Copernicus Institute of
Sustainable Development

The role of CCS in the provision of long-term security of power supply and deep CO_2 emission reduction

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Introduction: Background

Paris agreement

- Limit global warming well below 2°C, strive for 1.5 °C
- Estimated global C-budget: 400-1000 Gt CO_{2e} until 2100
- At least full decarbonisation of power sector likely needed
- C-negative technologies bioenergy with CCS (BECCS) direct air carbon capture (DAC) likely required

Decarbonisation of end-use sectors

- Electrification of transport and heat will lead to increased electricity demand

Security of low-carbon portfolios with high shares of intermittent renewable energy sources (iRES)

- Weather variability, impact of climate change

Introduction: Motivation

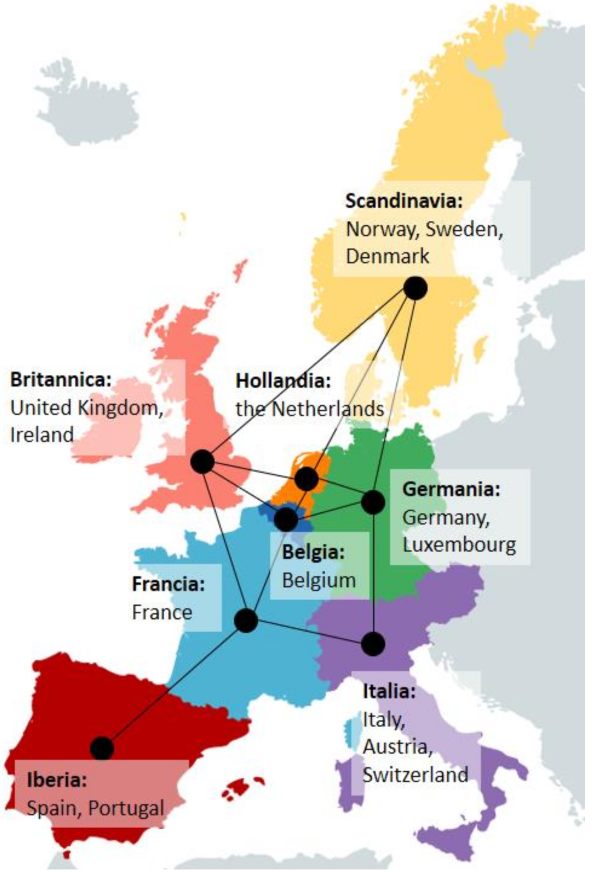
- Which generation portfolios are cost-effective for achieving **deep decarbonisation**?
- What is the **role of CCS** in these portfolios?
- How **sensitive** are these alternative portfolios to short-term weather variability and long-term climate change?

Method: Model setup

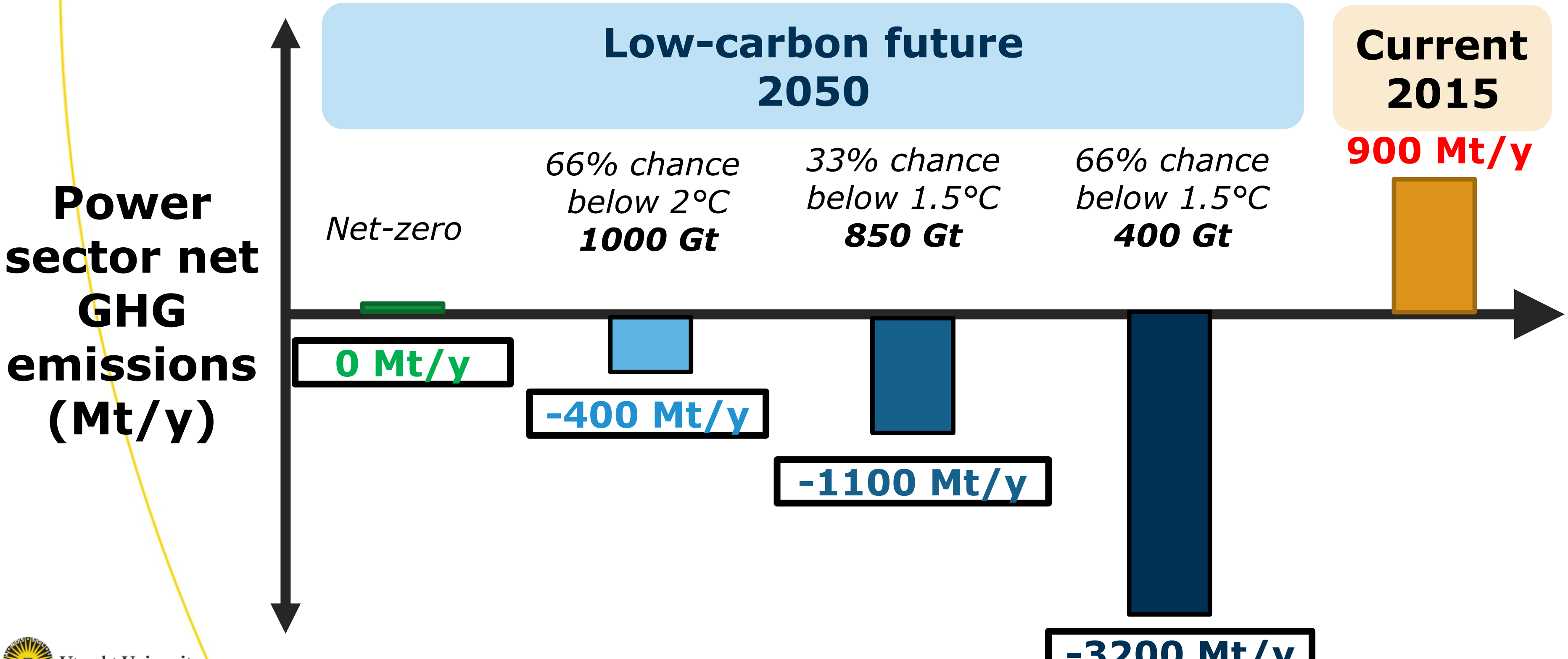
- Power system model built using PLEXOS® (Mixed-integer linear programming)
  - Objective: Min(*NPV(CAPEX+FOM+VOM+Fuel)*)

- Model Western Europe for year 2050

- Consider:
  - 33% higher demand (EVs + HPs)
  - Clean slate: no legacy generators
  - More ambitious climate action

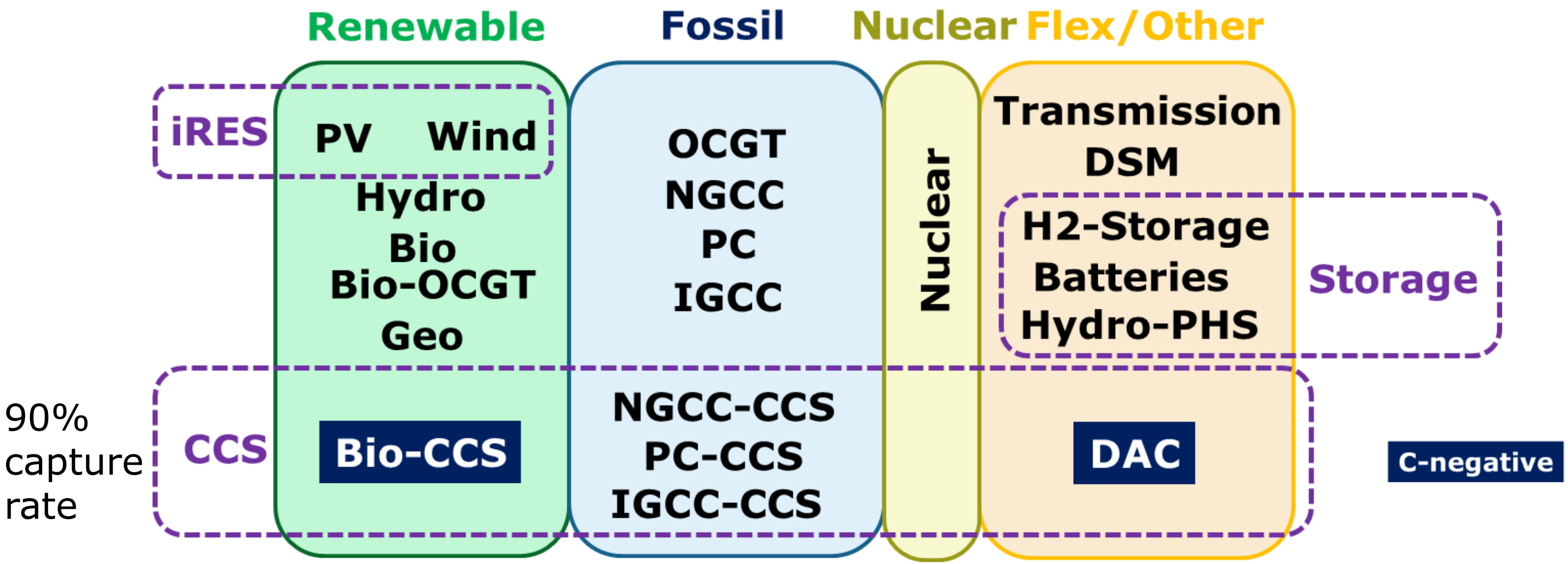


Method: Decarbonisation scenarios



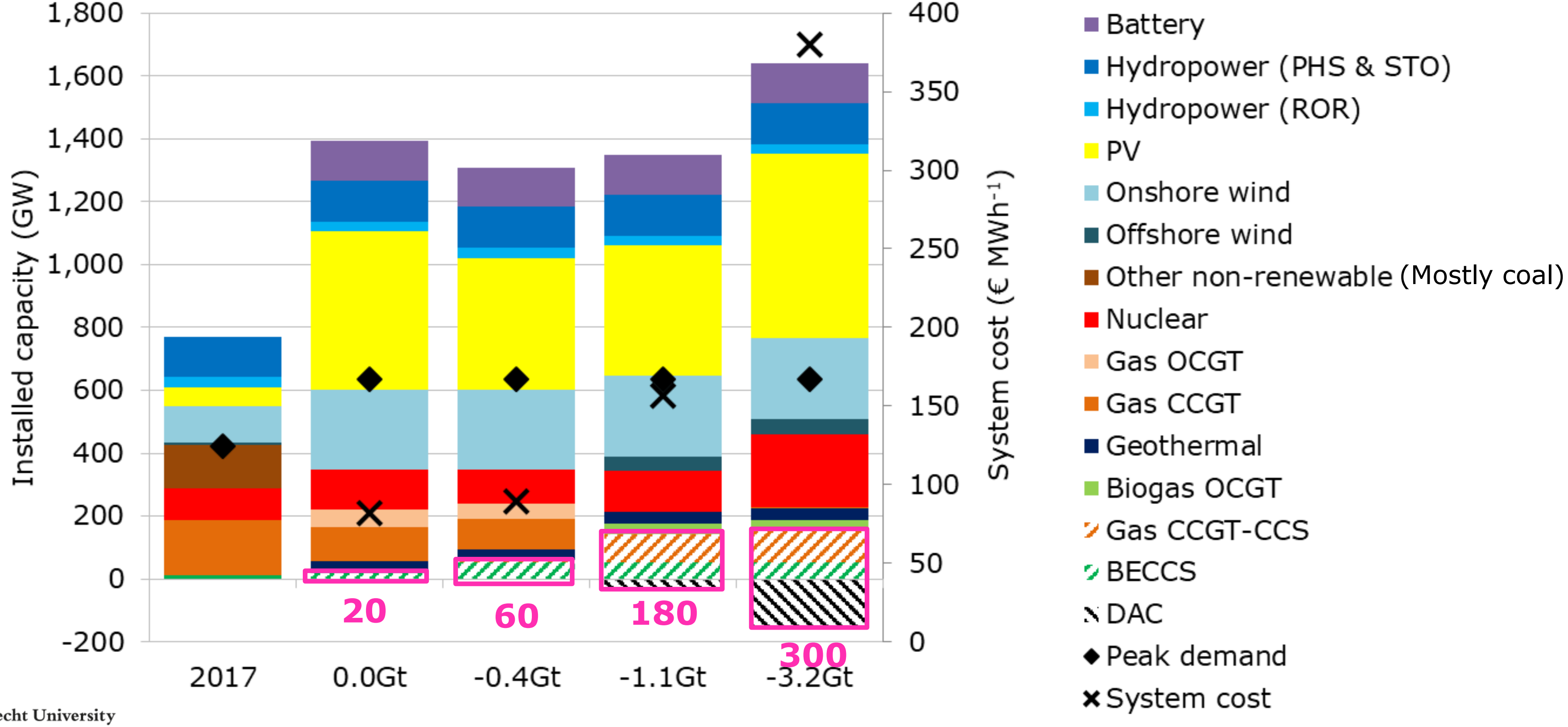
Global budgets from Anderson & Broderick (2017)

Method: Technologies



- Model free to optimise generation portfolios <u>except</u>:
  - ➢ Wind and PV limited by suitable area
  - ➢ Hydro, geo, battery(EV), transmission are fixed
  - ➢ Limited biomass (domestic potential ~5 EJ/y)

Results: Installed capacity



Results: Additional runs

For deepest decarbonisation scenario -3.2 Gt/y:

- Allow biomass import
  - **No biomass constraint**

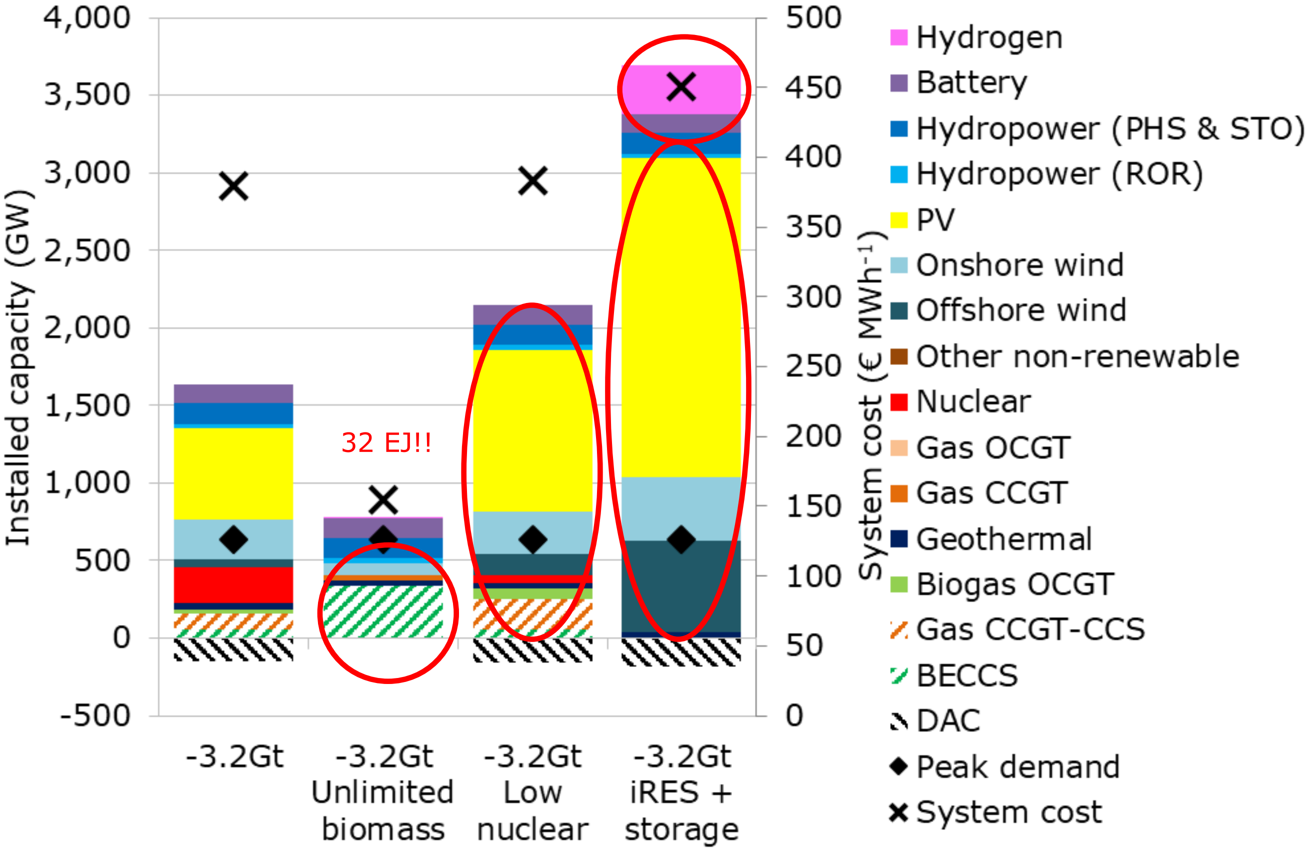
- Public opposition to nuclear
  - **Low nuclear (50 GW)**

- Opposition to nuclear, fossil, biomass
  - **iRES + storage + DAC only**

Results: Additional runs

Three sensitivities for deep decarbonisation:

- Unlimited biomass
- Low nuclear (50 GW)
- iRES + DAC + storage



Conclusion

- CCS plays **vital role** in deep decarb: enables BECCS & DAC
- **BECCS+NGCC** seems more cost-effective than NGCC-CCS, though biomass costs, env. impact & potential uncertain
- 90% CCS capture **limits** fossil-CCS in deep decarbonisation: residual emissions must be offset
- Deep decarbonisation with **wind and PV alone not possible**: need CCS to enable DAC, but even then expensive!
- Without NGCC-CCS or BECCS, **3x iRES and storage required**
- Nuclear marginally favored as zero-carbon baseload **but costs are uncertain**: any zero-C dispatchable mix will do (e.g. BECCS(+NGCC), NGCC-CCS (100%), iRES + storage, nuclear)

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