FONDAZIONE ENI ENRICO MATTEI

INVESTMENTS AND FINANCIAL FLOWS INDUCED BY CLIMATE MITIGATION POLICIES

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Milan, 21 January 2010

Introduction & Motivations

Studies on optimal mitigation strategies usually deal with overall macroeconomic costs.

We focus on investments and pure financial flows needed to support the required low-carbon transformations of the economies (i.e. only mitigation, no adaptation).

- Implications of mitigation policies in terms of investments are often overlooked.
- Some studies (e.g. IEA, 2008, p. 487; Russ *et al*, 2009; EC, SEC(2009) 1172, p. 4) mix the two concepts: investments are often referred to as costs of the climate policy.

..but, costs and investments inform on two very different aspects of climate policy and should not be confused.

Introduction & Motivations

- Investments: expenditures to increase productive capital that imply a financial transfer from one agent to another.
  - If investments are re-distributed among capital assets that have the same productivity (i.e. that yield the same output per unit of investment), the level of macroeconomic activity is not affected.

- Pure financial flows: transfers that do not result in productive capital investments (e.g. transactions on the carbon markets, revenues from carbon taxes).

- Macroeconomic costs: (e.g. a lower level of output) arise only when investments are redistributed from more productive uses to less productive uses.

Introduction & Motivations

We focus on mitigation policy, no adaptation:

1. Financial requirements to transform the power sector and to scale-up R&D activities in the energy sector.
2. Size of the financial flows associated to carbon pricing and the implications of climate policy on the international crude oil market.

Evaluation of results:

- Comparison with previous literature is difficult: heterogeneous assumptions (e.g. time horizon, policy targets…) & different modelling framework.
- Consider past investments in large infrastructures to put figures in perspective.

Table 1: Summary of models

ID	Model	Horizon	Policy Target	Endogenous demand	Reference
UNFCCC	ENV-LINKAGE/OECD	2100	550 ppm CO2 eq	no	UNFCCC (2007)
RECIPE	IMACLIM-R/REMIND-R/WITCH	2100	500-550 ppm CO2 eq†	yes	Edenhofer et al. (2009)
IEA	World Energy Model	2030	450 ppm CO2 eq 550 ppm CO2 eq	no	IEA (2008)
IPTS-JCR	GEM3/POLES	2050	Multiple‡	yes	Russ et al. (2009)
McKinsey	Global GHG Abatement Cost Curve v2.0*	2030	480 ppm CO2 eq	no	McKinsey (2009)
WITCH	WITCH	2100	550 ppm CO2-eq	yes	

Notes:

(*) The Global GHG Abatement Cost Curve v2.0 is not a model, but rather a measure of technical opportunities to reduce emissions of GHGs at a cost of up to 60€ per tCO2 eq of avoided emissions.

(†) RECIPE considers a default stabilization target of 450 ppm CO2; depending on assumptions about emissions of other GHGs, this corresponds to overall GHG concentrations of 500–550 ppm CO2 eq.

(‡) The target of the "Central Scenario" is defined on the basis of a set of 4 indicators: the group of developed countries have a -30% target compared to 1990 in 2020, whereas the emissions of developing countries in 2020 are limited to 20% below the baseline emissions.

Background: BaU and Policy scenarios

- Scenarios of long-term climate policy produced by the hybrid integrated assessment model WITCH.

- Refererence/BaU Scenario: there is no policy to reduce global warming.

- Policy scenario (550 ppm CC): stabilization of GHGs concentrations at 550 ppm CO2-eq at 2105 (i.e. 450 CO2 only level)
  - Full immediate co-operation among countries.

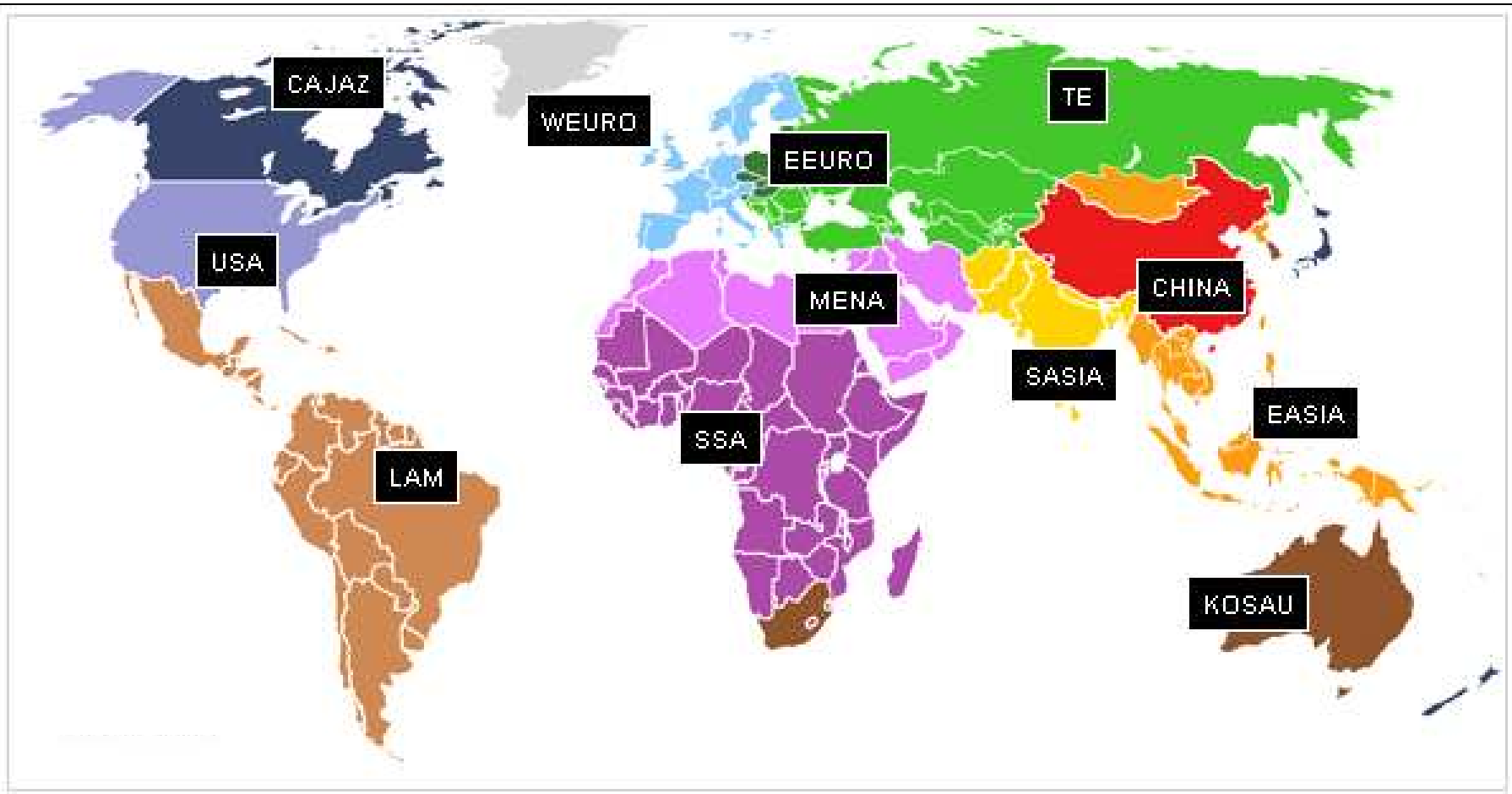


Figure 1 Macro regions in WITCH

Geographical aggregation:

- 12 regions are aggregated into two groups:
  - OECD: USA, WEURO, EEURO, KOSAU, CAJAZ.
  - non-OECD: TE, MENA, SSA, SASIA, CHINA, EASIA, LAM.

Transforming the power sector

Key Facts:

Although cumulative global investments in the power sector remain (almost) unchanged, some important changes occur…

- in the distribution across time,
- across regions,
- across power generation technologies

Transforming the power sector: overview

Table 1
(a) Investment as % of total investment by type

	Reference scenario			550 ppm CC scenario		
year	Final Good	Power sector	Energy R&D	Final Good	Power sector	Energy R&D
2005	96.46	3.46	0.08	96.78	3.11	0.11
2030	97.07	2.85	0.04	96.75	3.10	0.05
2050	97.58	2.34	0.02	97.28	2.53	0.03

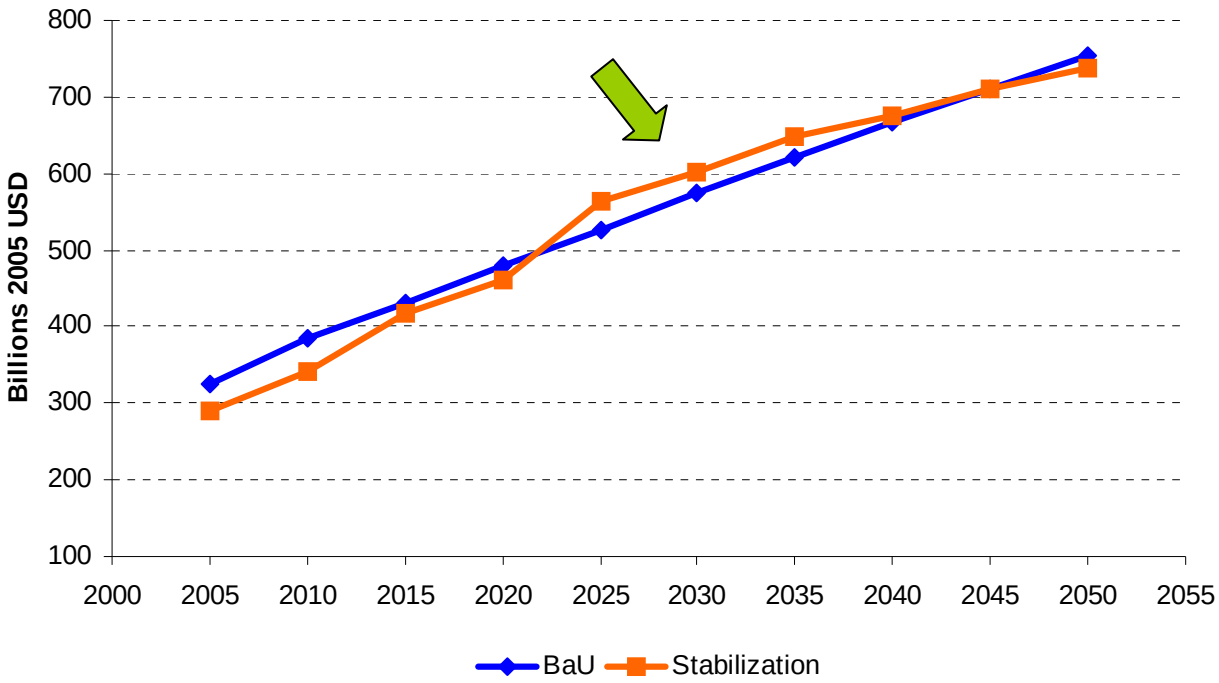
Implementation of the climate policy has two effects:

- **Effect 1**: Adoption of low carbon generation technologies implies higher investment costs per unit of installed capacity (w.r.t. traditional power plants).
- **Effect 2**: Higher energy efficiency (w.r.t. Reference) implies reduced demand for energy (w.r.t. Reference).
- The magnitude of the two effects is roughly the same.

Result: Financial requirements of the power sector do not change significantly

Transforming the power sector: the time pattern

World investment in the power sector, 2005-2050

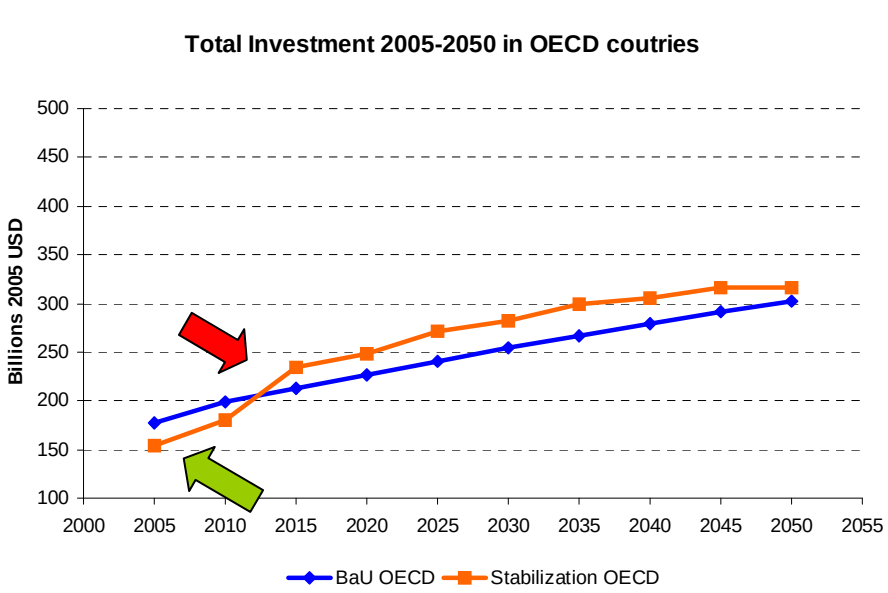


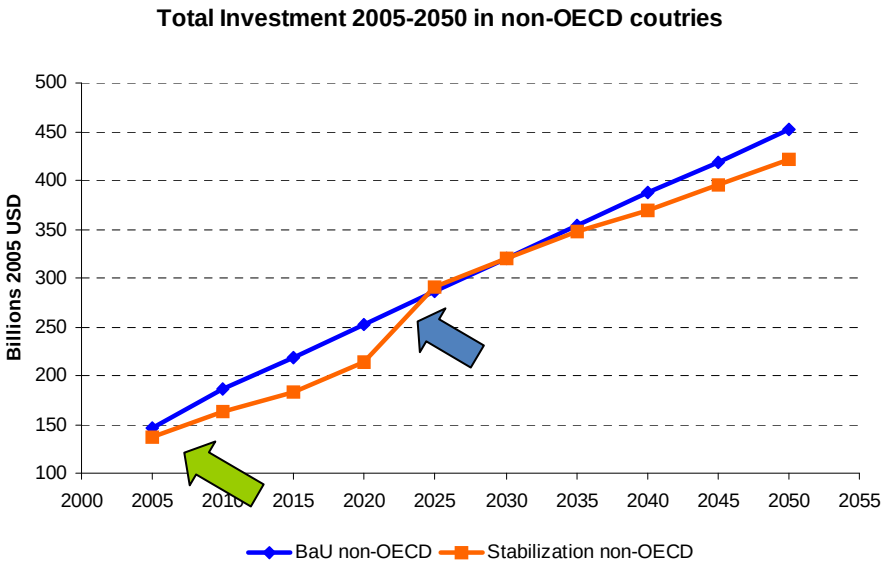
- Patterns in BaU and Stabilization are similar and converging
- Tackling climate change requires additional effort over a short period of time (2020-2045)

Transforming the power sector: regional pattern

Reallocation of investments is quick and can be described as a succession of jumps.

- Fast-growing investments in nuclear power explain the first jump between 2005 and 2010.
- Deployment of CCS technologies in 2010 in OECD countries
- … and with a lag of ten years, in Non OECD countries.





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Transforming the power sector: the regional (time) pattern

Regional (time) patterns:

- Investments in OECD countries will be higher in the *550 ppm CC* scenario from 2015 until 2050
- Non OECD regions will reduce investments from 2010 to 2025 and also from 2040 until 2050.
  - i.e. higher space for energy efficiency improvements in Non OECD regions

Transforming the power sector: regional pattern

- The USA and the EU will sustain the long run investment

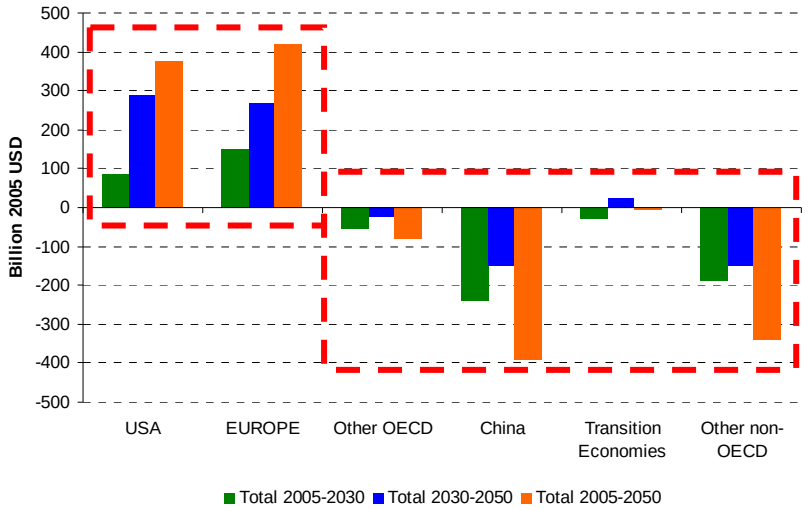
- The cumulative investment differential is negative for other countries

→ A big, but affordable effort…

An example for the US:

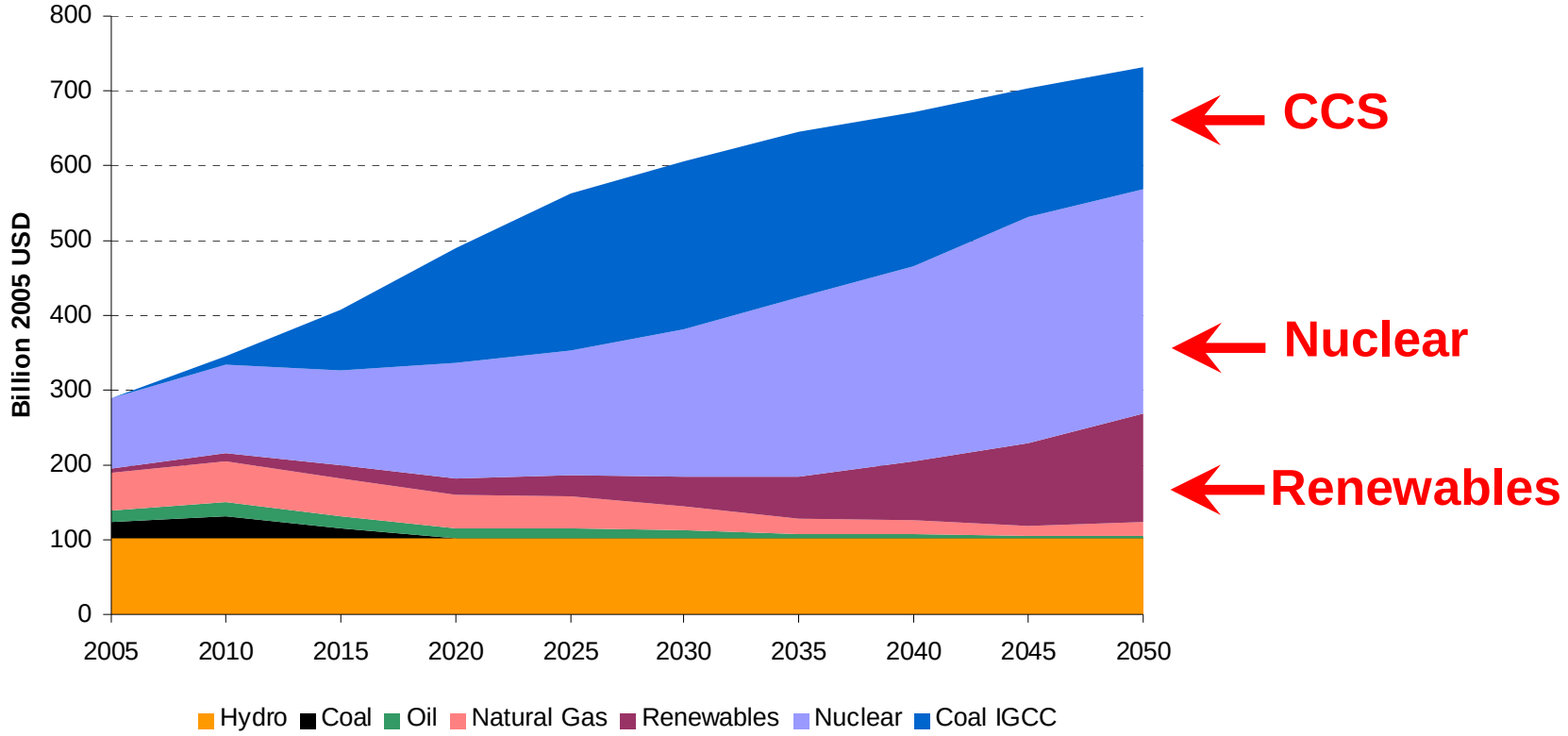
- USD 355.3 billion in 2050 is the additional cumulative investment faced by the USA to tackle climate change
- USD 425 billion for the Interstate Highway System, whose construction took 35 years (46,876 miles)

Cumulative investment w.r.t. Reference



Transforming the power sector: technologies

Total investment in the power sector 2005-2050, by production technology

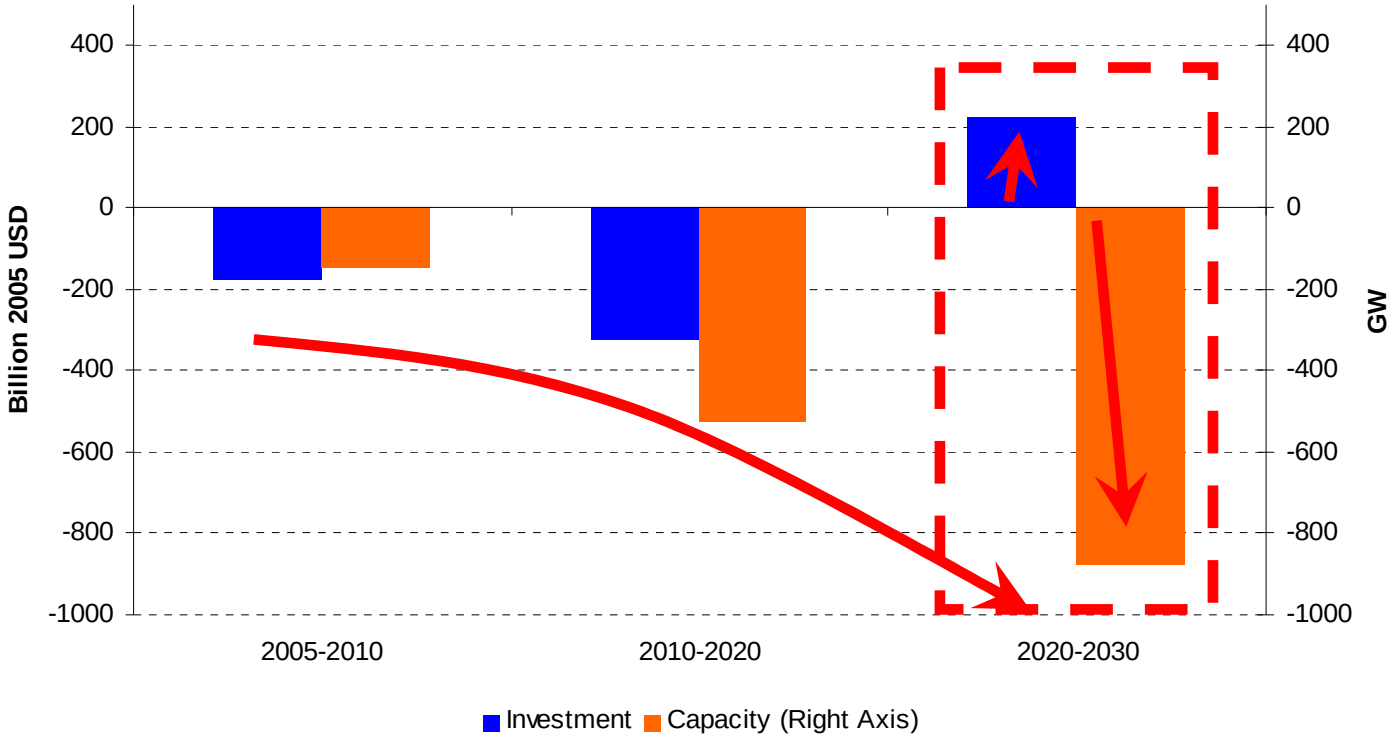


The decarbonisation of energy supply asks for a completely new energy mix:

- Conventional fossil fuels power plants are progressively substituted by nuclear, coal power plants with CCS and renewables

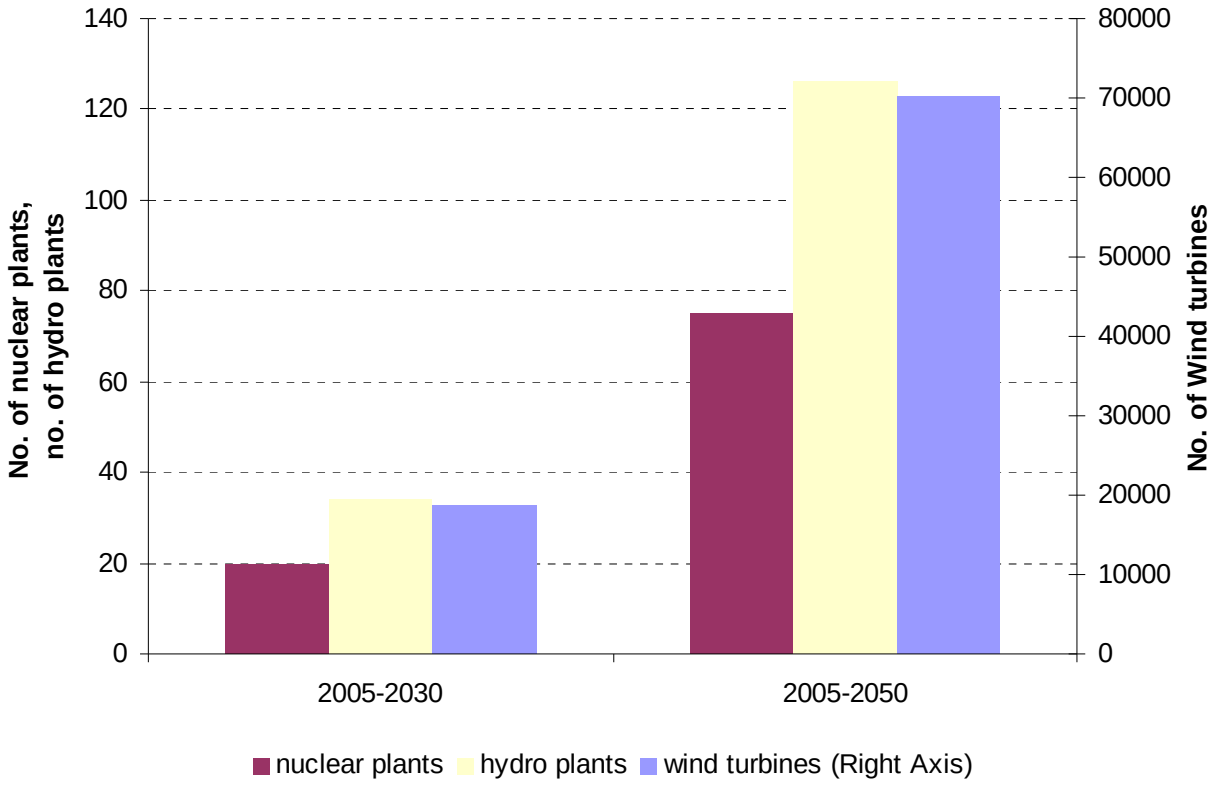
Transforming the power sector: additional capacity

- Investments in net power capacity additions (i.e. exclude investments to replace obsolete power plants):
- Overall the climate policy reduces the expansion of the power sector.
- Investments and new capacity additions have diverging patterns between 2020 and 2030
- The expansion of power capacity declines of about 800 GW (e.g. 800 average-sized coal or nuclear power plants),
- The amount of investments increases: the avg. cost of power plants increases: penetration of nuclear, renewables and coal with CCS.



Transforming the power sector: additional capacity

- Even if financially manageable, the transition to a zero-carbon power sector will be problematic…
- An experiment: what if power capacity can be expanded using either nuclear, hydroelectric or wind power plants?
  - i.e. How many new installations needed each year ?



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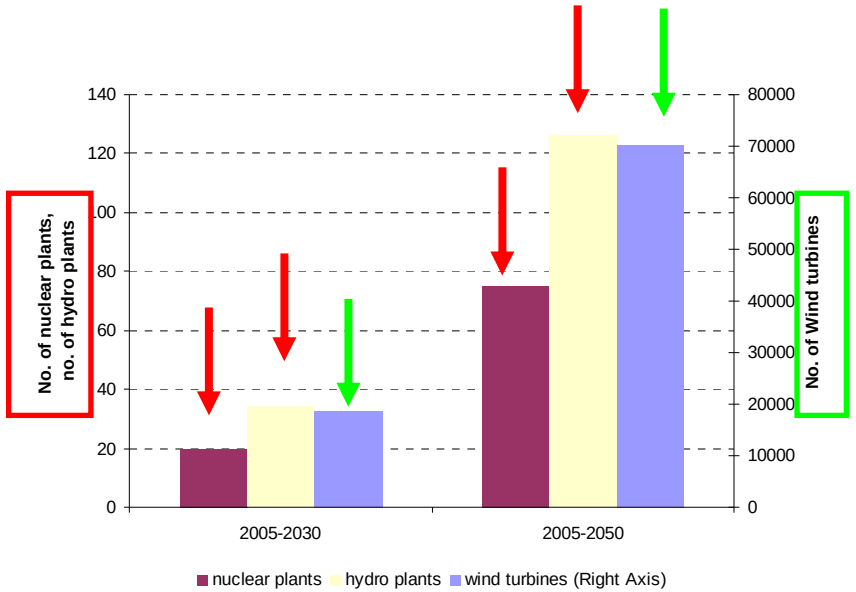
Transforming the power sector: additional capacity

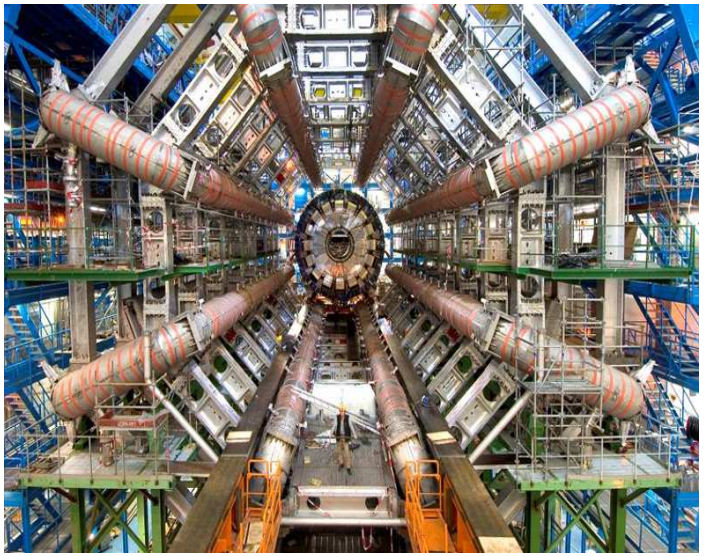
- (2005-2030) it would be necessary to install each year either
  - 20 nuclear plants (of 1,000 MW each),
  - or 33 large hydro plants (of 1,000 MW each),
  - or 18,490 wind turbines (of 3 MW each).
- (2005-2050):
  - 75 nuclear plants or,
  - or 126 hydro plants,
  - or 70,213 wind turbines

… a very hard task!!!



- In December 2009 there were 436 nuclear power plants in operation for a total net installed capacity of 370,000 MW.
- The Three Gorges Dam will reach, when at full operation in 2011, 18,200 MW.
- In 2008 there was an estimated wind installed power capacity of 121,188 MW, which is equivalent to 40,396 3MW turbines

Financing innovation

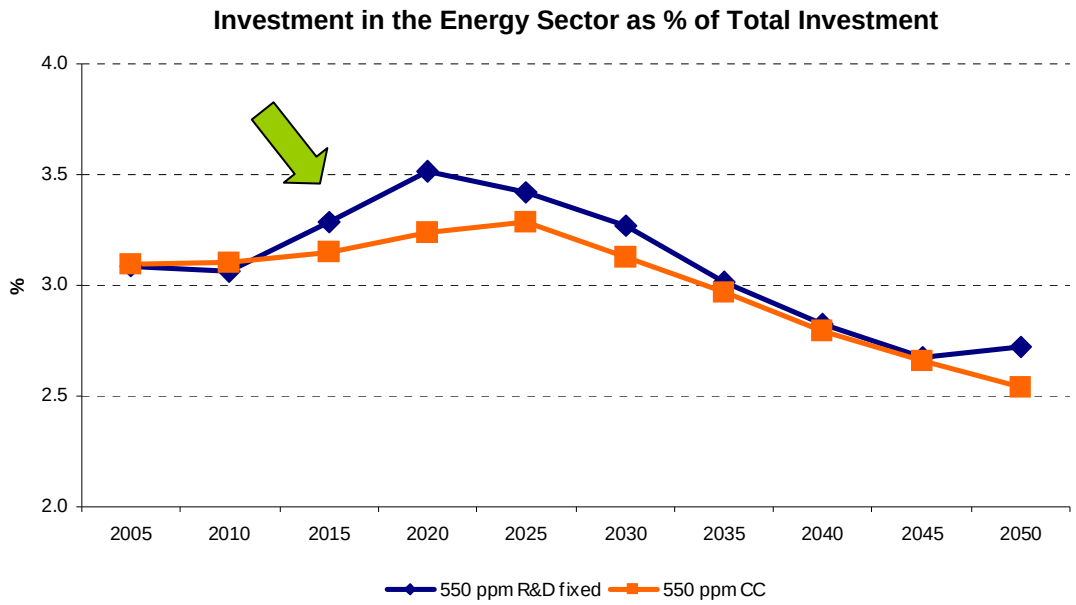


Key facts:

- R&D investments decrease energy investment as a whole
- R&D investments are modest in monetary terms but require fast expansion
- Revenues from auctioning carbon allowances can be a major source of income for R&D investments

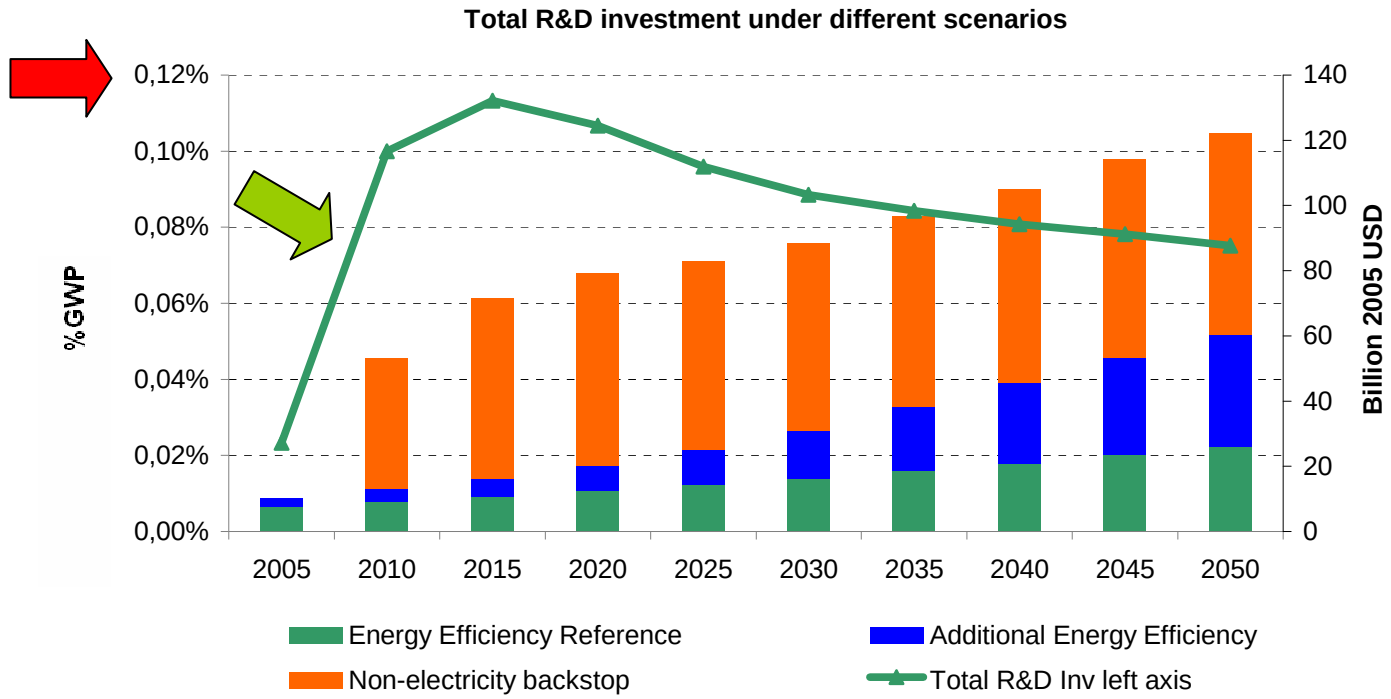
R&D investements for reducing investments in energy

- Stabilization policy requires energy efficiency improvements and energy decarbonization
- Higher investments in R&D will imply lower cost of breakthrough technologies and faster substitution of fossil fuels
- The percentage of investments directed to the energy sector is higher when R&D investments are forced to remain the same as in the Reference scenario



R&D investments: monetary and temporal dimension

Fast expansion
Modest in GWP terms



R&D investments in a scenario with constraints

The amount of R&D investments are a function of the technological scenario that we use

In a Constrained Policy scenario (550 ppm constraints) where:

- nuclear electricity is fixed to current generation levels
- the penetration of renewable is limited to 25% of total electricity supply

R&D investments

- increase with respect to the 550 ppm CC scenario and
- there are R&D investments in electricity backstop

		R&D Investment (Billion 2005 USD)					
		No limit			Limit on nuclear and renewables		
		Additional energy efficiency	R&D Back NEL	R&D Back EL	Additional energy efficiency	R&D Back NEL	R&D Back EL
OECD	2020	6,22	33,49	--	7,09	33,26	7,08
	2030	11,05	29,65	--	12,23	29,27	5,57
	2050	23,73	28,44	--	25,67	28,05	5,59
Non OECD	2020	1,70	25,61	--	1,84	25,54	4,86
	2030	3,70	27,85	--	3,97	27,55	4,00
	2050	10,59	33,35	--	11,33	33,00	5,02
World	2020	7,91	59,08	--	8,93	58,80	11,93
	2030	14,76	57,50	--	16,20	56,82	9,56
	2050	34,31	61,79	--	37,01	61,06	10,61

R&D investments: govenments support

- **Large scale projects** will be costly and will require the partnership of many governments
- Private investors might not be willing to undertake the **high risks** of frontier research for backstop
- Knowledge market **externalities** are particularly acute for the basic research activity needed to develop backstop

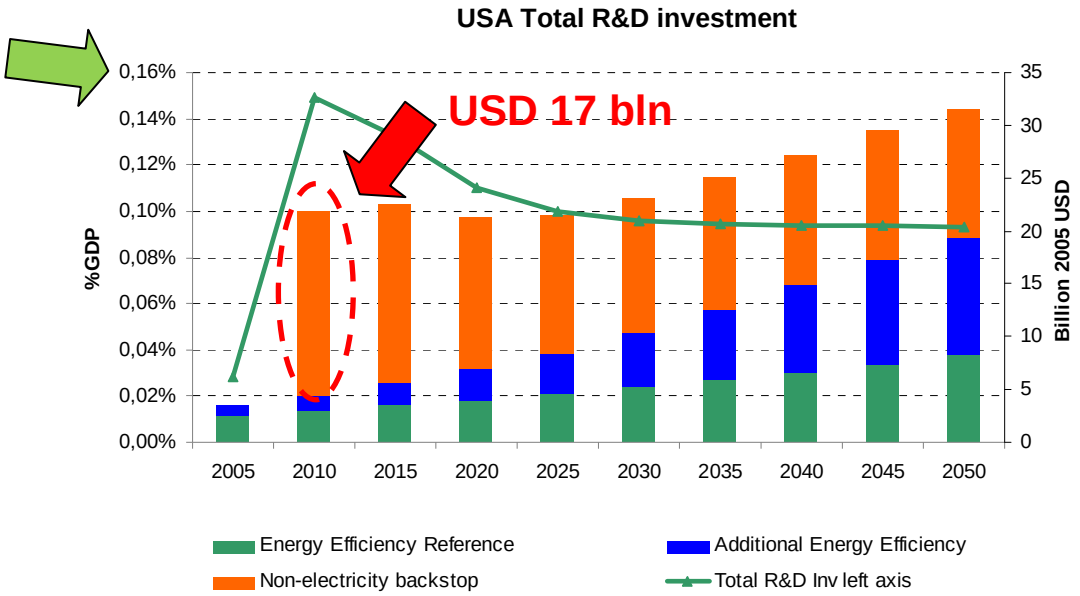
…these difficulties can be overcome

- **Past** experience
- Revenue from **auctiong** carbon permits

Past experience: the US case

In the past vast amounts of resources have been successfully mobilized to finance ambitious technological advancements in a short time frame

- The 1960s NASA Apollo Space Programme required investments of USD 97.9 billion over 13 years (around USD 7.5 bln per year)
- It is comparable to what would be necessary to spend in backstop fuel in the US
- Apollo investments reaches 0.4% of the average national GDP during the peak year which is less than what is required for total US R&D investment



Revenues from auctioning carbon permits

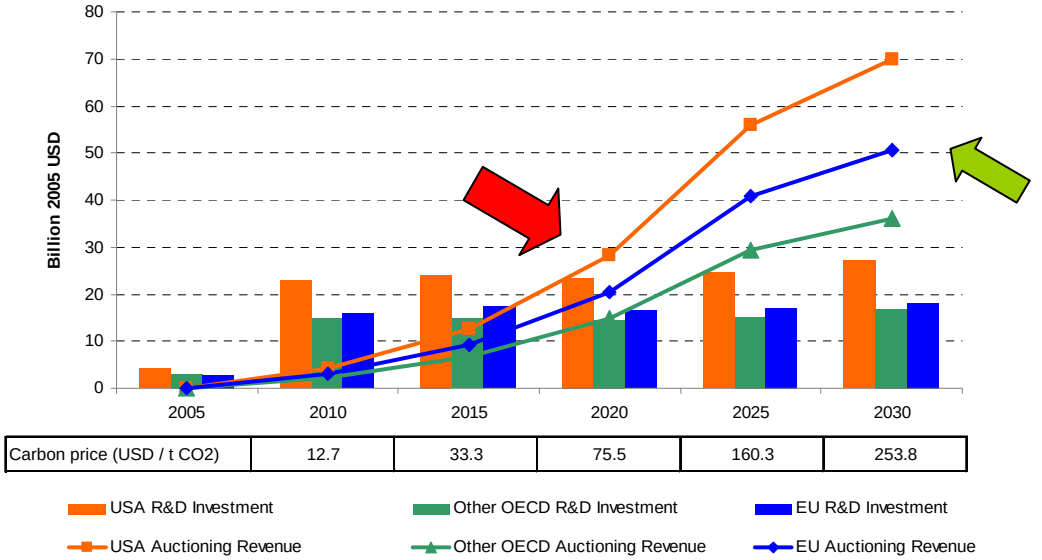
Revenues from auctioning carbon permits can be a major source of income for R&D investments

Assuming 20% of permits are auctioned in all regions…

…the growing price of carbon generates a flow of income sufficient to cover all R&D investments in advanced economies starting from 2020

After 2020 the revenues from auctioning will largely exceed the demand of funds to cover energy related R&D

Stabilization Scenario: Auctioning revenue (20% auctioned) and R&D investments



The exact share of permits to cover R&D investments

- We compute the exact share of permits to be auctioned to cover investments in R&D in the US, Europe and other OECD countries
- Initially low carbon price and high R&D spending require about three quarters of permits to be auctioned
- In 2030 the share declines to a modest 5% mainly because the price will increase substantially after 2020

Revenues from auctioning carbon allowances should initially be devoted almost exclusively to finance R&D while at the end it will sufficient only a small share of them

Weighing auctioned revenue and R&D investments

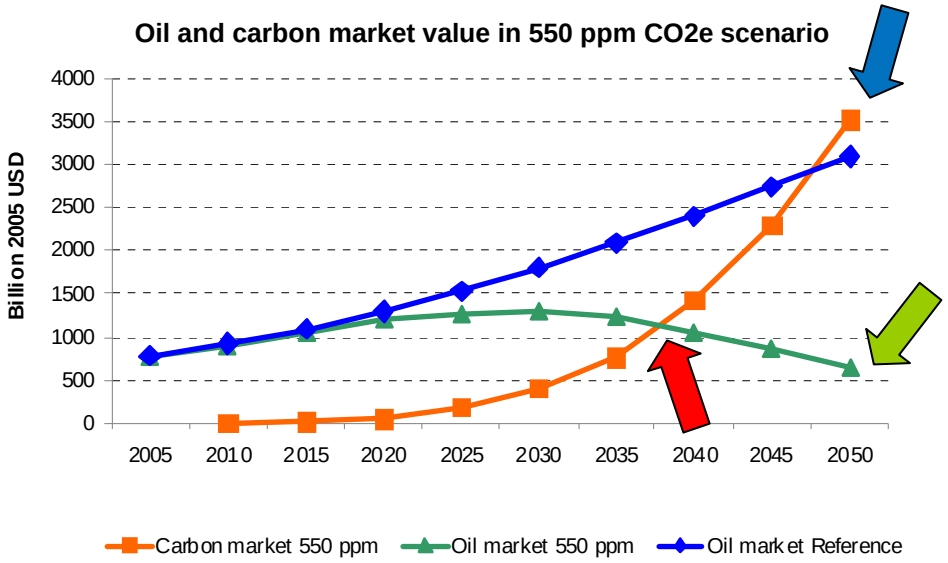
	OECD		USA		Europe	
Years	% of permits auctioned	R&D investments = auctioning revenue (Billion 2005 USD)	% of permits auctioned	R&D investments = auctioning revenue (Billion 2005 USD)	% of permits auctioned	R&D investments = auctioning revenue (Billion 2005 USD)
2010	76%	48.128	71%	21.906	75%	15.296
2015	28%	51.151	27%	22.453	27%	15.494
2020	14%	49.917	13%	21.278	13%	15.380
2025	9%	50.634	8%	21.541	8%	15.540
2030	5%	53.686	5%	23.005	5%	16.270

From “Fossil Finance” to “Carbon Finance”

Key facts:

- Carbon market dominates oil market in terms of value
- Carbon market could act as a tangible indirect source of investments in the energy sector
- Carbon trade would become a primary source of revenues for low income countries

The carbon market dominates the oil market



- Carbon market will be larger than the oil market by a factor of 6 by 2050 with the take-over between 2035-2040
- The value of the carbon market will increase exponentially reaching more than USD 3.5 trillion in 2050 for the combined effect of
  - larger trade of carbon permits
  - growing carbon price
- The financial flows associated to oil transactions will decline for
  - a contraction of demand
  - lower oil prices

Scenarios on the carbon markets

We use a set of Policy scenarios with different emissions permits allocation rules:

- **550 ppm CC:** Policy scenario used the “contraction-and-convergence” rule to distribute emissions permits internationally
- **550 ppm EPC**: Policy scenario used the “equal-per-capita” rule which distributes emissions permits in proportion to population

Different assumptions on the degree of openness of the international carbon market limiting international carbon offsets:

- **550 ppm CC:** free access to the international carbon market
- **550 ppm CC 25%:** limit the purchase of international offsets to 25% of the national abatement target
- **550 ppm CC 50%:** limit the purchase of international offsets to 50% of the national abatement target
- **550 ppm CC 75%:** limit the purchase of international offsets to 75% of the national abatement target

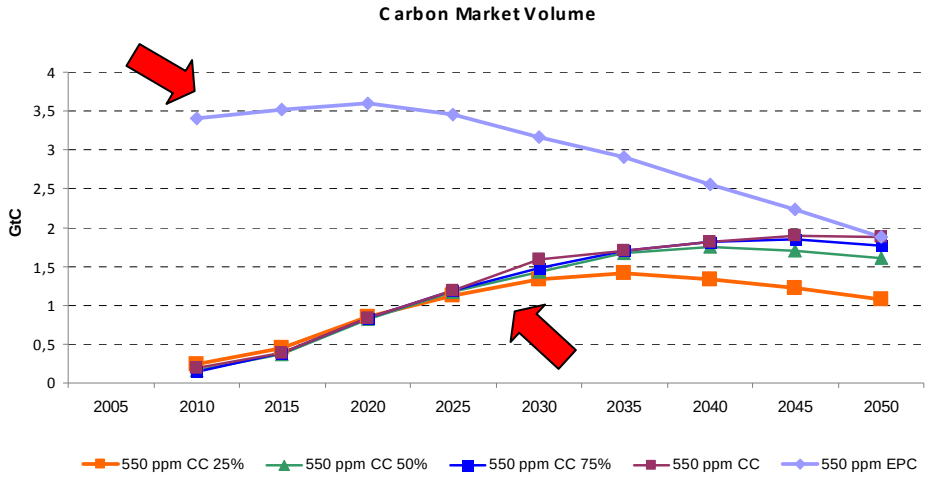
Carbon market size

The most important factor influencing the size is the allocation rule

The EPC scenario displays a much higher volume of international carbon offsets because:

- the largest fraction of global emission permits is distributed to low income-high population regions with very low per capita emissions and low abatement targets
- in the CC there is less need to trade because permits are distributed where emissions are

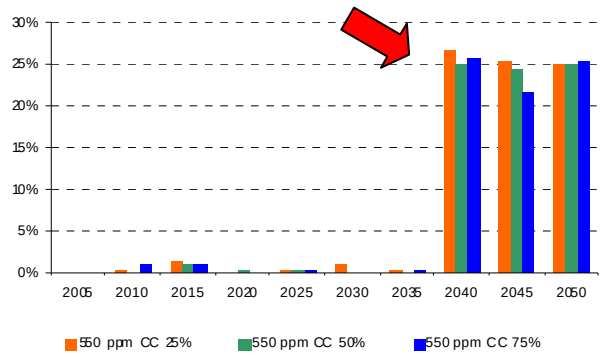
The limit to the access to international offsets become binding after 2030



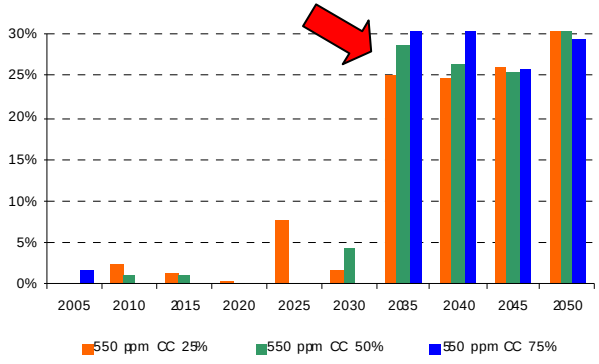
Financing investments through the carbon market

Limits to international offsets produces several implications:

- marginal abatement costs are not equated globally but they are higher in regions with a deficit of carbon permits
- only the cheapest abatement opportunities are financed leaving the most expensive unexploited
- investments to decarbonize the energy sector will increase with respect to the Policy scenario without constraints
  - by 25% in Europe by 2040
  - between 25-30% in the US by 2035



Europe



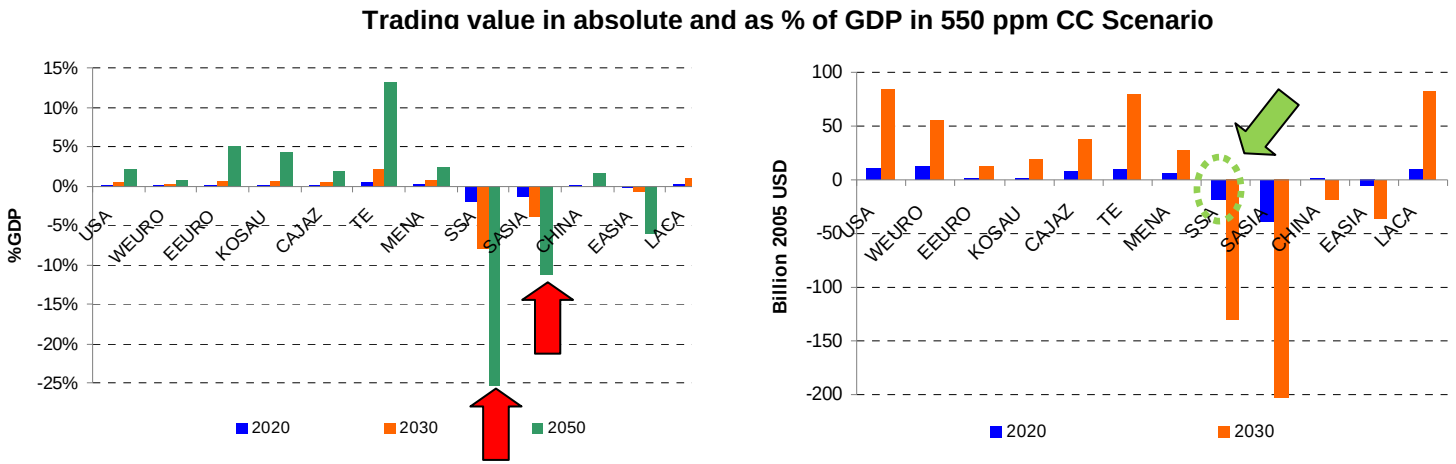
US

Financial flows associated to carbon trading

Carbon trade would become a primary source of revenues for low income countries in all the scenarios

With unrestricted access to international offsets Sub-Saharan Africa (SSA) and South Asia (SASIA) are the two largest suppliers of cheap abatement options

- In 2050 financial inflow in these two regions would be 25% and 11% of annual regional GDP
- In 2020 the transfer to Sub-Saharan Africa would be around USD 18 billion around 50% of 2007 the net Official Development Assistance to Africa



Conclusion (1)

We explore what are implications of the stabilization policy for:

- investments in the **power generation sector**
- the financial requirements to foster **R&D activities**
- the dynamics of **carbon markets**

- **Energy sector**
  - ✓ Climate policy **will not induce** higher investments in electric power generation with respect to the Reference scenario
  - ✓ Low-carbon world asks for a completely **new energy mix**: conventional fossil fuels power plants are substituted by nuclear, coal power plants with CCS and renewables
  - ✓ **Criticalities** will emerge when large investments have to be diverted – in a relatively short time frame – towards complex and risky technologies

Conclusions (2)

- **R&D**
  - ✓ It would be optimal to scale-up energy-related R&D expenditures from the very beginning of climate policy
  - ✓ The **fast expansion** of R&D spending represents a challenge from a managerial perspective, but the overall financial requirements are **minimal**
  - ✓ **Governments** will support R&D, especially large scale, very uncertain, projects using revenues from carbon allowances
- **Carbon market**
  - ✓ If a successful, stringent, long-term, mitigation policy will be put into place, the twenty-first century will see the **emergence of carbon finance**
  - ✓ Carbon market value and size are influenced by **allocation rules** and its **degree of openness**
  - ✓ Limiting international carbon offsets we investigate how carbon market acts an **indirect source** of investments in energy sector
  - ✓ Carbon trade would become a primary source of revenues for **low income countries**

Thank you!

For further information please visit:
http://www.witchmodel.org/

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