# ECON4925 Resource economics, Autumn 2014

**Lecture 5: Fossil fuels and climate change I: optimal policy**

**Outline of lecture 5 and 6:**

Elementary climate physics (lecture 5)

* Perman section 9.5.1
* Hoel (2011) section II
* Hoel and Kverndokk (1996), section 2 (first 1 ½ page)
* Sinn section 1 and 2
* Lecture note 5B example 2

Optimal climate policy (lecture 5)**:**

* Lecture note 5B example 2
* Hoel and Kverndokk (HK); you may skip section 4.

Non-optimal climate policies (lecture 6)

* Incomplete or poorly designed carbon taxes (Hoel 2011; Sinn section 5 (without mathematical details))
* Other policy instruments (Greaker et al.; Hoel 2014)

**Brief introduction about climate change**

*Measurements*

Emissions (flow): 1 tonne C = 3,67 tonnes CO2

Concentration in atmosphere (stock): 1 Gt (=109 tonnes) C = 0,47 ppm (parts per million)

*Climate change*

* The stock of greenhouse gases in the atmosphere affects climate (with a lag)
* Greenhouse gases consist of

1. CO2 from fossil fuel use, approx 60%
2. Other CO2 (mostly deforestation), approx. 20%
3. Other greenhouse gases; approx. 20%

* Shall only consider (a)
* Emissions of CO2 give an increase of the concentration of CO2 in the atmosphere. This concentration gradually declines as CO2 is absorbed in the ocean and other carbon sinks
* A very rough description of the carbon cycle:
  + 25% of carbon emissions remain in the atmosphere “for ever”
  + 75% of carbon emissions depreciate at a rate of 1-1.5% a year
* If a total amount of 4(S\*-S(0) ) is extracted we thus get a development of carbon in the atmosphere as below, with A representing slow extraction and B representing fast extraction:



**Notation and assumptions in HK-model:**

*Resource extraction and substitute production*

* *x* is resource extraction
* *A* is accumulated resource extraction: 
* *c*(*A*) is unit cost of extraction (simplest case *c*(*A*) zero up to , then “infinitely high”)
* *u’(0)=b* ( in HK)
* *S* is the stock of carbon in the atmosphere (beyond the pre-industrial level of 280 ppm CO2)

*Greenhouse gas accumulation*

Emissions measured so they are equal to resource extraction:

 (i.e. a simplification; we consider in particular the case of )

*Costs and benefits*

* *u*(*x+y*) is utility (in terms of numeraire good) of use of resource and substitute
* *D*(*S*) is a climate damage function.

*Social optimum*

Maximize s.t.  and 

*Some results (see also Hoel, 2014)*

Without climate costs:

 determines total extraction

 determines price development

With climate costs assuming :

 determines total extraction

 determines price development

Carbon tax to achieve social optimum (see HK):



(two ways of writing the same; obvious interpretation)

Note that  if  is constant (i.e. either  or )

It follows that



from first expression for 

 for and 

from second expression for 