# When Starting with the Most Expensive Option Makes Sense

## Marginal Abatement Cost Curves & optimal abatement pathways

Adrien Vogt-Schilb

Stéphane Hallegatte

Vogt-Schilb, A., Hallegatte, S., 2011. When starting with the most expensive option makes sense: Use and misuse of marginal abatement cost curves. *World Bank Policy Research Working Paper* 5803
http://go.worldbank.org/FH1N0AUJT0

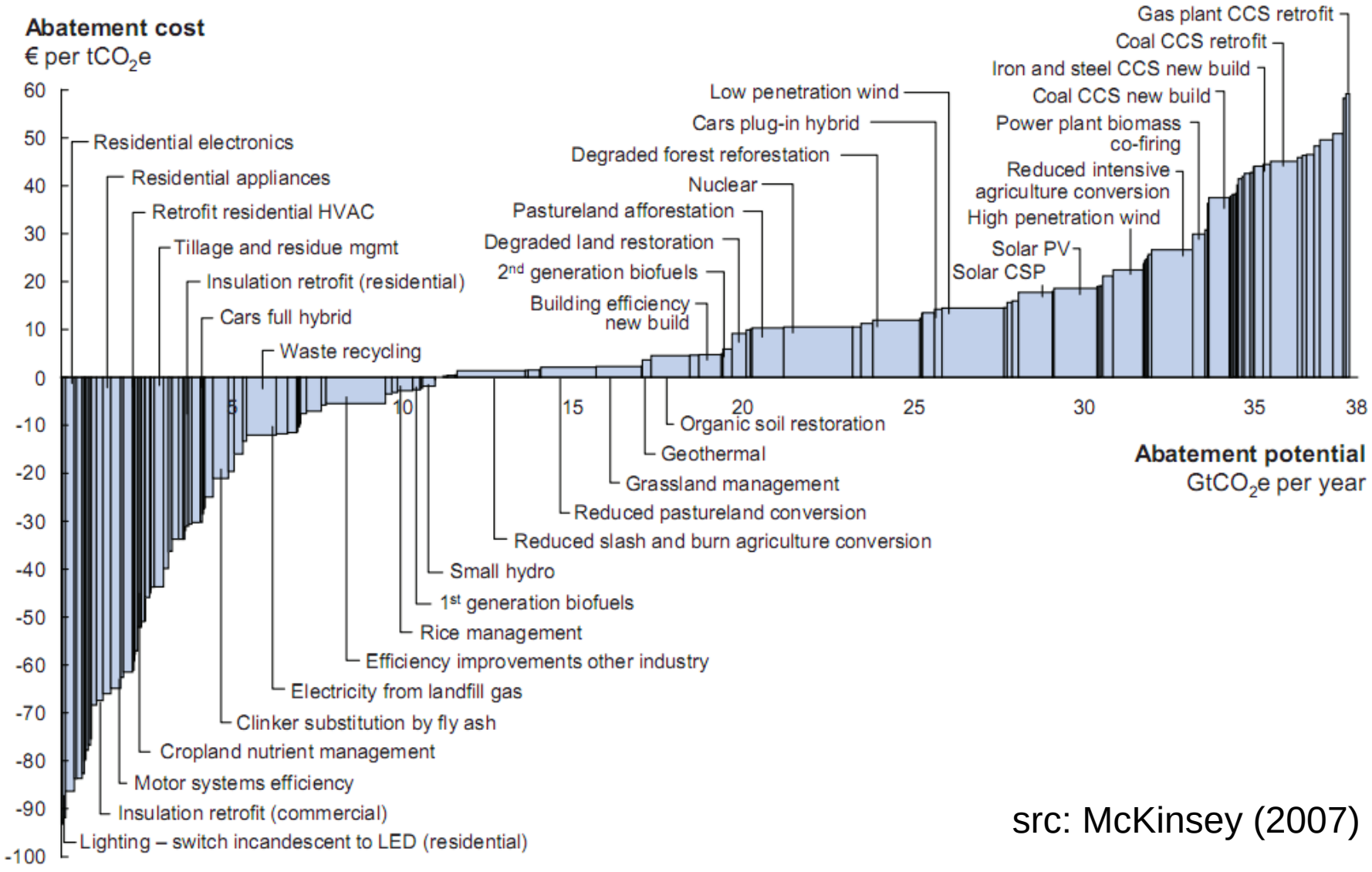
FAEE 16 December 2012

# This work starts from two questions

1. A lot of mitigation activities are available. In which order should they be implemented?

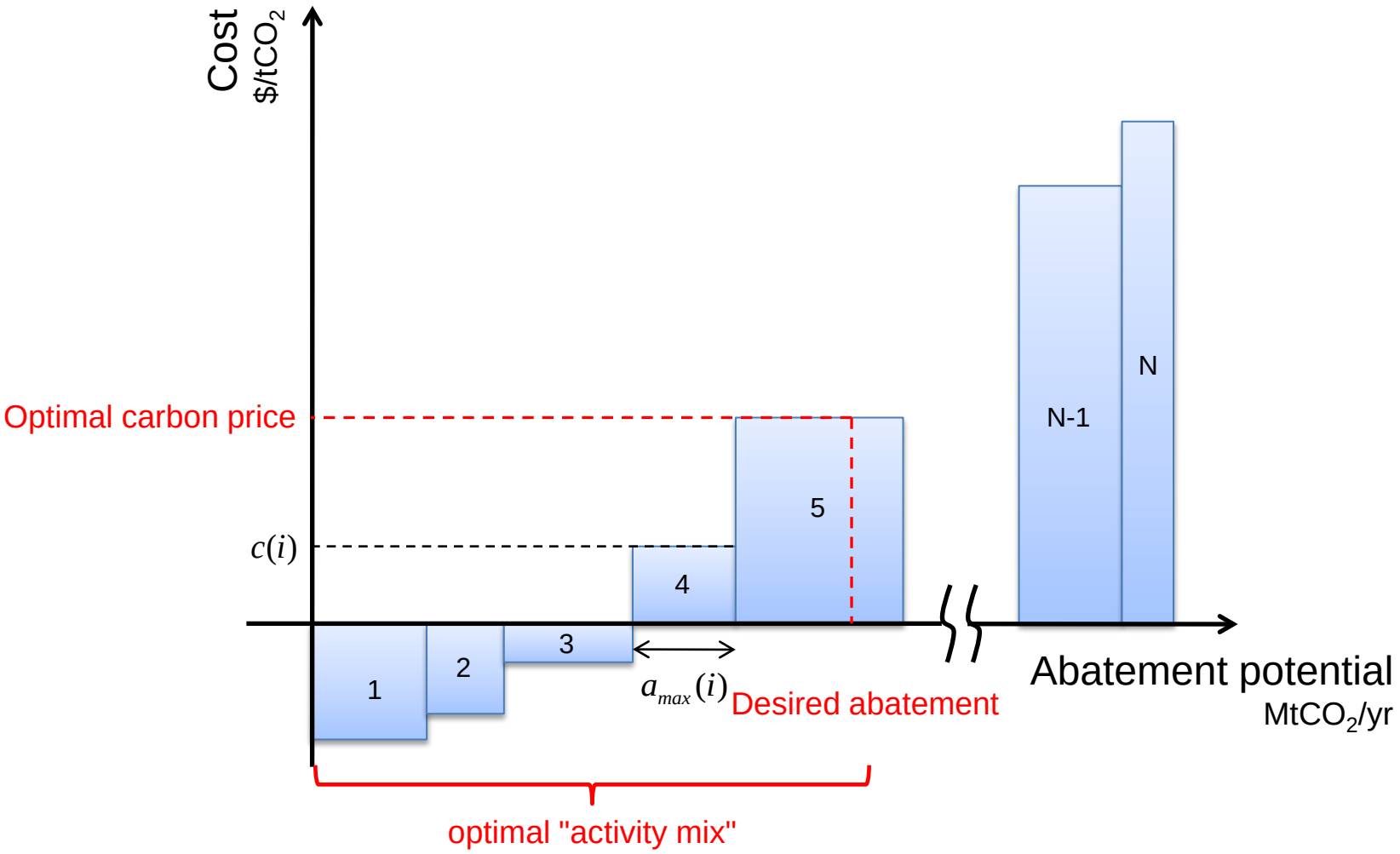
2. How can we use the information from a Marginal Abatement Cost (MAC) curve (on costs and potentials of each activity) in order to decide this?

# MACCs present information on abatement costs and potentials for a set of mitigation activities

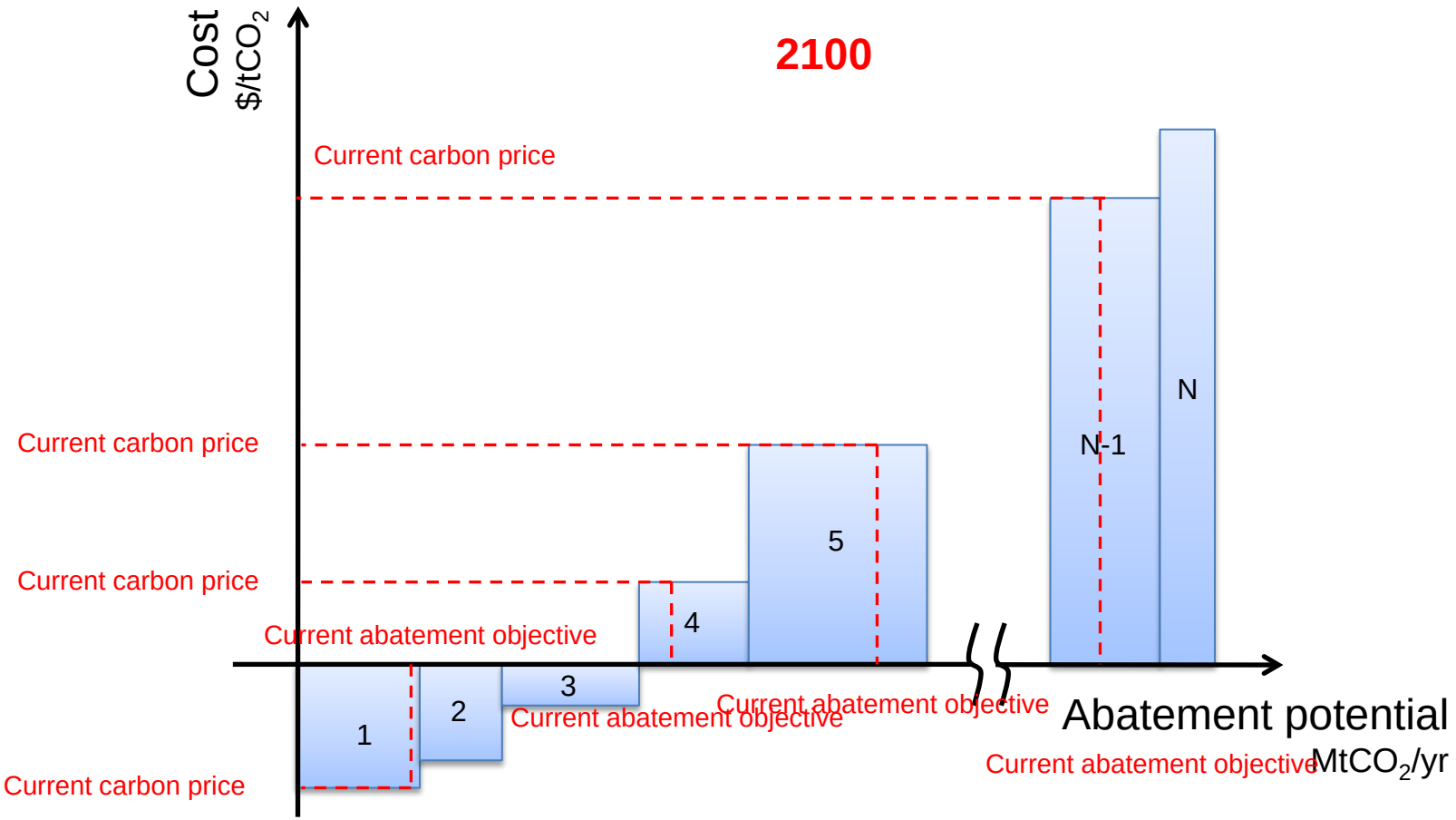



src: McKinsey (2007)

# Interpreting MACCs as *merit-order* curves …



# … imply that expensive options should not be implemented in the short term




(The MACC could also evolve through time (e.g. learning by doing))

# Our main results

1. MACCs are not abatement supply curves : listed activities may take decades to implement (eg: building retrofitting, switching from fuel to electricity in the cars sector)

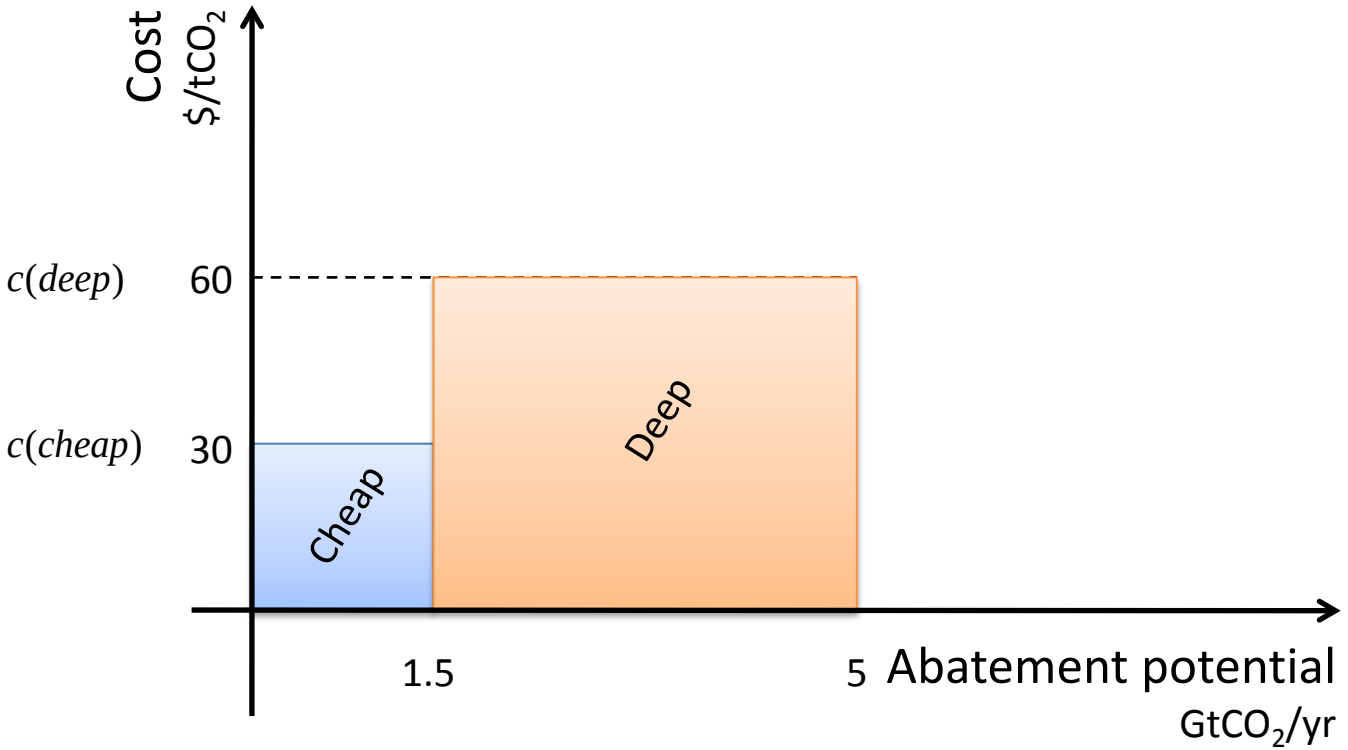
2. MACCs already provide critical information on costs and abating potential. This can be completed with information on implementation speed of each measure.

3. Exclusive use of cheap options to reach the short-term targets would lock the economy in a carbon-intensive pathway

4. Abating through expensive but high-inertia options in the short term may be optimal even if cheaper options exist

# The model

# Our model uses a MACC with two activities,…



# … and we add a third dimension, the *cost in time*

| | Abatement cost $c$ ( \$/tCO$_2$) | Abatement potential $a_{max}$ ( MtCO$_2$/yr) |
|---|---|---|
| Cheap | 30 | 1 500 |
| Deep | 60 | 3 500 |

**Table 1:** Numerical assumptions

1. Abatement is done through abatement investment at a constant unitary cost

$$I(i,t) = a(i,t) \cdot c(i)$$

2. The social planer will chose abatement options in order to minimize total discounted cost

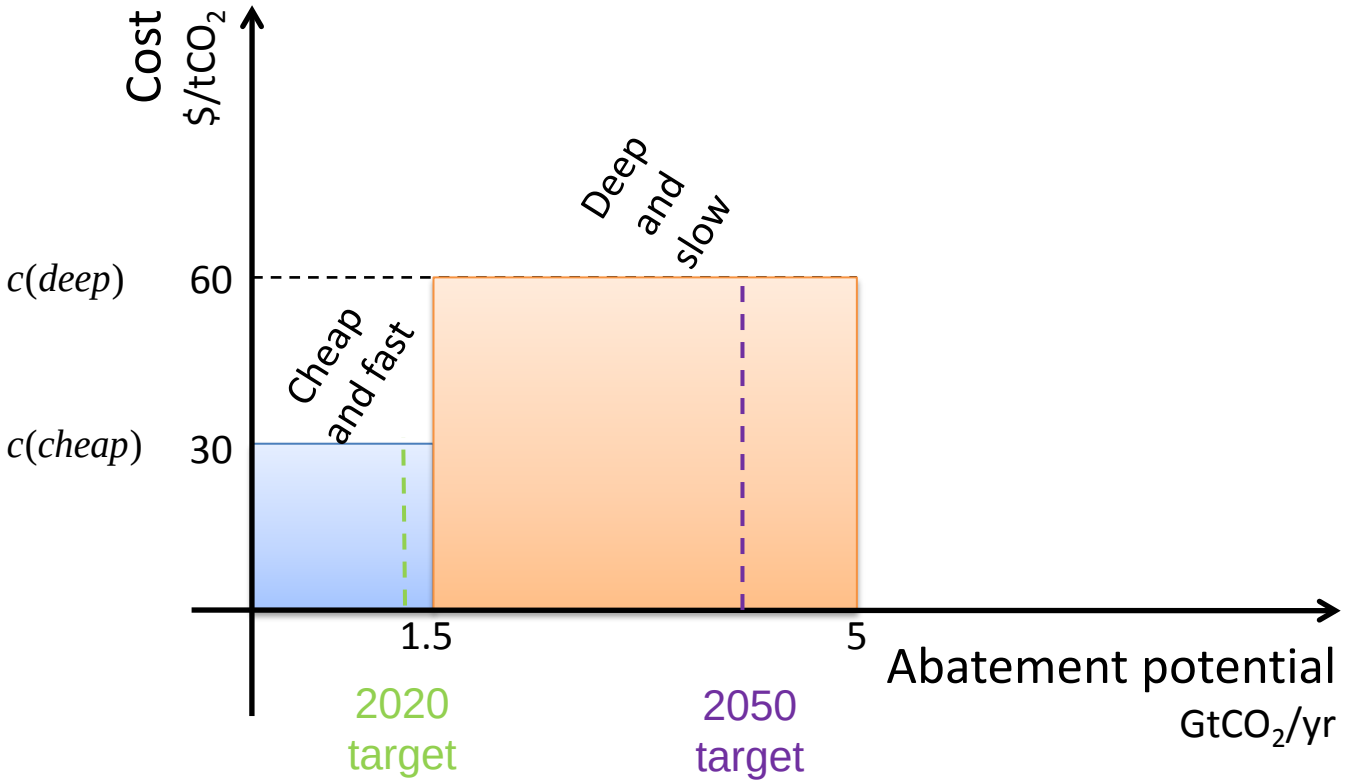
$$C = \sum_{t=0}^{T} \sum_{i=1}^{N} \frac{I(i,t)}{(1+\rho)^t}$$

T = 2050 temporal horizon
N =2 number or activities

3. The implementation pace of each activity is constrained by exogenous upper bound α

$$a(i,t+1) \leq a(i,t) + \alpha(i)$$
$$a(i,t) \leq a_{max}(i)$$

# We constrain the model with emission targets on the future



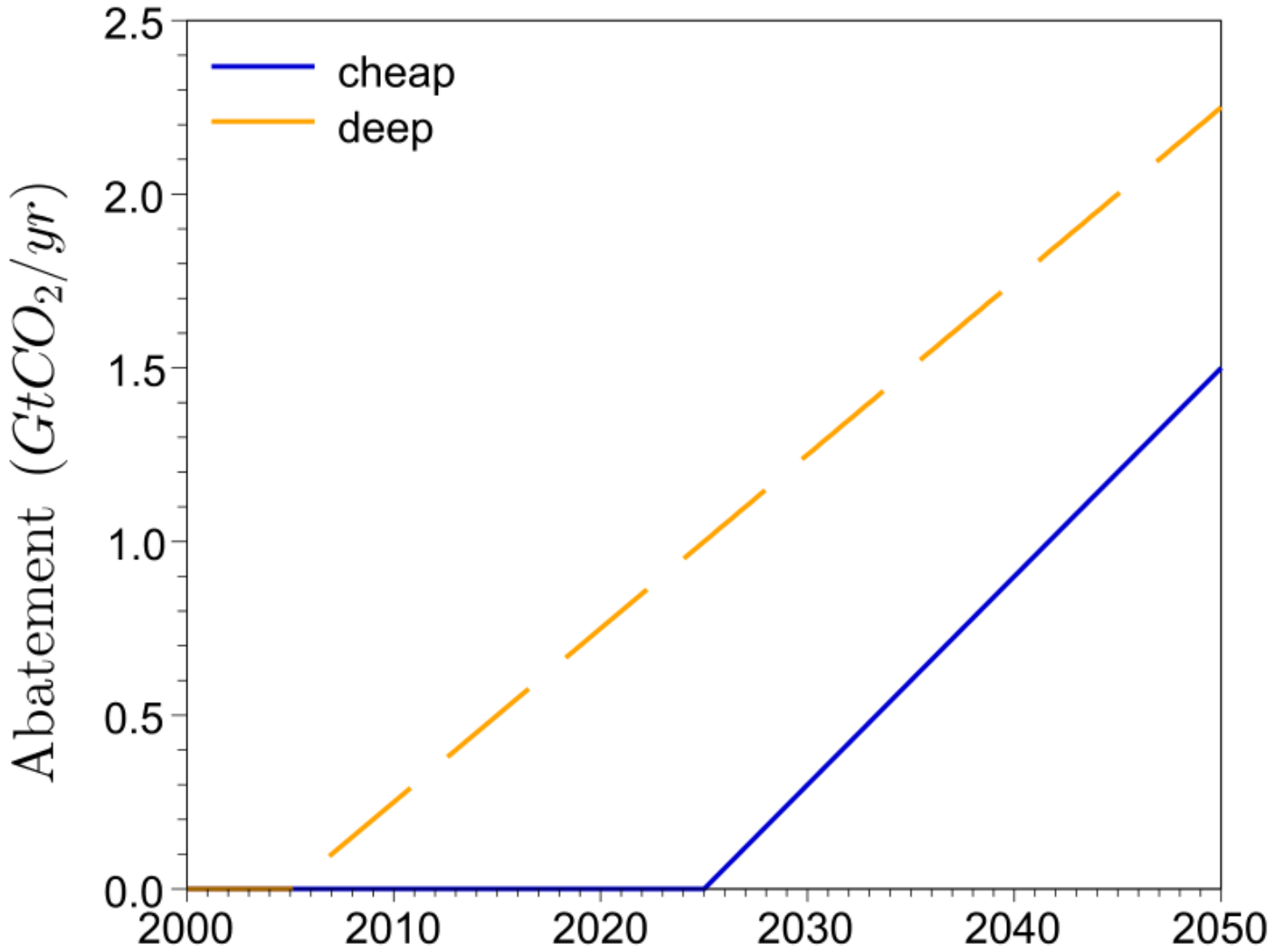

Should we comply to the 2020 target using only the cheap option?
Should we start by implementing cheap and use deep only after ?



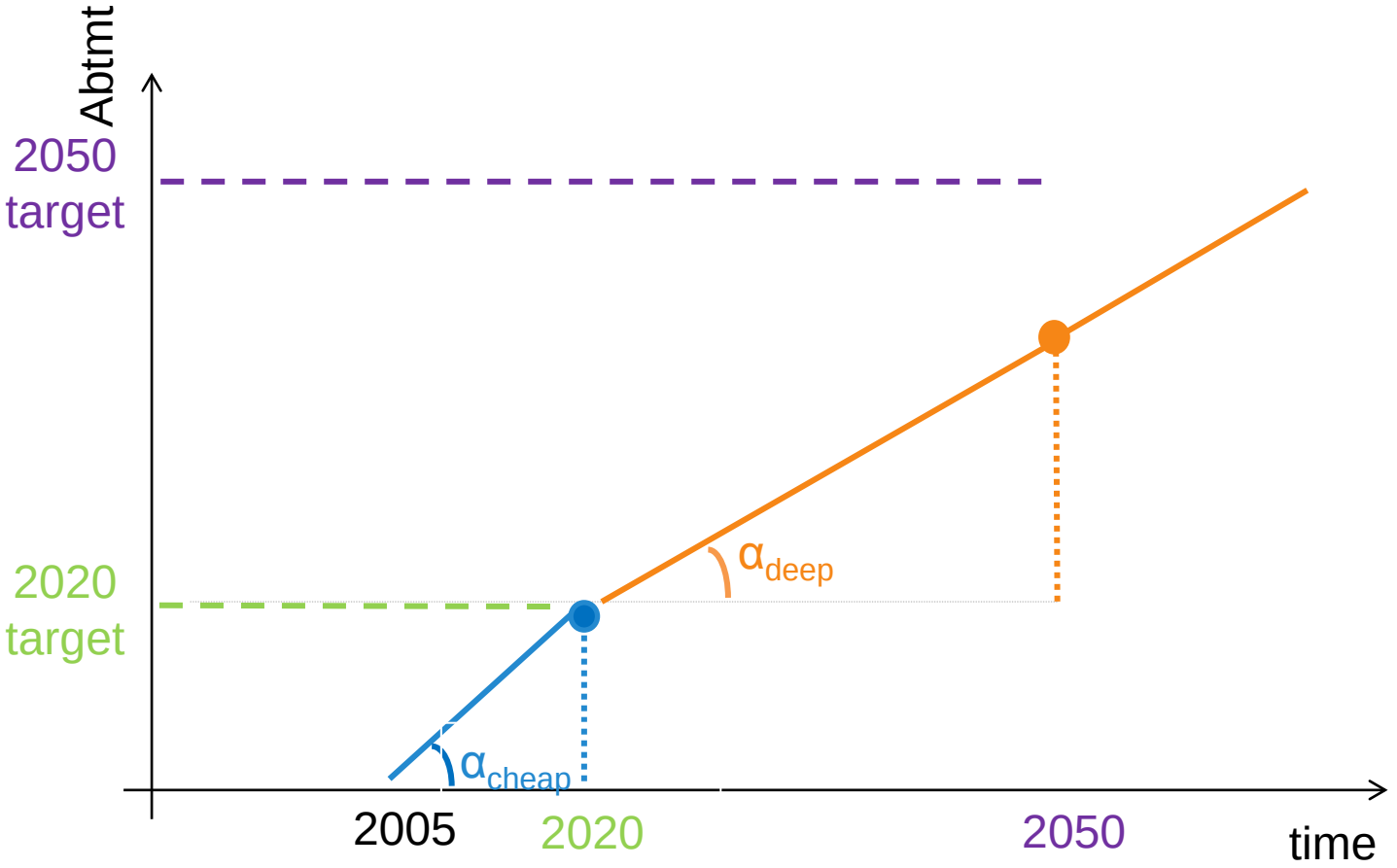
(A: We should not)

# Results

# The optimal strategy to achieve the 2050 target starts with the most expensive option !

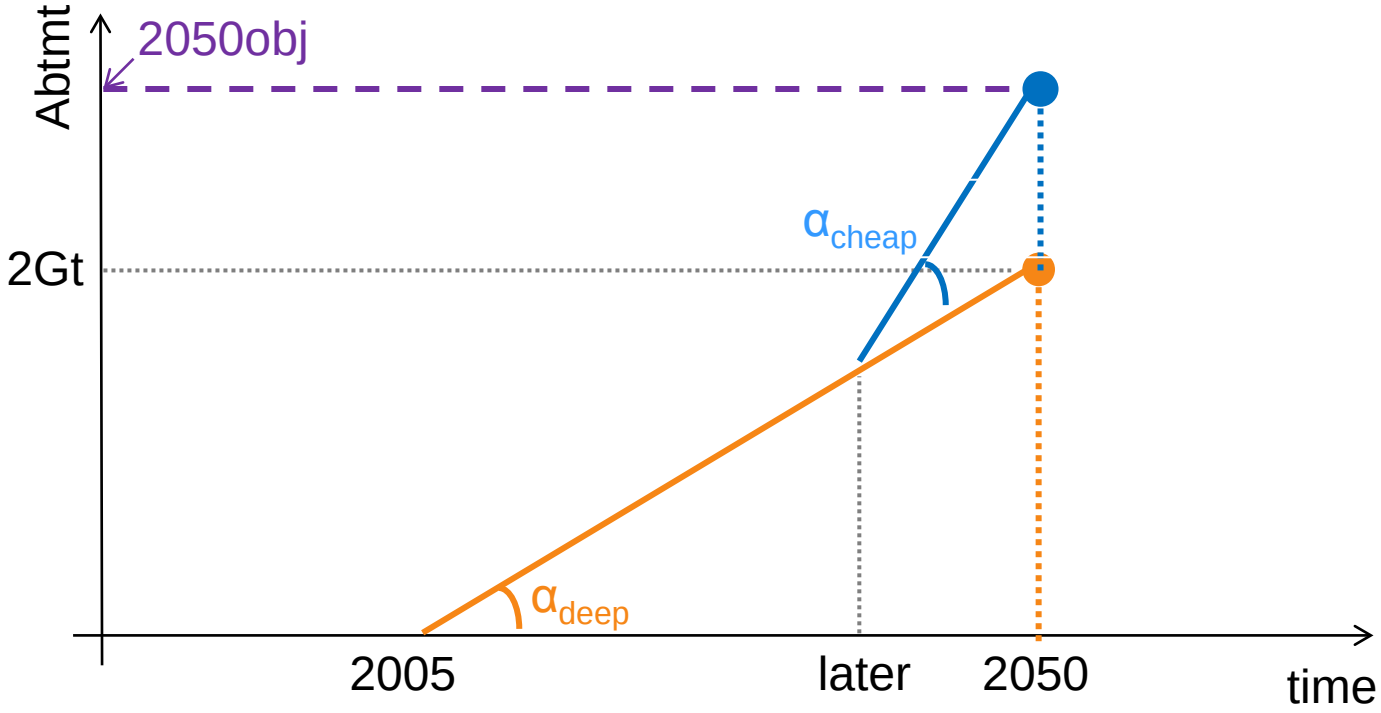


# Reaching a shorter-term target using just cheap options may cause carbon-intensive lock-in



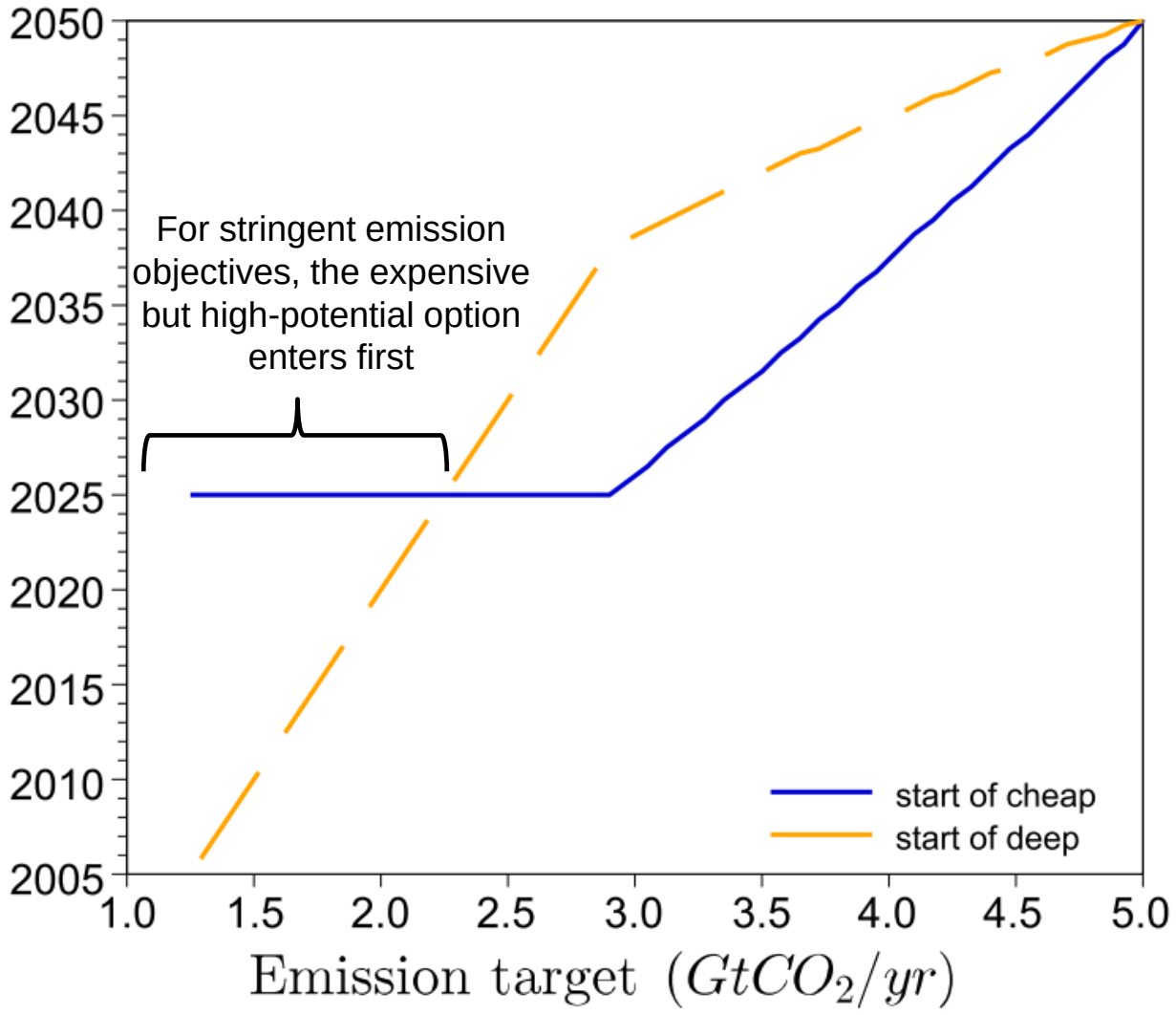

1. The 2020 target is reachable by implementing only the cheap option.
2. In 2020, attention goes to the 2050 target. Economic agents implement deep at the maximum speed
3. The 2050 target is not reachable at time…
4. …even if deep still has mitigation potential

# When there is inertia, starting with the most expensive option makes sense…

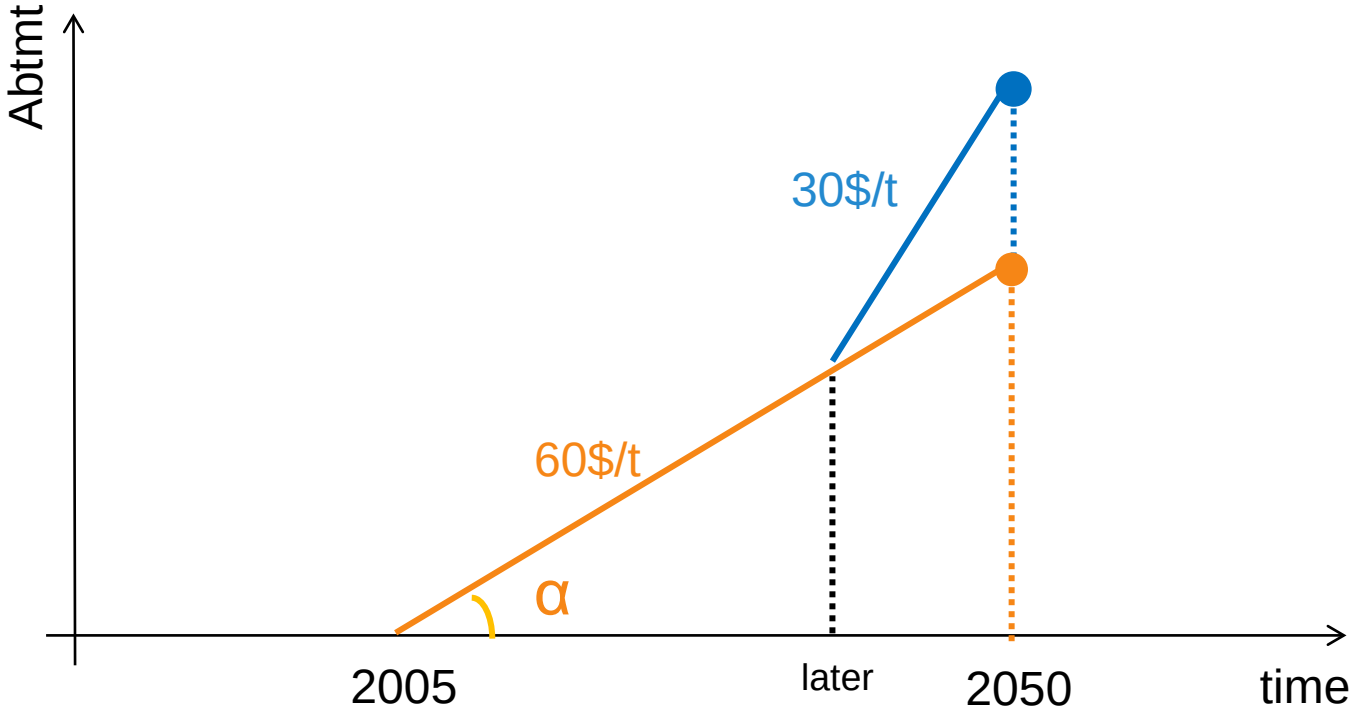



1. Assume that one knows that the optimal abatement from expensive solar power in 2050 should be 2Gt
2. Installing that much solar power takes time (this point does *not* take LBD into account, doing so would exacerbate our message, see del Rio Gonzalez 2008)
3. We should start to implement solar plants now
4. Cheaper but faster-to-implement options required in 2050 may enter later

# …as the optimal short term strategy depends strongly on the long term objective



# Sectoral or technological policies may complement efficiently the carbon price




- In this case, what is the good carbon price?
- Instead of  setting an expensive carbon price in every sector, abatement through expensive and inertial options (e.g. urban planning and infrastructure) may be achieved with targeted policies
- In the electric sector for instance, feed-in tarrifs for renewable electricity and the EU-ETS for switching from coal to gas

# Our main results

1. MACCs are not merit-order curves, options have a cost, an abating potential, and an implementation speed.
2. Abating through expensive but high-inertia options in the short term may be optimal even if cheaper options exist
3. Reaching short-term targets with cheap options only is not optimal, and may lock the economy in a carbon-intensive pathway
4. May sectoral policies be part of a an efficient abatement policy?
5. Different marginal abatement costs across sectors is not necessarily a bad thing.

# Thank you for your attention

**References**

•IEA, 2011. World Energy Outlook, Paris, France: IEA/OECD.

•del Rio Gonzalez, P., 2008. Policy implications of potential conflicts between short-term and long-term efficiency in CO2 emissions abatement. Ecological Economics.

•Kesicki, F. & Ekins, P., 2012. Marginal abatement cost curves: a call for caution. Climate Policy

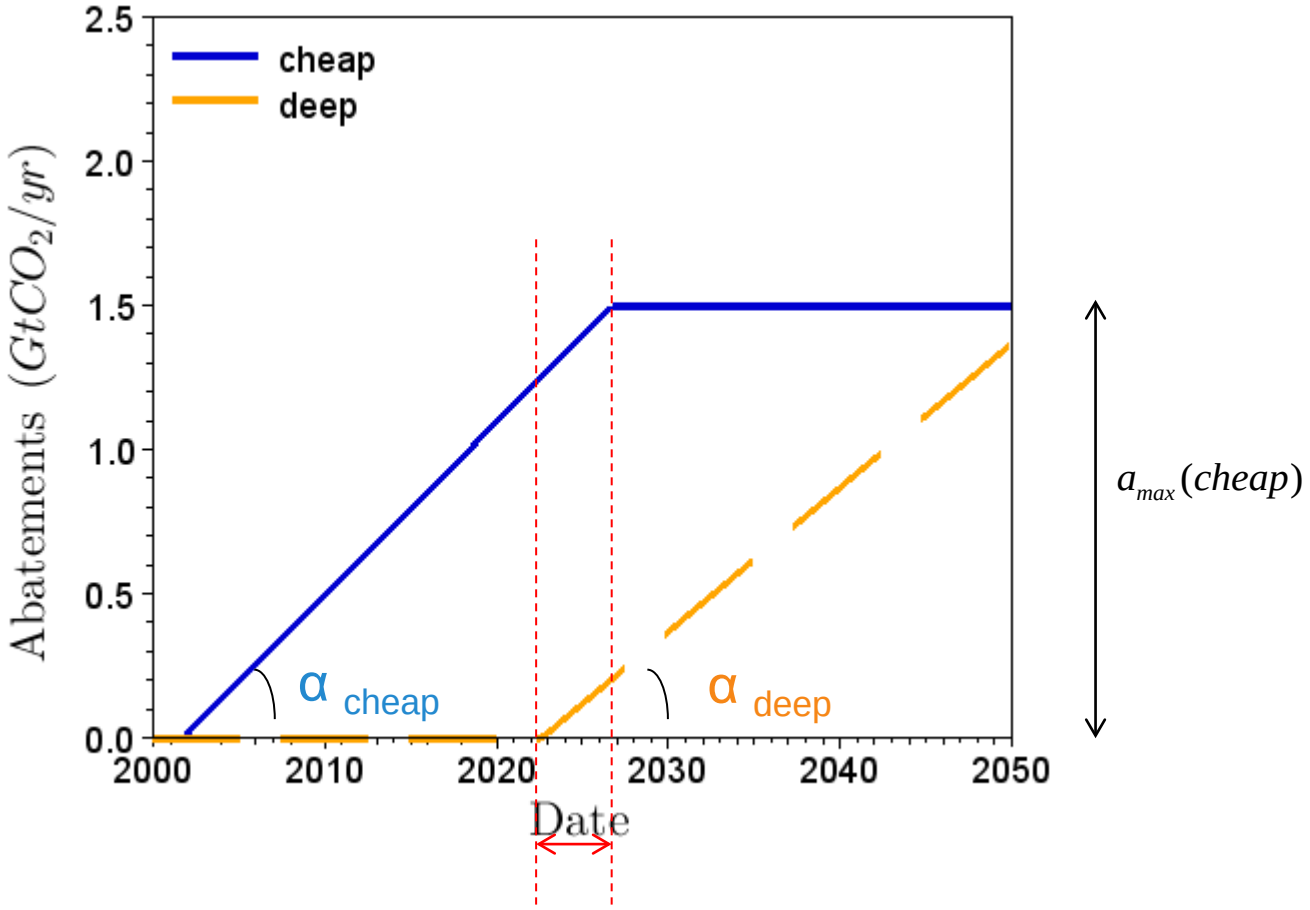
•McKinsey and Company, 2007. Reducing US Greenhouse Gas Emissions: How Much at What Cost? Tech. Report.

**This work:**

• Vogt-Schilb, Adrien and Stéphane Hallegatte. *When Starting with the Most Expensive Option Makes Sense : Use and Misuse of Marginal Abatement Cost Curves*. World Bank Policy Research Working Paper 5803. Washington DC

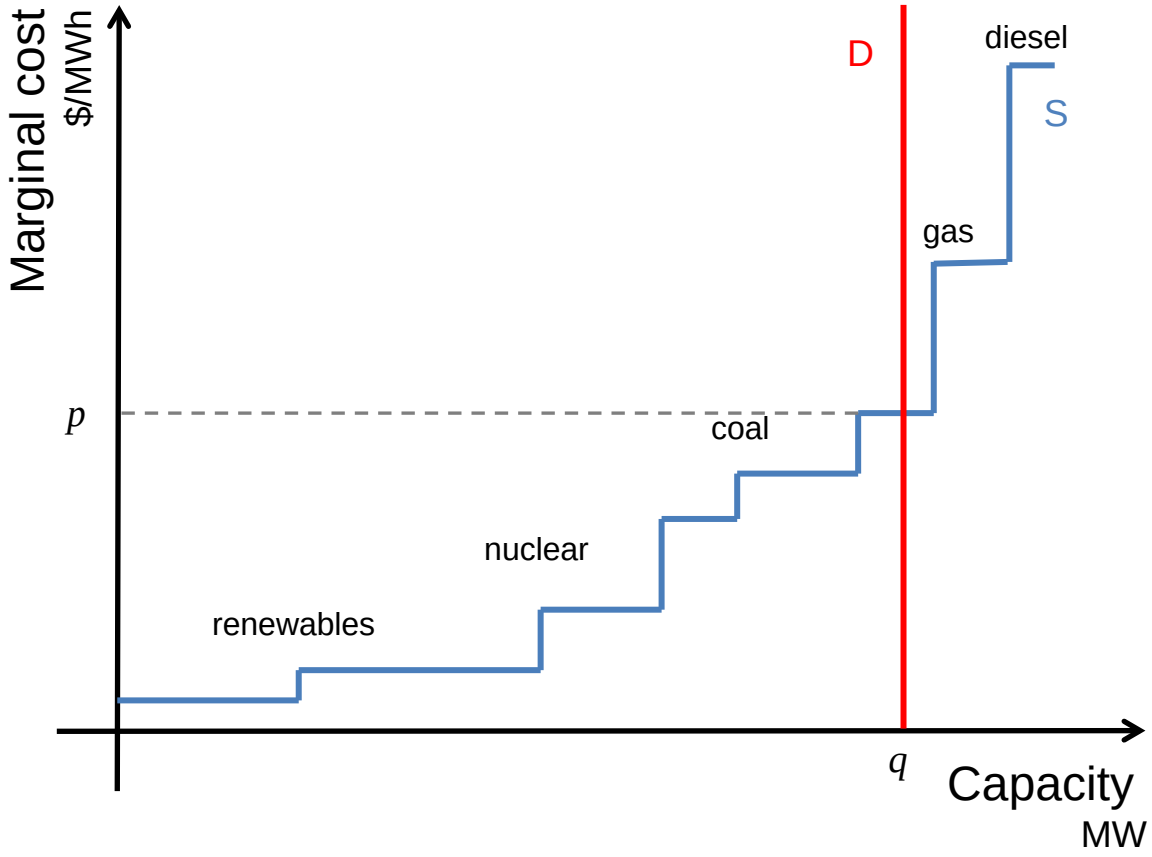
•*Newer version on request :* *vogt@centre-cired.fr*

# Implementing expensive options before the whole potential of cheaper activities has been exploited




This is the optimal strategy to cope with a given carbon budget
(or in other words to achieve a given cumulative abatement, which is represented by the sum of the areas under the curves)

# Merit-order curves may be used as supply curves only when they represent options that are available instantaneously




The question here is how to use the immediately available plants to satisfy the demand for the next *minutes, not* to choose investments for the next *decade*

# … and we add a third dimension, the *cost in time*

| | Abatement cost $c$ ( \$/tCO$_2$) | Abatement potential $a_{max}$ ( MtCO$_2$/yr) |
|---|---|---|
| Cheap | 30 | 1 500 |
| Deep | 60 | 3 500 |

**Table 1:** Numerical assumptions

1. Abatement is done through abatement investment at a constant unitary cost

$$I(i,t) = a(i,t) \cdot c(i)$$

2. The social planer will chose abatement options in order to minimize total discounted cost

$$C = \sum_{t=0}^{T} \sum_{i=1}^{N} \frac{I(i,t)}{(1+\rho)^t}$$

T = 2050 temporal horizon
N =2 number or activities

3. The implementation pace of each activity is constrained by exogenous upper bound α

$$a(i,t+1) \leq a(i,t) + \alpha(i)$$
$$a(i,t) \leq a_{max}(i)$$

# … and we add a third dimension, the *cost in time*

| | Abatement cost $c$ ( \$/tCO$_2$) | Abatement potential $a_{max}$ ( MtCO$_2$/yr) |
|---|---|---|
| Cheap | 30 | 1 500 |
| Deep | 60 | 3 500 |

**Table 1:** Numerical assumptions

1. Abatement is done through abatement investment at a constant unitary cost

$$I(i,t) = a(i,t) \cdot c(i)$$

2. The social planer will chose abatement options in order to minimize total discounted cost

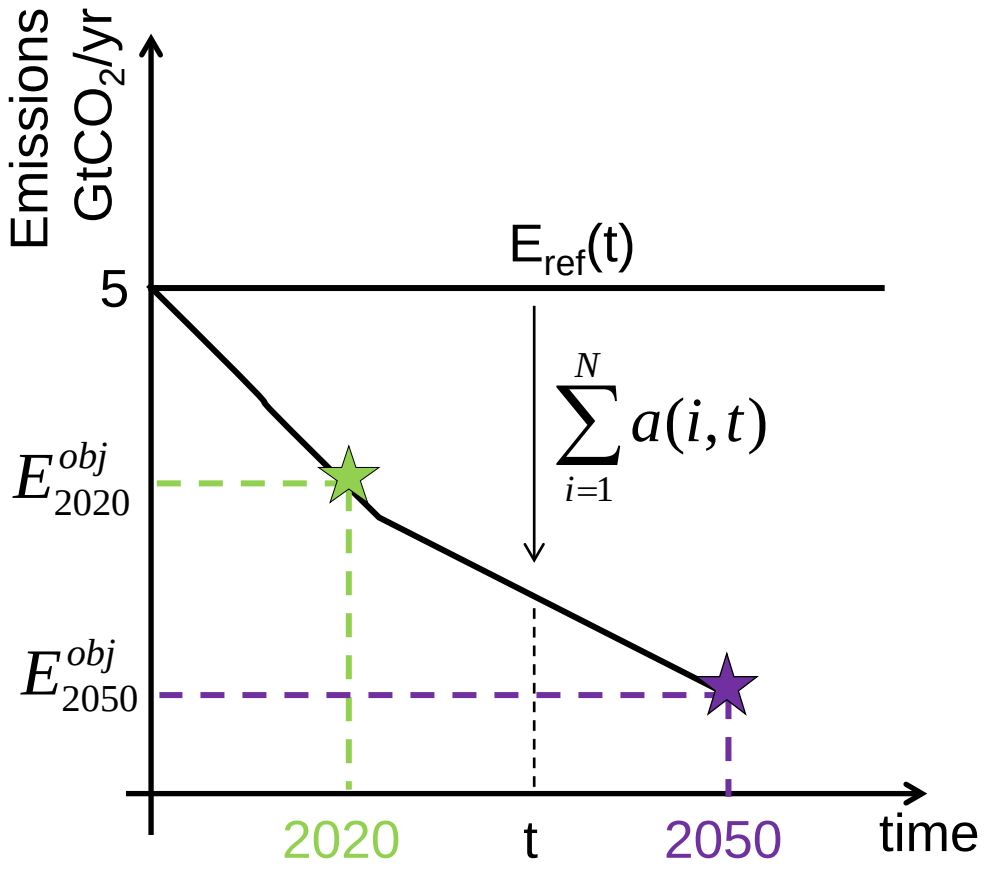
$$C = \sum_{t=0}^{T} \sum_{i=1}^{N} \frac{I(i,t)}{(1+\rho)^t}$$

T = 2050 temporal horizon
N =2 number or activities

3. The implementation pace of each activity is constrained by exogenous upper bound α

$$a(i,t+1) \leq a(i,t) + \alpha(i)$$
$$a(i,t) \leq a_{max}(i)$$

# We constrain the model with emission targets on the future




1. Baseline emissions are constant (to 5Gt/yr)
2. We set a long term emission target
3. Because of α, emissions will decrease smoothly
4. Later, we add an intermediate target