Abatement, R&D policies, and negative emission technology in climate mitigation strategies

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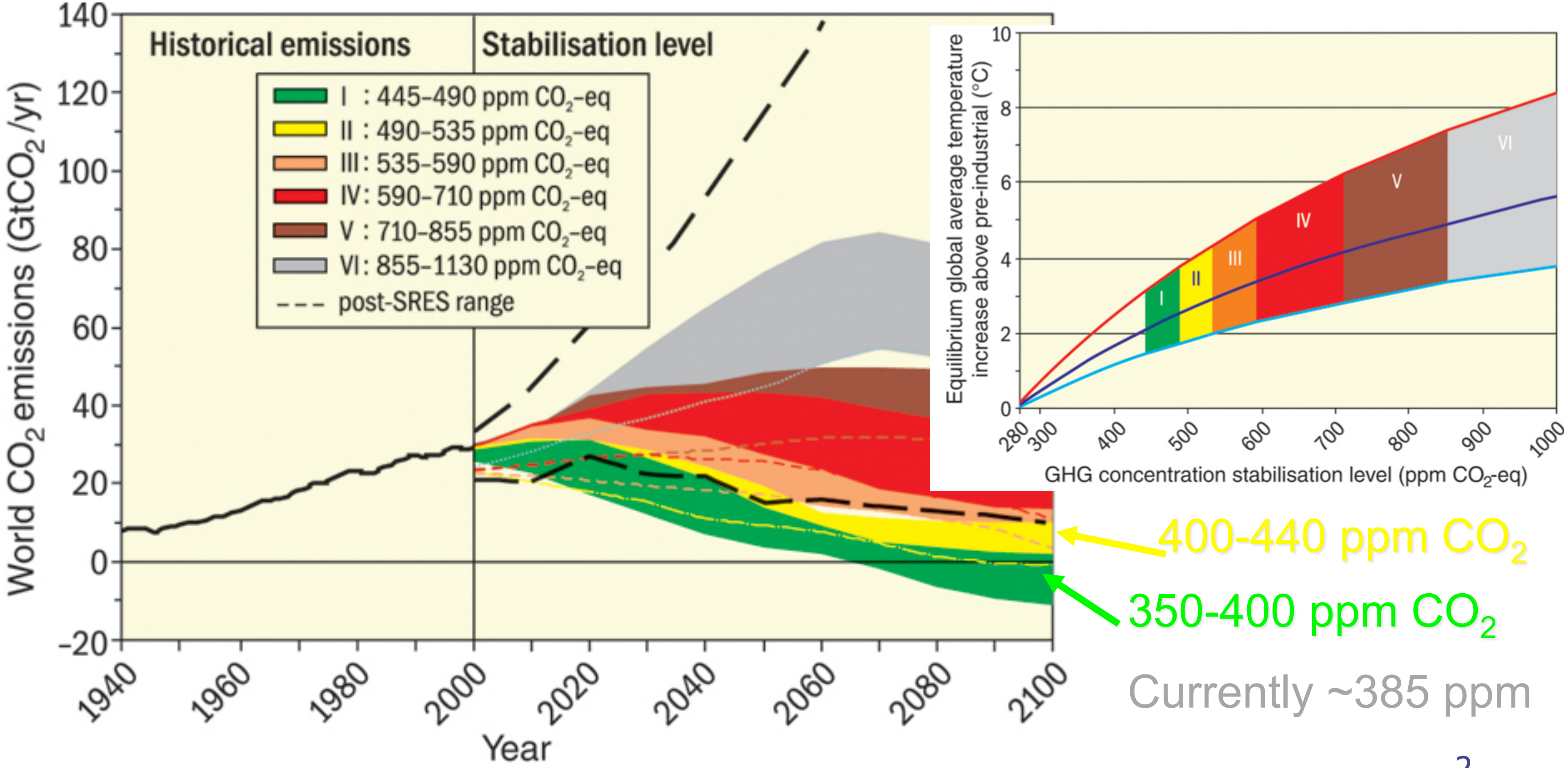
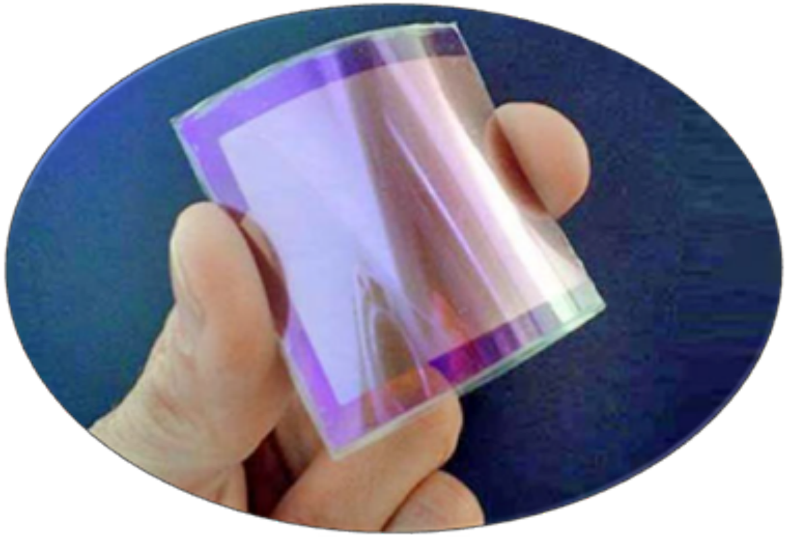
The green path requires global CO2 emissions to flatten for the next decade and then decrease to nothing (and below) over the rest of the century.



Where would you place scarce time and money?



How should we get both near-term and long-term abatement?

- Market failures in emission pricing & innovation.
- Standard economic theory: multiple market failures ideally require multiple policy instruments.
- Previous research: optimal portfolio includes both emission & technology policies.
- Climate policy design depends on how these instruments are weighted.

Research questions

- Given the immense uncertainties, what type of policy portfolio is the most robust?
- How do uncertainty about technological change and GHGs affect the composition of the optimal policy portfolio?

Outline

- The model
  - Decision variables
  - Representing technological change
  - CO_2 constraint for 2100
- Results
- Implications

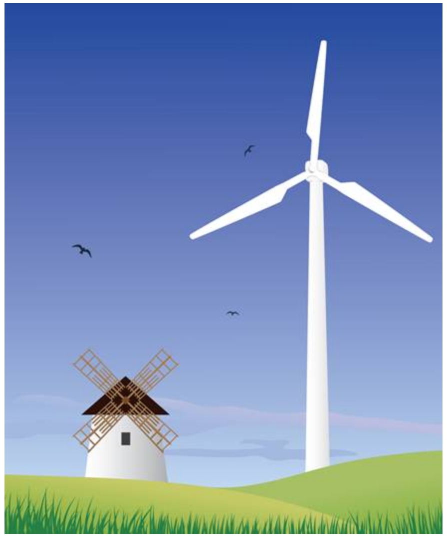
Model horizon: three periods

- 2010-2029: Near-term
- 2030-2049: Medium-term
- 2050-2099: Long-term

Decision variables:
5 policy types with 5 investment levels

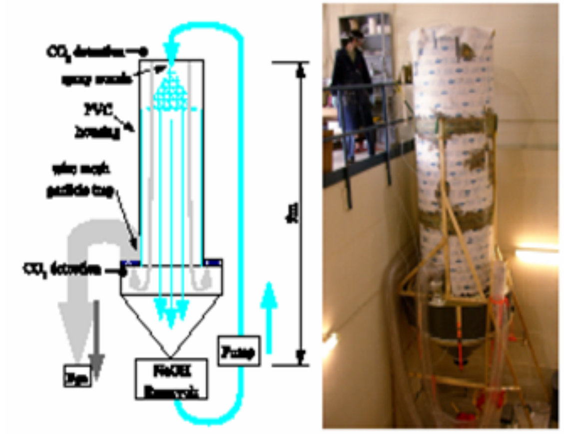
Emission intensity R&D

Carbon-free R&D



Emission reductions

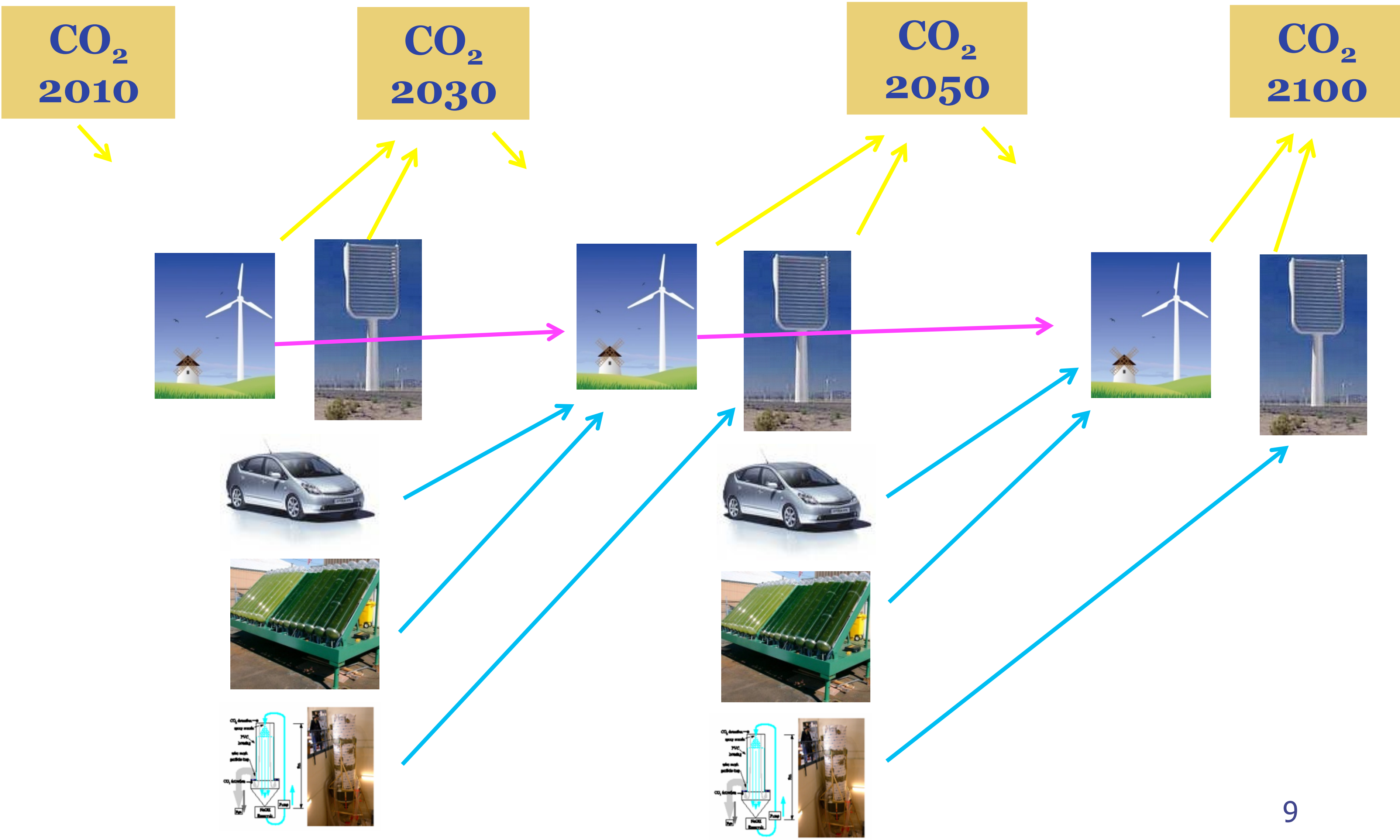
Air capture



Stolaroff (2006)

Air capture R&D

Minimize expected costs while keeping the expected CO_2 concentration in year 2100 beneath a threshold.



Abatement options from 0 to 100% of BAU emissions

BAU_t

Abate "1" (0%)

Abate "2" (25%)

Abate "3" (50%)

Abate "4" (75%)

0

Abate "5" (100%)

Emissions in period *t*

Air capture options for a period range from 0 to 100% of period 3's BAU emissions.

Air capture "5"	(100% of BAU_3)
Air capture "4"	(50% of BAU_3)
Air capture "3"	(25% of BAU_3)
Air capture "2"	(10% of BAU_3)
Air capture "1"	(0% of BAU_3)

Expected 2100 CO_2 concentration ≤ exogenous threshold in each period

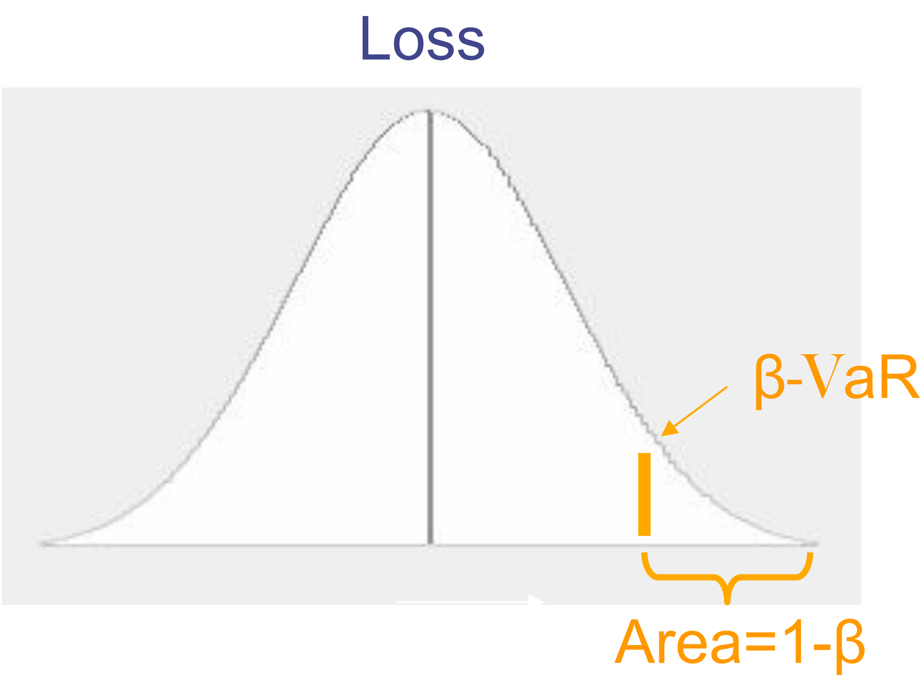
Threshold (ppm)	
Most stringent	**390**
Middling stringency	**435**
Least stringent	**550**

CO_2 starts at 385 ppm and would rise to:

	Low-BAU	High-BAU
2030	428	428
2050	481	493
2100	617	749

CO_2 constraints → combined risk tolerance & temperature change beliefs

β-Value-at-risk (VaR) = smallest loss one would obtain less than (1-β)% of the time



β-Temperature-at-Risk (TaR)
Smallest temperature change one would exceed no more than (1-β)% of the time

Results from Lemoine (2010) allow to re-express CO_2 constraints in terms of TaR, β, tail shape.

550 ppm	435 ppm	390 ppm
(4ºC, 0.90, fatter-tailed)	(4ºC, 0.95, fatter-tailed)	(2ºC, 0.90, fatter-tailed)
(4ºC, 0.99, thinner-tailed)	(2ºC, 0.90, thinner-tailed)	

Results

The goal is to find:

1) Policies that are robust to beliefs about parameters and targets

2) Parameters that are crucial for determining the optimal portfolio

174 unique model runs

Base case	All-cheap	No discounting
Cheap abatement	Limited R&D scope	Perfect ITC
Cheap air capture	Greater R&D scope	Better ITC for both techs
Cheap R&D	Limited R&D control	Better ITC for intensity tech
Cheap intensity R&D	High discounting	No ITC

All combinations of:

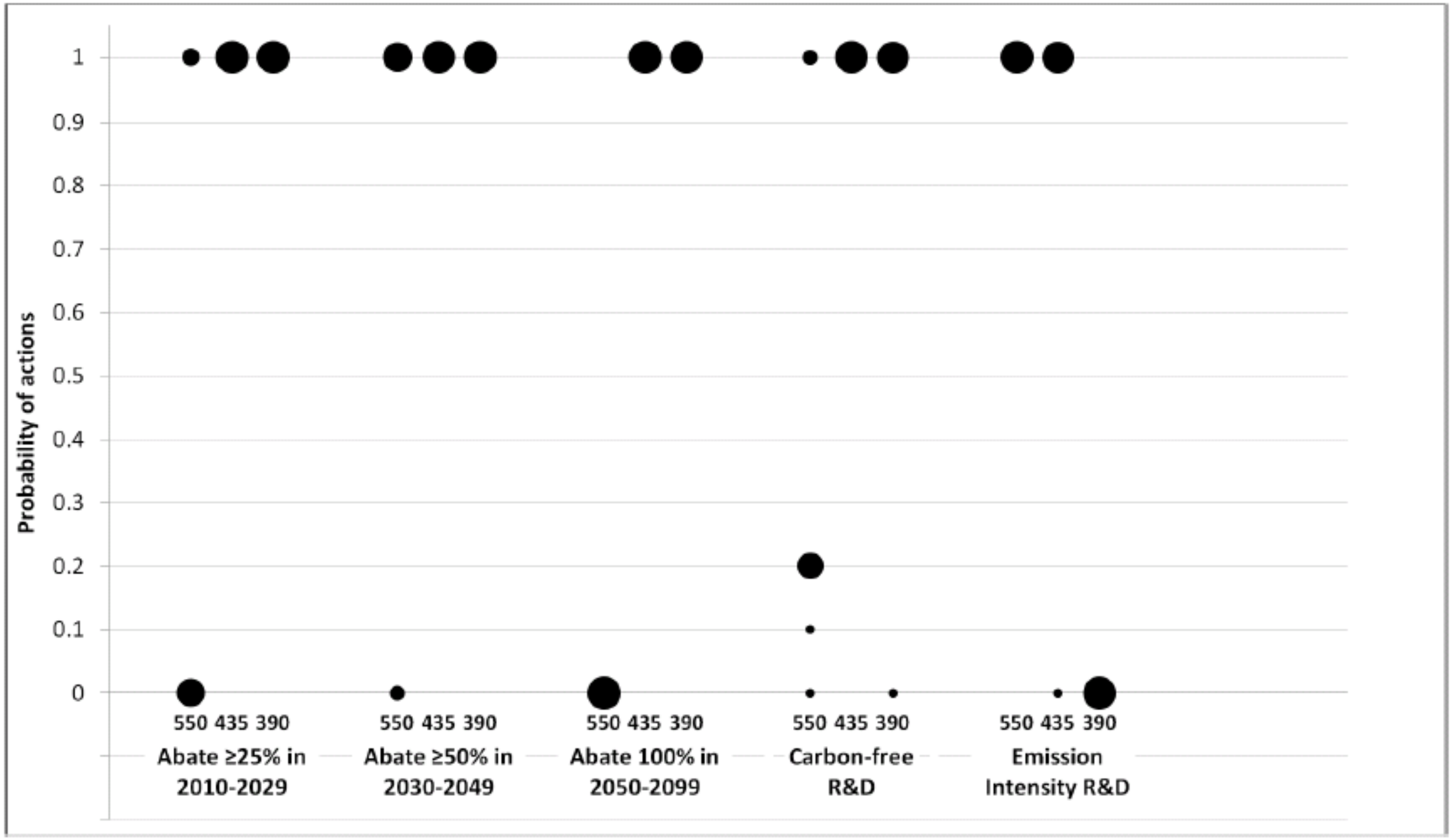
a) 3 CO_2 constraints

b) low- and high-BAU emissions

c) in-/feasible air capture

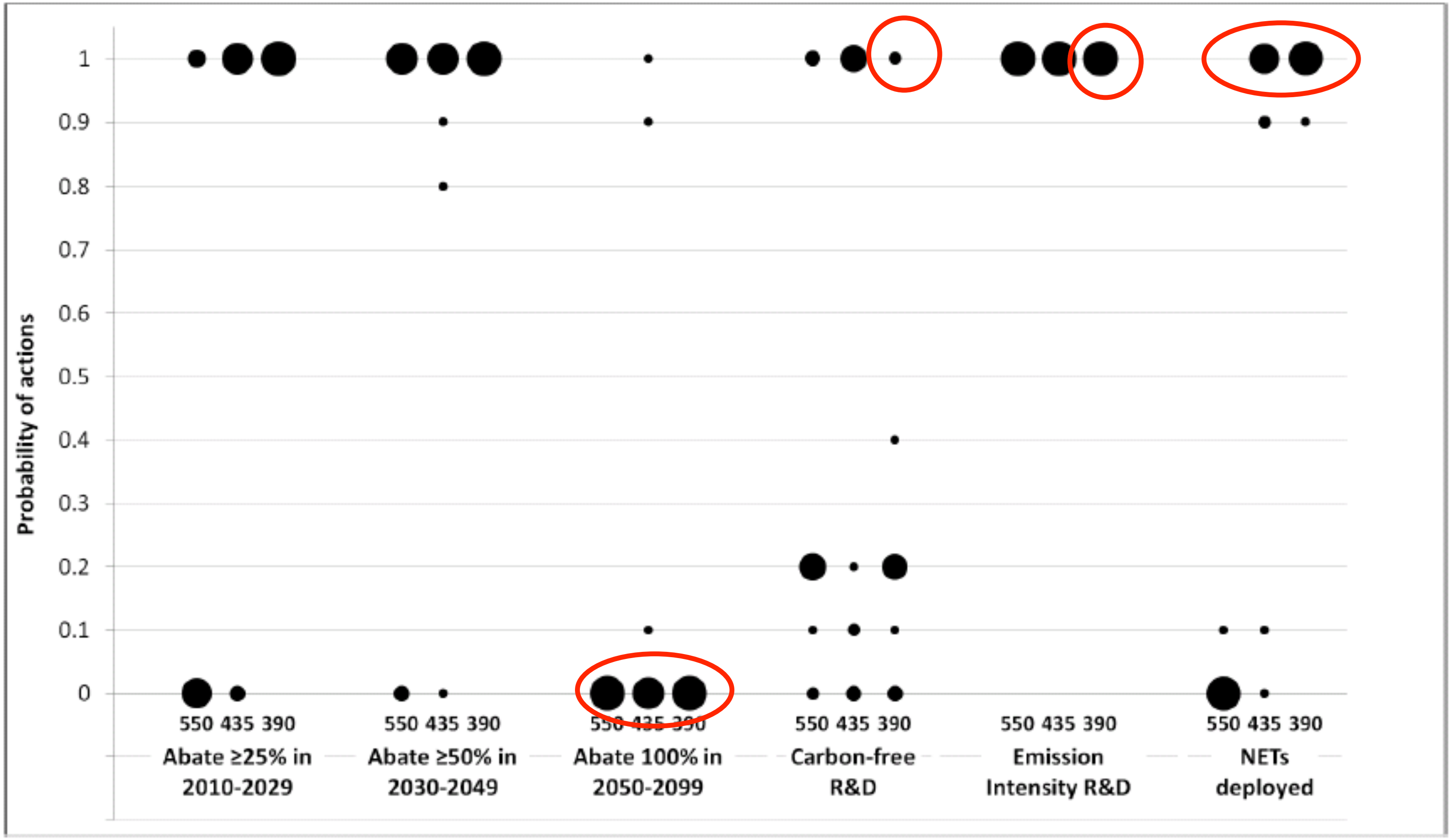
d) 15 scenarios below
   (14 for cases with infeasible air capture)

Probability of doing type of action in each parameterization



(a) NETs unavailable

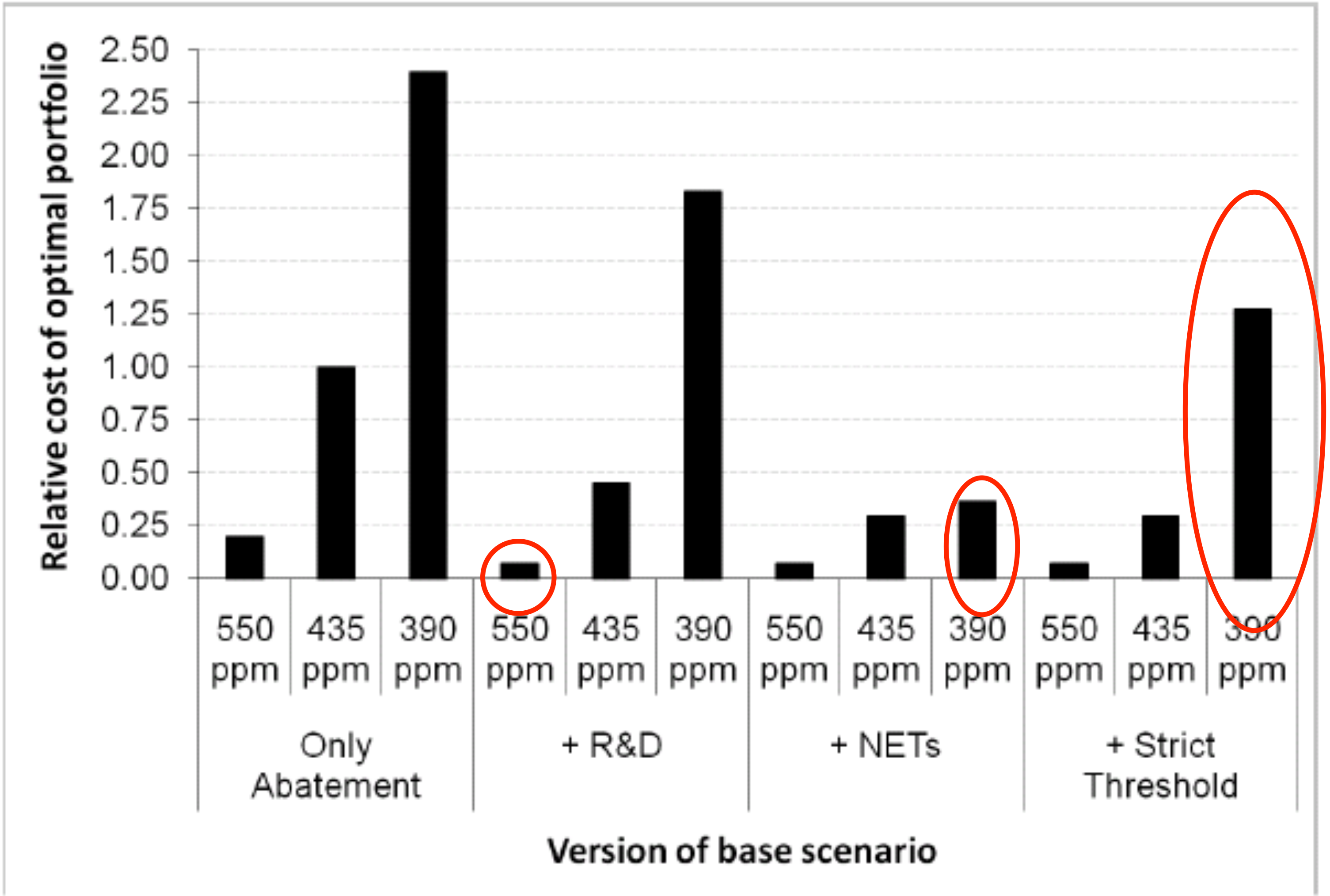
- Big-picture actions are not conditional on technological outcomes, instead being driven mostly by the CO2 constraint.
- Some policy choices are not sensitive to climate targets or to parameters' values.



(b) NETs available

- NETs and emission intensity R&D are complements, substituting for carbon-free R&D and abatement.
- NETs buy more flexibility!

Expected Cost of Optimal Policy Portfolio



Conclusions

- Robustness: cost-minimizing climate policy portfolios emphasize abatement of 50-100% by 2050 in nearly all cases.
- Near-term target of at least 25% abatement by 2030 seems warranted to keep future options open (depends on risk preference).
- Technology options can greatly reduce the portfolio cost.
- Public R&D should focus on carbon-free technologies when NETs are not available and on emission-intensity technologies if NETs are an option.

References

- Lemoine, D.M. 2010. Journal of Climate 23(16): pp. 4395-4415 (doi:10.1175/2010JCLI3503.1)

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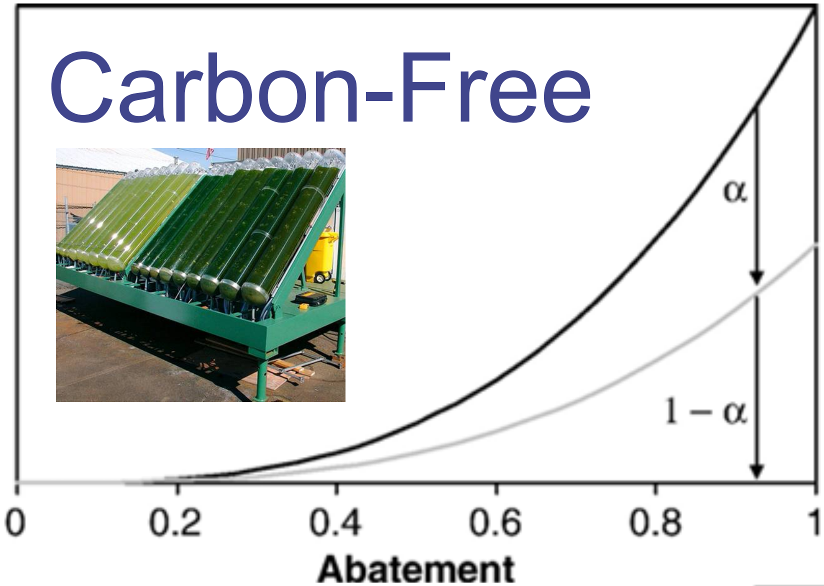
- NitroEurope

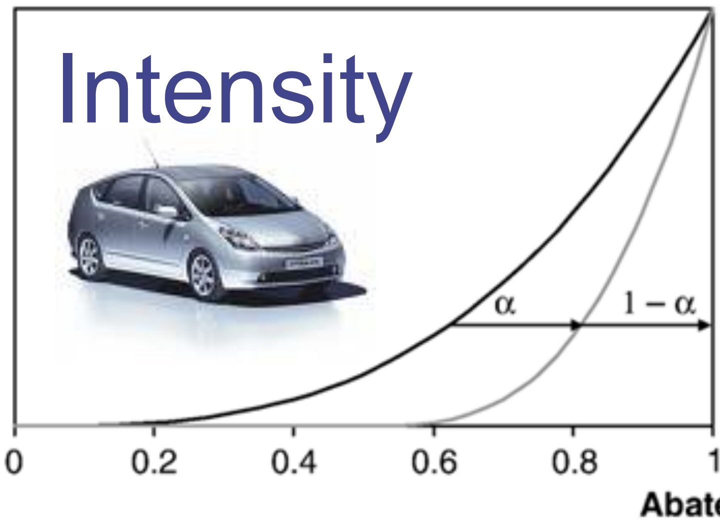
Technical Appendix

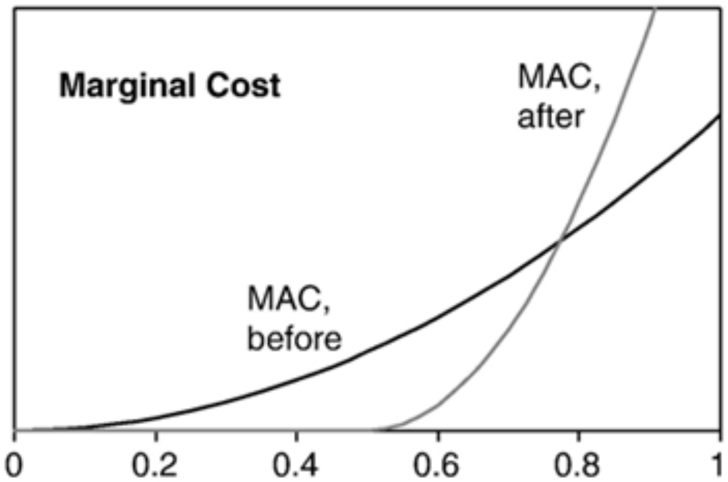
New abatement technology: 2



$$\tilde{c}(\mu,\alpha) = [1-\alpha]c(\mu)$$

$$\tilde{c}(\mu,\gamma) = c\left(\max\left[\frac{\mu-\gamma}{1-\gamma}, 0 \right] \right)$$





Baker and Adu-Bonnah (2008)

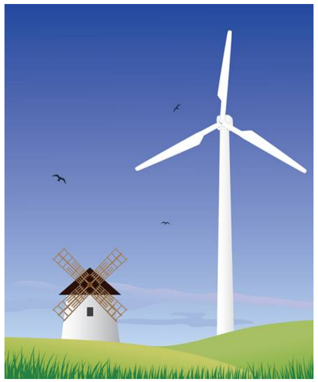
Technological change produced by direct R&D funding & induced technological change (ITC)

Decision variables:

a) % of maximal target aiming for with R&D $

b) abatement level (yielding ITC)

$\bar{\alpha}$



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ITC

Total targeted shift in abatement cost

Parameters enable varying cost of each type of R&D and effectiveness of ITC (proxy for innovation market failure).

Targeted % shift in cost ⇒ probability distribution over technology outcomes

$$\text{Let } x = \min[\overline{\alpha} + ITC, \alpha^H]$$

Tech outcome α_t:	No change (α_{t-1})	Target hit (x)	Maximal success (α^H)
Probability:	$p_\alpha (1-x)$	$1 - p_\alpha$	$p_\alpha x$

p: vary control over/riskiness of each R&D type.