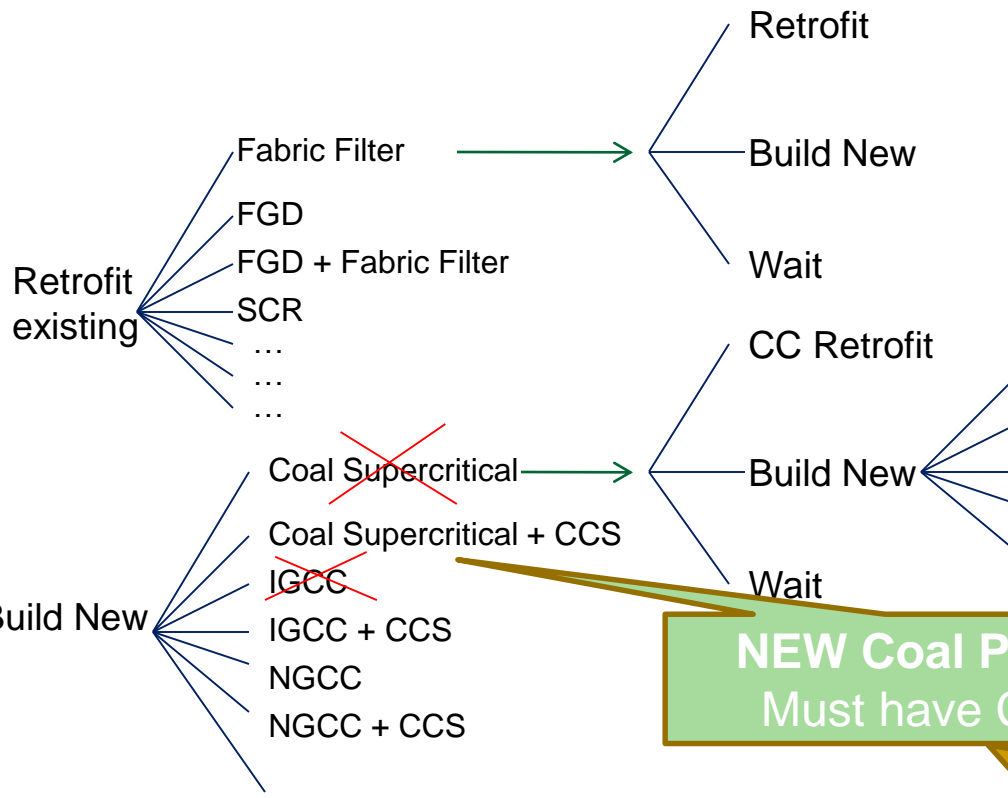


# Alternative Compliance Payments for coal-fired power plants: The value of waiting to invest

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**NEW Coal Plants**  
Must have CCS

***A policy with ACP can result in lower emissions, and lower costs: Patino-Echeverri, Burtraw & Palmer (JRE 2013)***

~~Wait – buy allowances~~

Decision in 2016

Decision in 2017

**EXISTING Plants must retrofit or be replaced**

What is the value of keeping alive the option to wait ?

# The value of allowing some plants to wait

- Is it possible that in the near future (3-5 years) there will be

1. better retrofit technologies?
2. better replacement plants?
3. more information about coal/gas prices to facilitate the choice of fuel?
4. Good arguments to limit natural-gas use?

If the answer to any of these is yes

then

**A policy that** allows some plants **to wait** in their decision of retrofitting or replacing may be superior than an inflexible technology policy

Two years ago I showed the conditions under which a flex policy with ACP would be superior (lower emissions)

# The value of waiting to invest

1. Retrofit one coal plant with CCS (90% capture)

Uncertainty on the relative cost of coal vs gas also increases the value of waiting

2. Replace 2 plants with NGCC

The benefit of waiting **increases** with higher  $\pi$

path-breaking tech is successful

Heat rate is reduced 20% for coal plants and 5.6% for NGCC plants

3. Pay ACP and wait



$1 - \pi$

path-breaking tech is not yet successful

Three coal plants: How to reduce emissions by 30%?

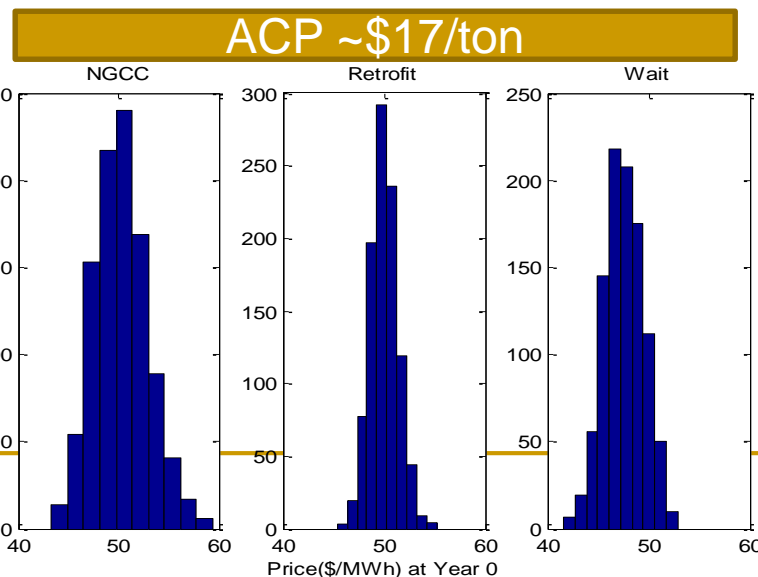
The benefit of waiting **decreases** with ACP value

We assume deadline is 3 years

Can choose 1, 2 or 3 depending on deadline of ACP policy

# We solve this decision problem for different ACP values and under the following assumptions (with Fei Xu)

- Coal prices follow geometric-Brownian motion
- Natural gas prices are equal to coal prices multiplied by a “ratio” which is also a r.v. following a Ornstein & Uhlenbeck process
- Technological change: Time for improvement in heat rate follows an exponential distribution



Retrofit has higher expected value but lower risk

Waiting seems to be better

# Effect of ACP value

- **If fees are very high:**
  - All investment will happen in the first period
    - even if it is very likely that a new breakthrough technology will be developed in the future
- **If fees are very low:**
  - All investment will happen at the end of the 3 years
  - even if seeing a breakthrough in technology is unlikely... its worth paying a small fee to keep the option to benefit from a remote possibility and know more about fuel prices

How to set an ACP that is just right?

# Define two metrics to bound possible values of fees

- **1% Upper Threshold Value Fee (1% UTVF):**

The maximum option fee to make 1% or less of the simulations result in investment occurring at the beginning of year 1.

“Maximum fee so that under almost any fuel price scenario people wait beyond the first year”

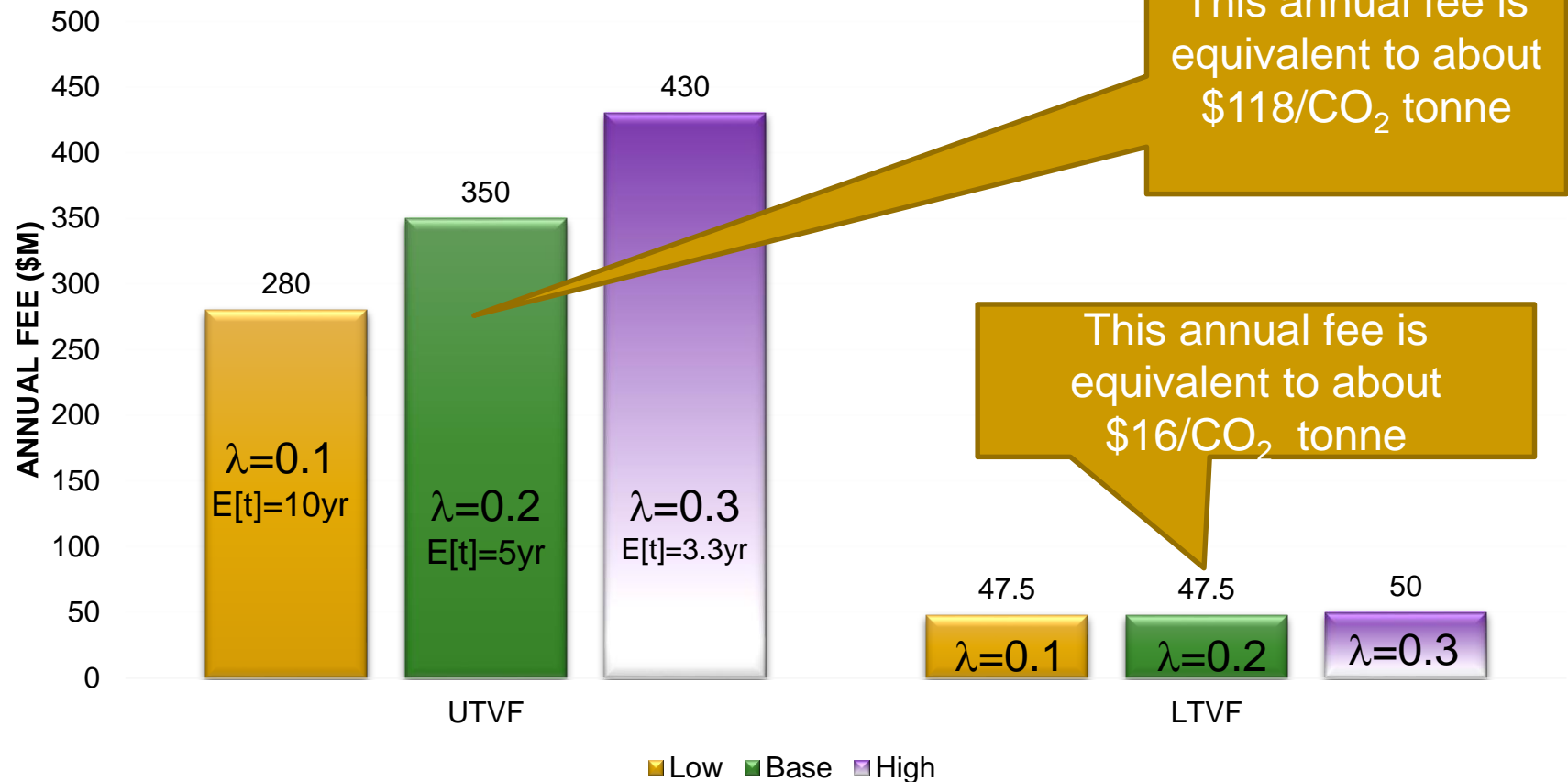
- **1% Lower Threshold Value Fee (1% LTVF):**

The minimum fee to make 1% or less of the simulations result in investment occurring at the end of year 3.

“Minimum fee so that almost no fuel price scenario makes people wait until the end of the third year”

# UTVF and LTVF under expectations of Technological Change

**Total paid as ACP in a year**





# Concluding remarks

Flexible technology policy for both new and existing paths can be designed to exceed the economic and environmental protection outcomes of inflexible traditional technology policy

Analytical and numerical estimates of bounds for ACP converge when looking at individual investors

More analysis is needed to estimate the power system's benefits of this policy accounting for contributions to resource adequacy and operational reliability

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# Thank you!

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