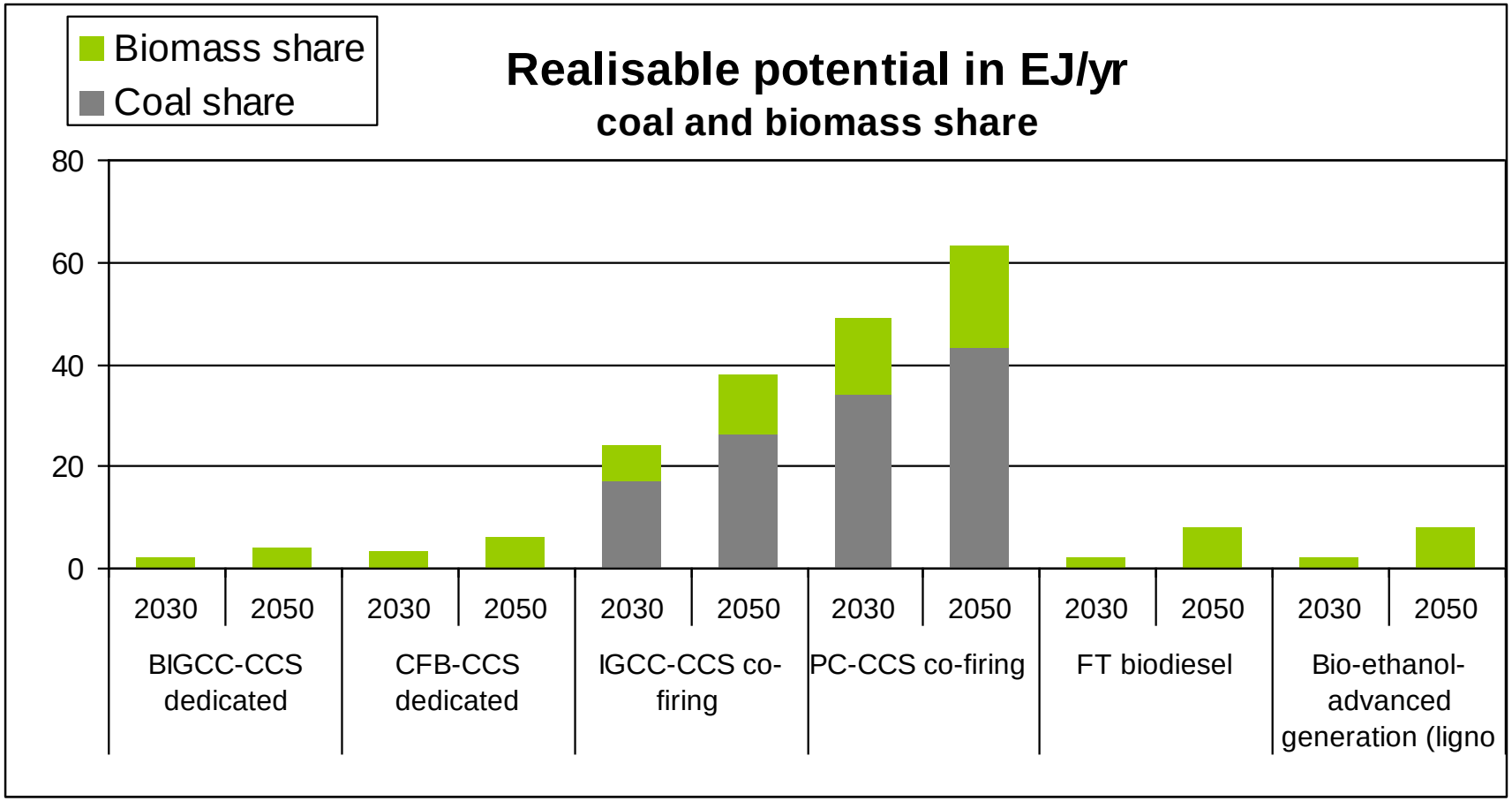
Results – technical potential



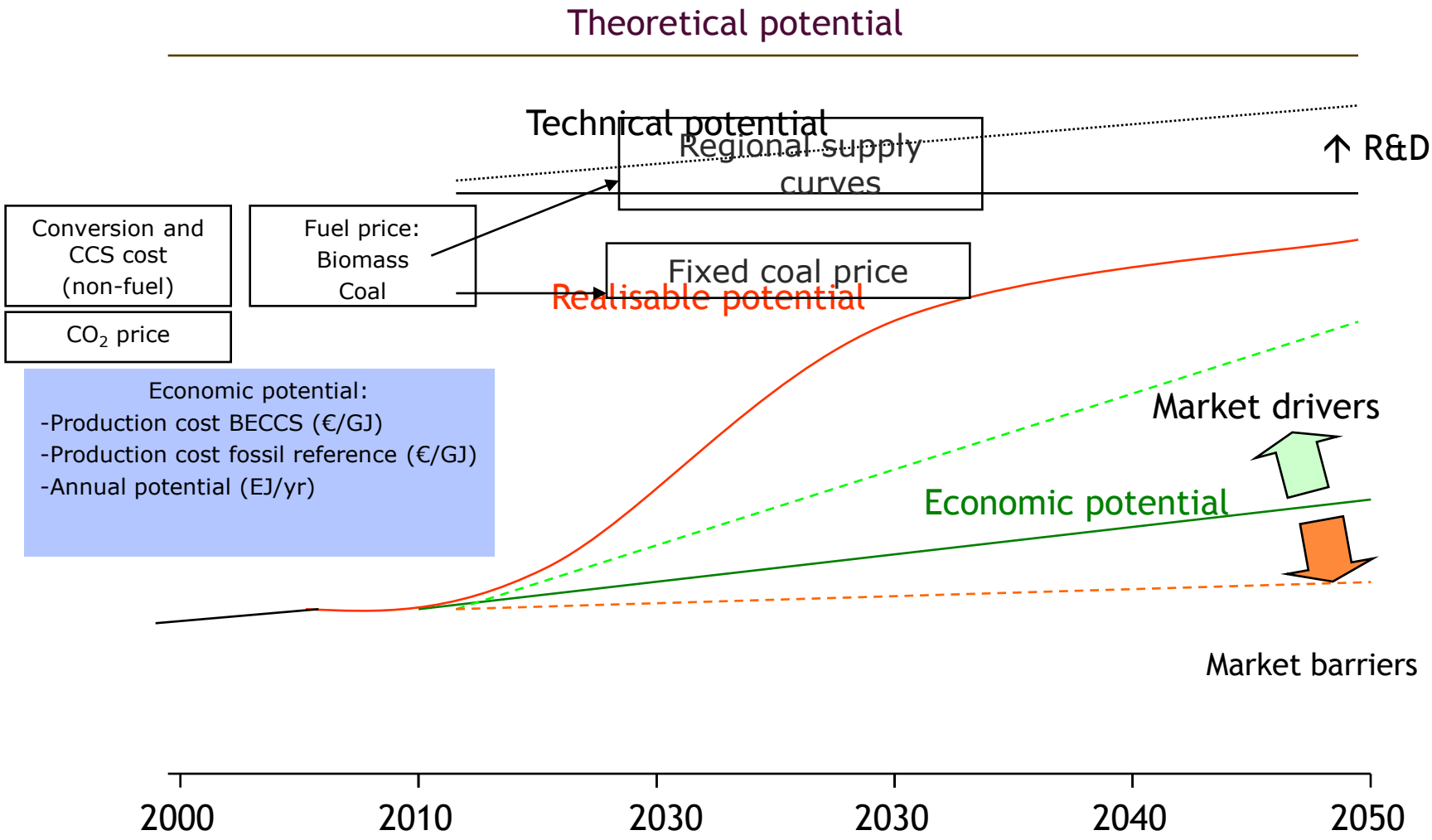
Realisable potential



Results – Realisable potential



Economic potential

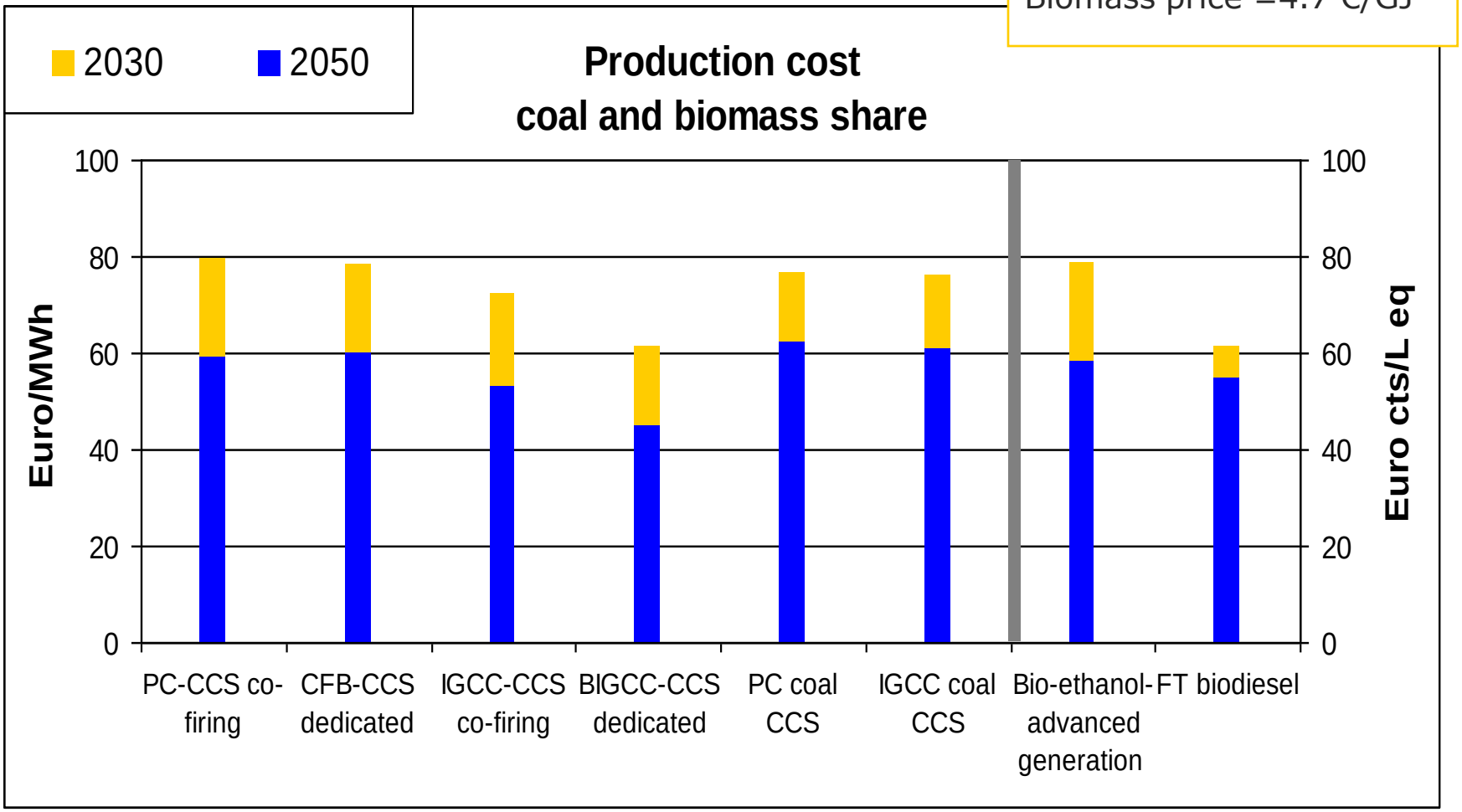


Results – economic potential

CO2 price = 50 €/ton

Coal price = 3.7 €/GJ

Biomass price =4.7 €/GJ

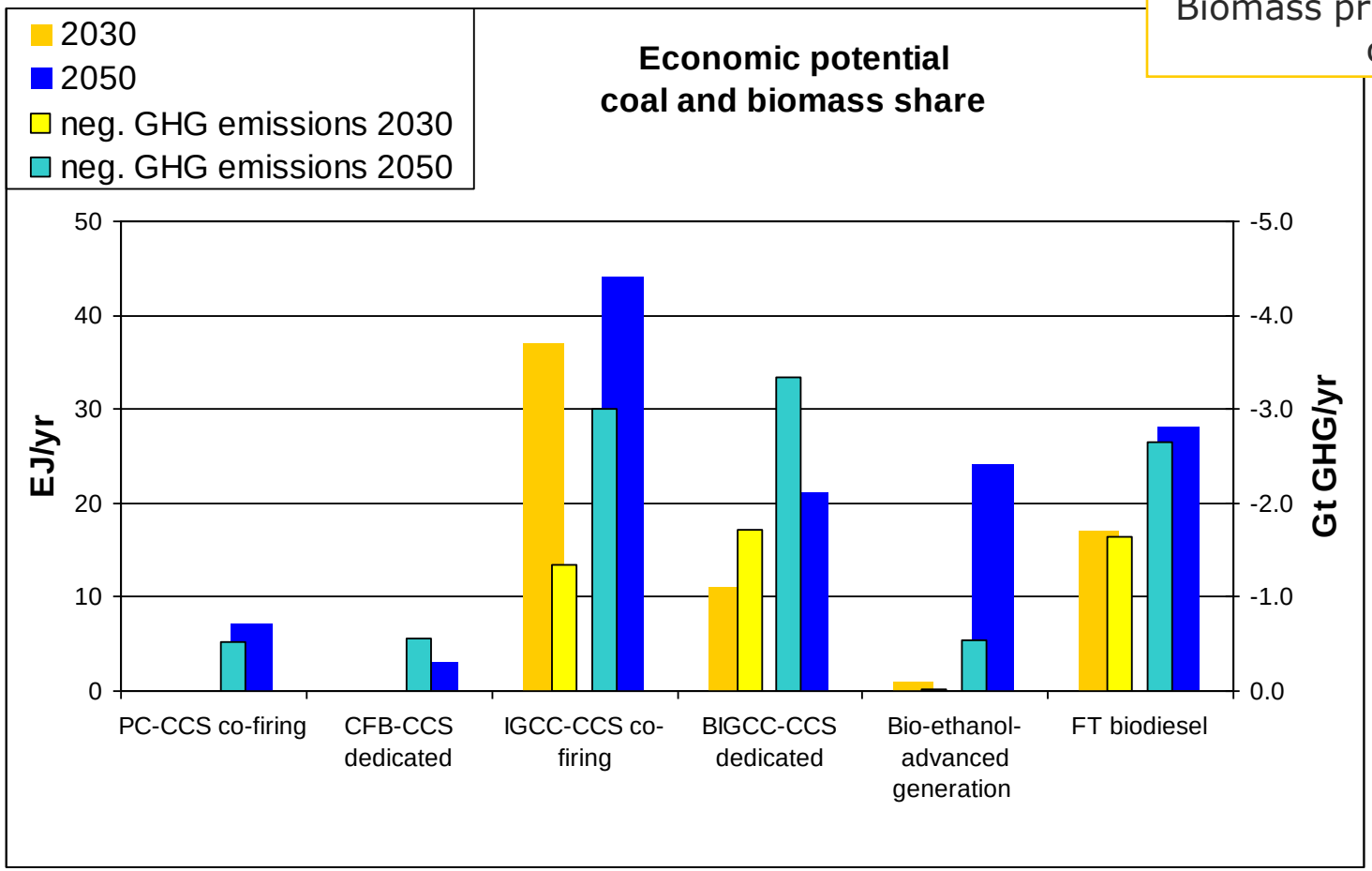


Results – economic potential

CO2 price = 50 €/ton

Coal price = 3.7 €/GJ

Biomass price = supply curve



Barriers and Drivers for BE-CCS

- CO2 price/tax
  - Clarity of status BE-CCS under ETS
- Fuel cost
  - Secure supply of sustainable and low cost biomass
  - Coal price
- GHG performance bio-fuel chains
- Availability of storage capacity
- Maturity of market and technology
- Public perception Bioenergy, CCS and combination

Conclusions

- Technical potential BE-CCS options is large
  - Up to 33% of global electricity demand in 2050 ~ -10 Gt
  - Up to 31% of global fuel demand in 2050 ~ -5 Gt
  - Biomass potential is limiting factor
- Realisable potential BE-CCS options is smaller
  - Biomass share 10% of global electricity demand in 2050
    - Co-firing installed capacity + CCS retrofit is largest
  - Biofuels up to 5% of global (conservative)

Conclusions

- Economic potential with CO2 price = 50 €/ton
  - Biomass share up to 11% (22 EJ_{final}/ yr) of global electricity demand in 2050
    - CO2 and coal price dominant effect on potential
  - Up to 16% (28 EJ_{final}/ yr) of global fuel demand in 2050
    - Price of alternative fuels (fossil gasoline/diesel) dominant
  - Electricity BE-CCS routes expected competitive with CO2 price of ~50 €/ton (and up) and secure low price biomass supply
  - Biofuel BE-CCS routes already competitive with CO2 price of ~20 €/ton compared to biofuel without CCS

Performance BE-CCS options

Technology	Capacity (MW_e)[1]	Biomass share[2]	Capture efficiency	Efficiency penalty (% pts.)	Net Generating efficiency (LHV)
PC-CCS co-firing	Up to 1000	30%-50%	90%-95%	10% 6%	41% 48%
CFB-CCS dedicated	Up to 500	100%	90%-95%	13% 8%	34% 42%
IGCC-CCS co-firing	Up to 1000	30%-50%	90%-95%	7% 4%	45% 52%
BIGCC-CCS dedicated	Up to 500	100%	90%-95%	7% 4%	43% 50%

Main techno economic data BE-CCS technologies

										Capital cost		O&M cost					
Technology	Year	Capture type	% biomass	Product	Conversion efficiency	Conversion efficiency w capture	Capture efficiency	Full load hours	Conversion	Capture inst (Euros/kWfinal)	Conversion(Euro/kW)	Capture inst (Euros/kWfinal)	O & M (% of conversion installation	O & M (% of capture installation)	Conversion Costs/Gj_out	Costs CO2 capture /GJ_out
PC-CCS co-firing	2030	Post	30%	ELEC	51%	41%	90%	7800	1477	675	61	50	4%	7%	7.75	4.33
CFB-CCS dedicated	2030	Post	100%	ELEC	47%	34%	90%	7800	1581	1397	53	84	3%	6%	7.86	8.27
IGCC-CCS co-firing	2030	Pre	30%	ELEC	52%	45%	90%	7800	1315	615	63	37	5%	6%	7.21	3.64
BIGCC-CCS dedicated	2030	Pre	100%	ELEC	50%	43%	90%	7800	1616	615	70	46	4%	7%	8.60	3.96
PC-CCS co-firing	2050	Post	50%	ELEC	54%	48%	95%	7800	1360	422	48	31	4%	7%	6.85	2.70
CFB-CCS dedicated	2050	Post	100%	ELEC	50%	42%	95%	7800	1456	873	56	52	4%	6%	7.49	5.15
IGCC-CCS co-firing	2050	Pre	50%	ELEC	56%	52%	95%	7800	1133	385	52	23	5%	6%	6.13	2.27
BIGCC-CCS dedicated	2050	Pre	100%	ELEC	54%	50%	95%	7800	1272	385	51	29	4%	8%	6.62	2.49
BioEthanol-advanced generation (ligno cellulosic)	2030	Post	100%	FUEL	29%	29%	11%	8000	1580	36	79	7	5%	6%	8.56	0.37
BioEthanol-advanced generation (ligno cellulosic)	2050	Post	100%	FUEL	36%	36%	13%	8000	1064	37	38	7	4%	6%	5.25	0.37
FT biodiesel	2030	Pre	100%	FUEL	42%	42%	54%	8000	1615	78	71	23	4%	6%	8.42	1.08
FT biodiesel	2050	Pre	100%	FUEL	42%	42%	54%	8000	1296	62	57	6	4%	6%	6.75	0.42

PC= Pulverized coal

CFB= Circulating fluidized bed

IGCC = integrated gasification combined cycle

FT= Fischer Tropsch

Cost figures without fuel cost, all figures in $€_{2010}$

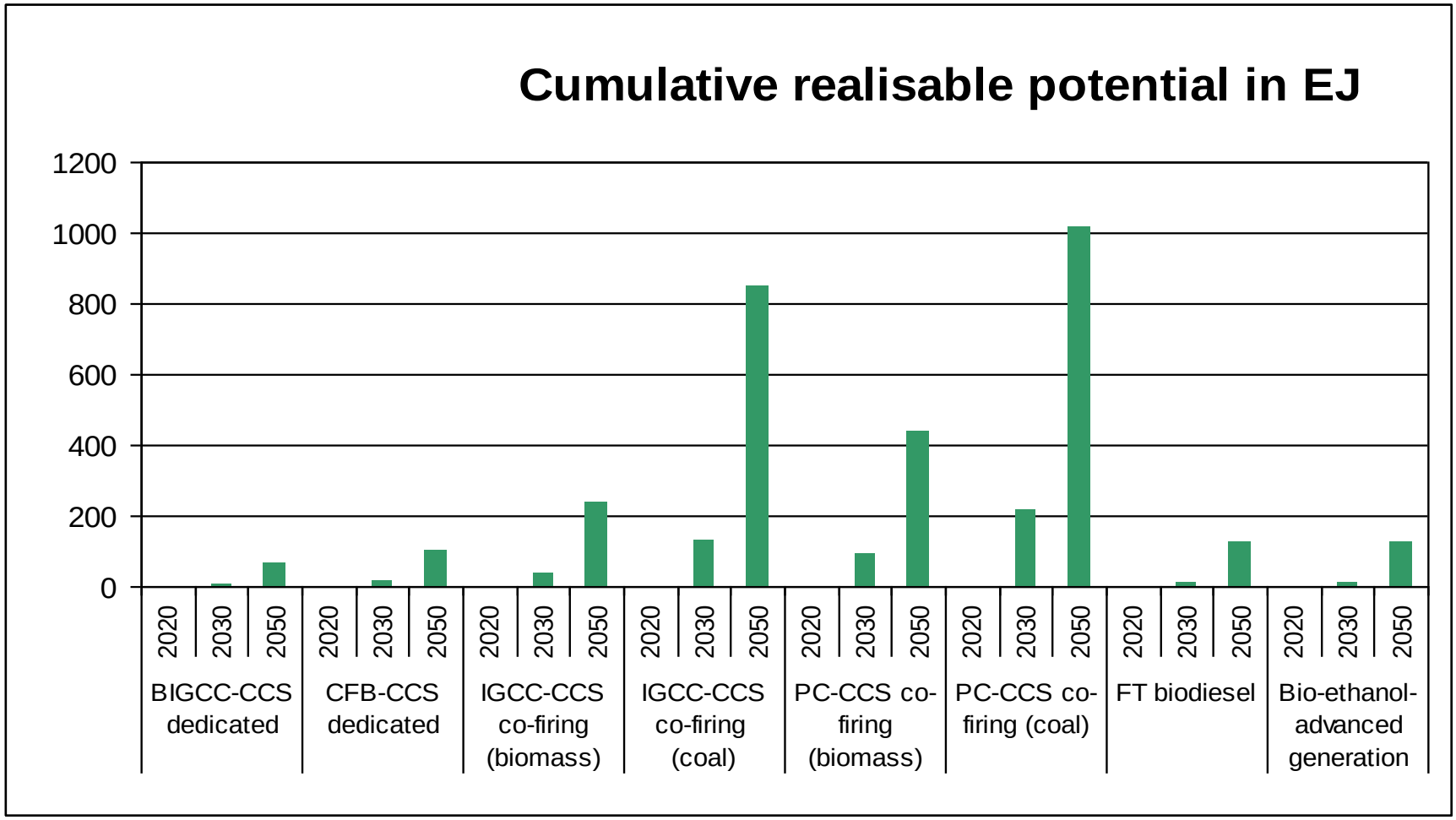
General Assumptions

Discount rate	Medium	Value:	10%
Energy crop scenario	A2	*for cost curves only, not for potentials*	
Forerstry residues scenario	Low		
Criteria biomass	Strict	*From Van Vuuren 2009*	
Technology route	IGCC-CCS co-firin	*3*	
CO2 Resevoirs type	All	Except	-
Storage potential estimation	Best		
Storage capacity saturation period (years)	50		
CO2 price 2030	20		
CO2 price 2050	20		
Biomass densification cost	1.7		
Biomass transport cost	0.4		
Average CO2 storage costs (EUR/tonne C(	5		
Average CO2 transport distance (km)	200-500 km	Costs (€/tonne)	5

For the technical potential, we assumed that 1/50 of the total storage capacity can be used annually, i.e. the saturation period of the total capacity is 50 years (at immediate full deployment).

Emission factor coal (kg/GJ)	94.6		
Coal price ($/GJ) 2030	4.85	Value in €/GJ:	3.73
Coal price ($/GJ) 2050	4.85	Value in €/GJ:	3.73
Crude oil price ($/barrel) - 2010	72	Value in €/barrel:	8.72
Crude oil price ($/barrel) - 2030	112.95	Value in €/barrel:	13.68
Crude oil price ($/barrel) - 2050	147.33	Value in €/barrel:	17.85
Diesel - High $/litre	1.28	Value in €/litre:	26.36
Diesel price - Low $/litre	0.78	Value in €/litre:	16.06
Gasoline price - High $/litre	1.23	Value in €/litre:	28.50
Gasoline price - Low $/litre	0.56	Value in €/litre:	12.97

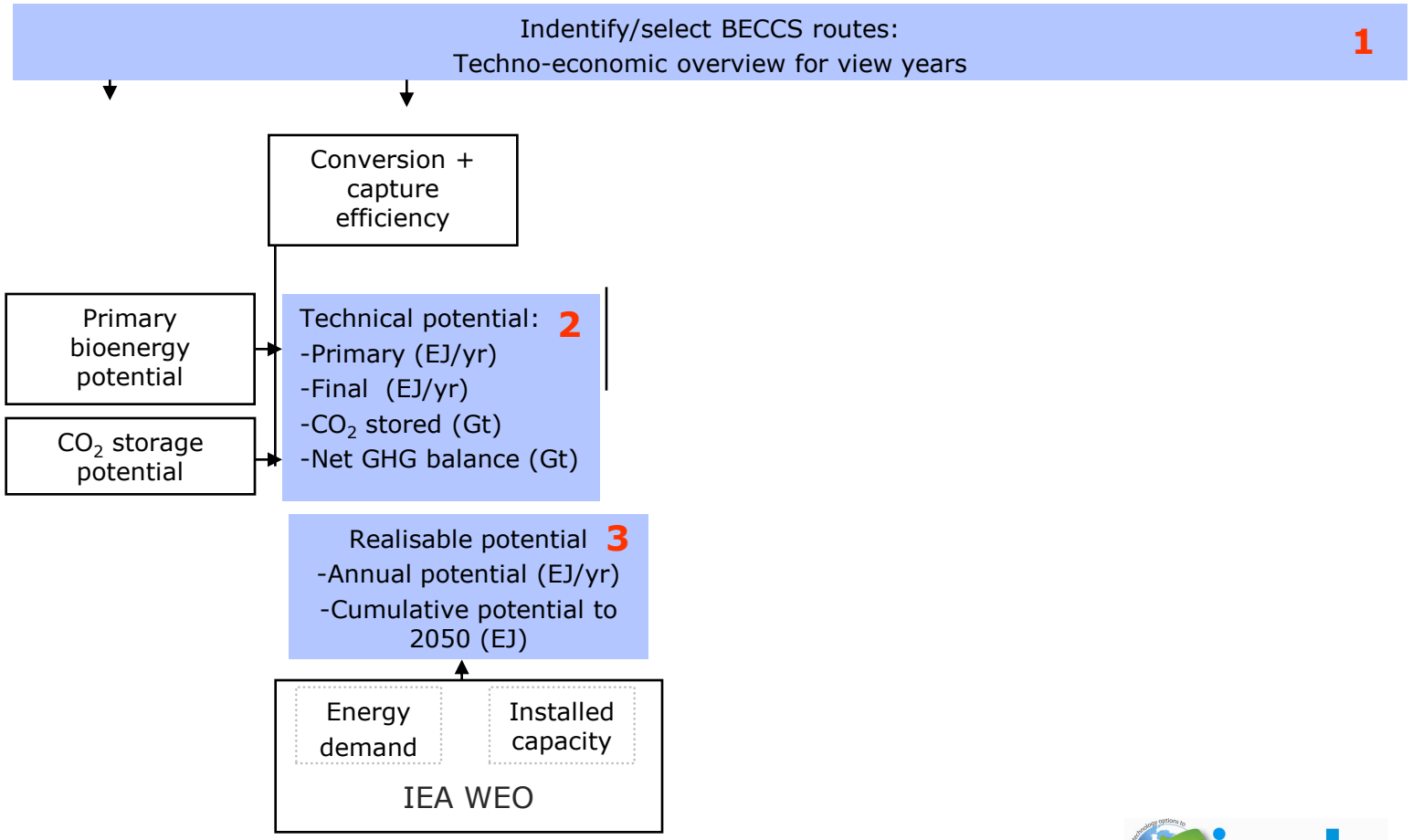
Results – Realisable potential



Sensitivity analysis

- Technical potential
  - Biomass supply limiting factor in most of 7 regions
- Economic potential
  - CO2 price dominant
  - Coal price strong effect
  - Discount rate (capital intensive routes)
  - Transport storage cost of CO2 (prod. Cost. -6% to + 14%)

Research steps – realisable potential



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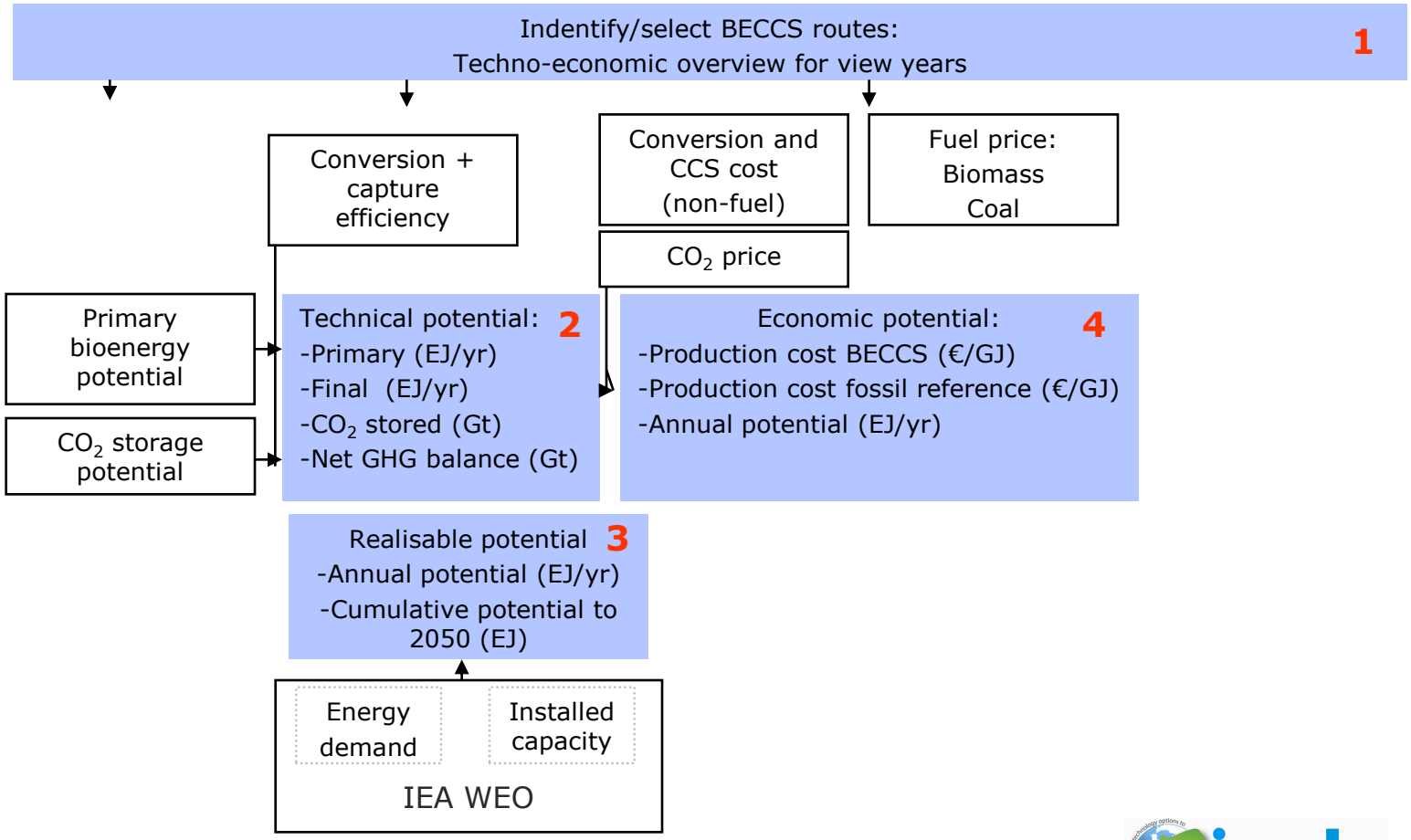

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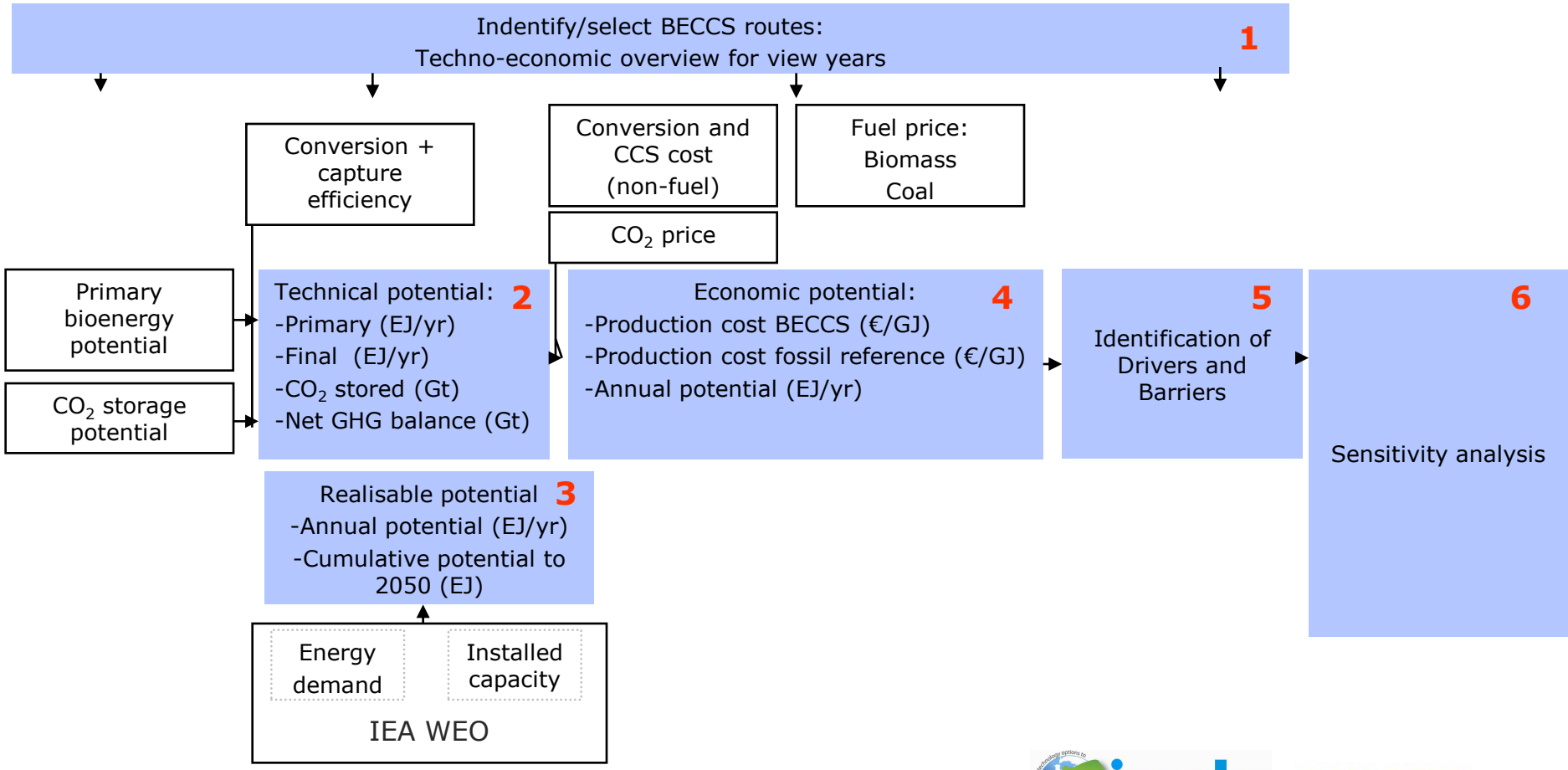

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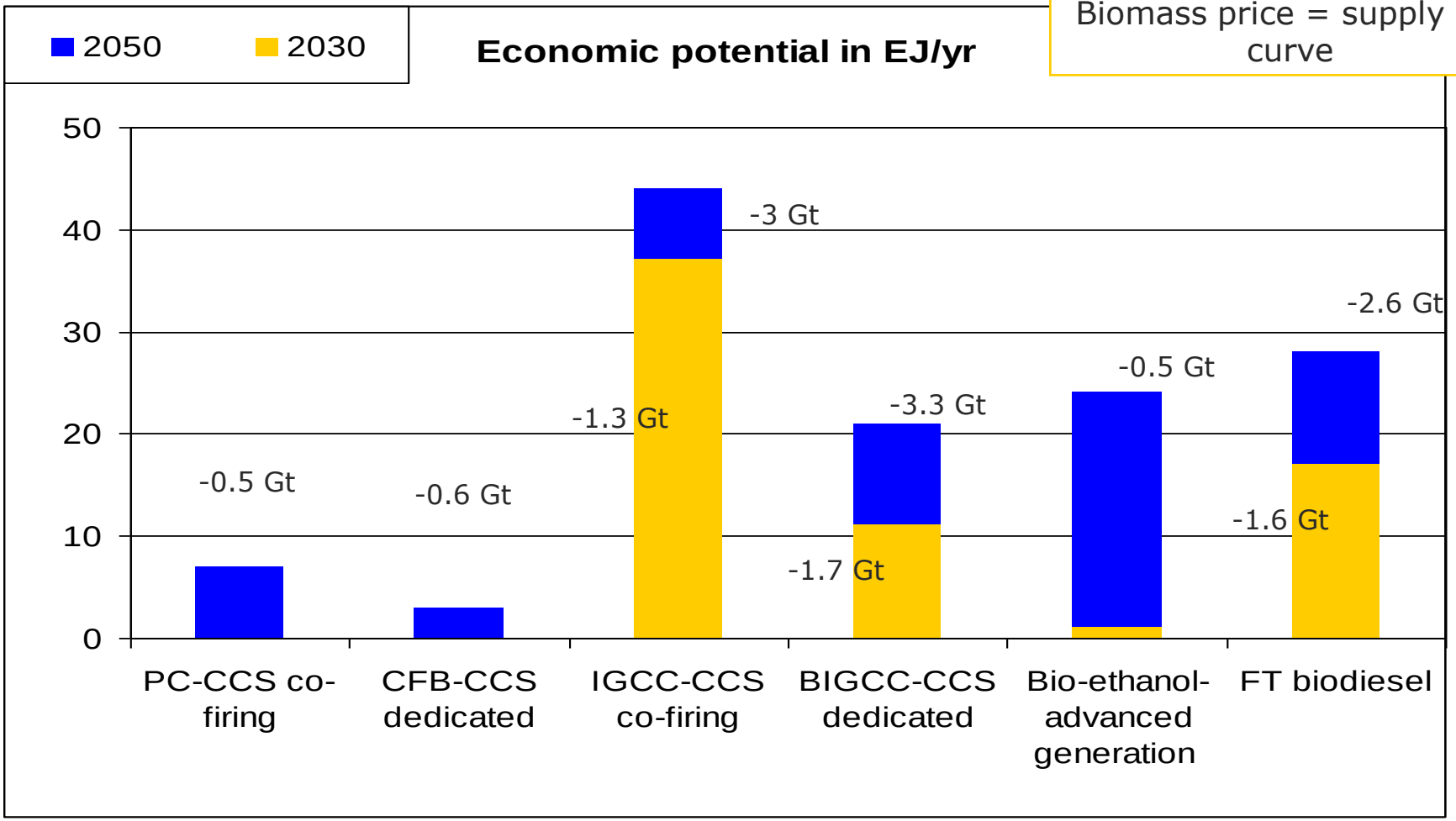

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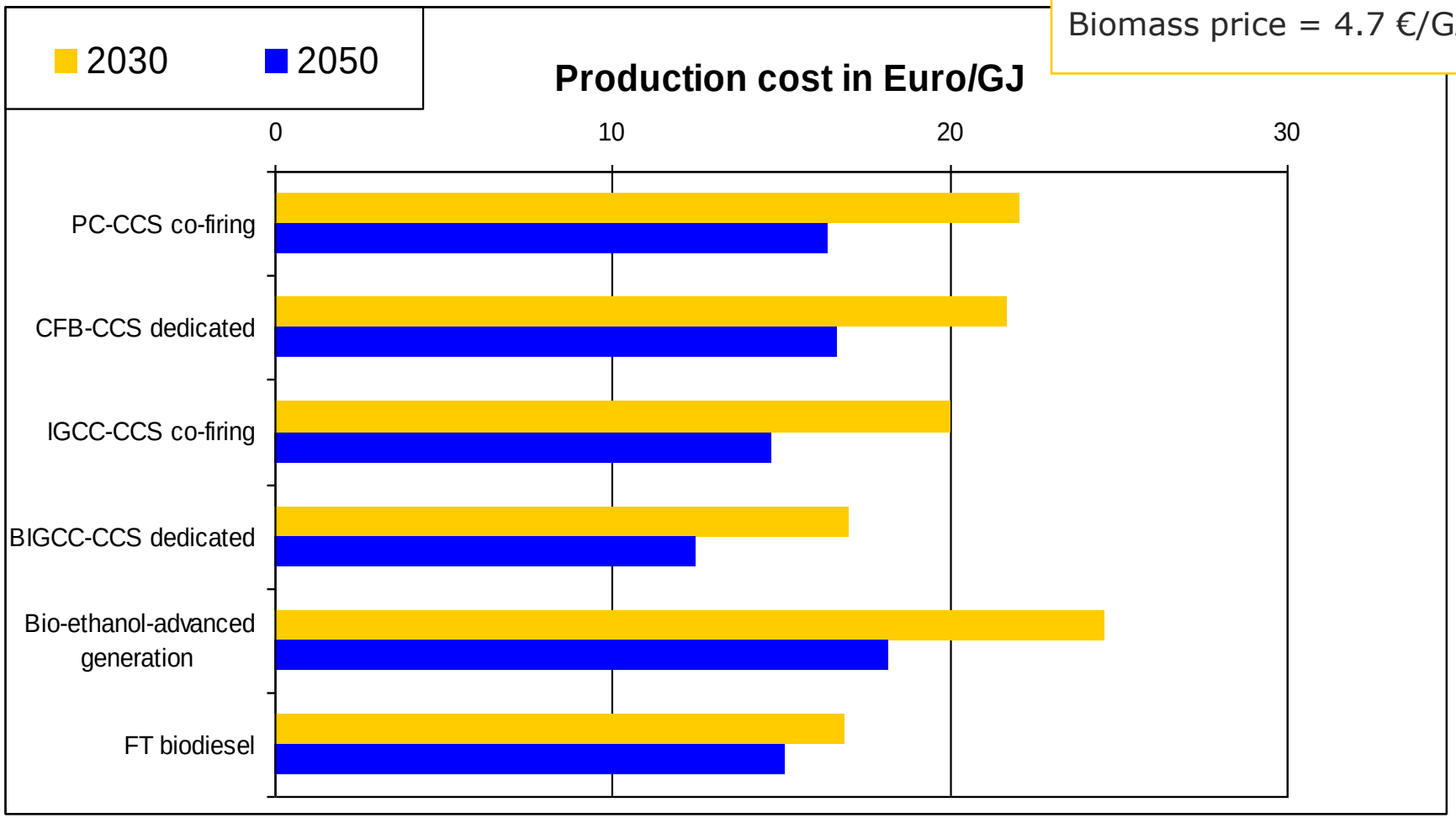

Conclusions 1/2

- Technical potential BE-CCS options is large
  - EL: Biomass share up to 66 EJ_{final}/ yr in 2050 → 33% of global
  - -10 Gt negative emissions
  - BF: Up to 53 EJ_{final}/ yr in 2050
  - 31% of global
  - -6 Gt negative emissions
- Realisable potential BE-CCS options is smaller
  - EL: up to 20 EJ_{final}/ yr → 10% of global
  - BF: up to 8 EJ_{final}/ yr → 5% of global

Conclusions 2/2

- Economic potential with CO2 price = 50 €/ton
  - EL: Biomass share up to 22 EJ_{final}/ yr in 2050
  - BF: Up to 28 EJ_{final}/ yr in 2050
  - BE-CCS routes only competitive under high CO2 price and low price biomass supply