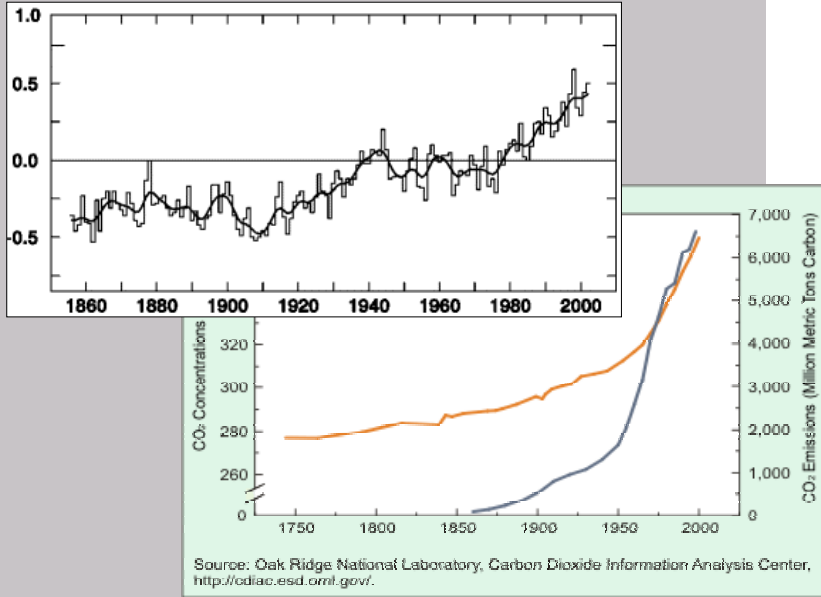


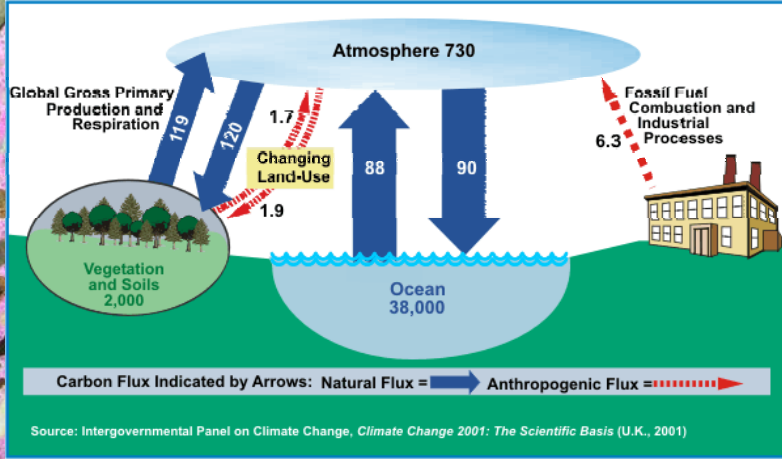
# CO<sub>2</sub> indhold i atmosfæren

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# CO<sub>2</sub>-kredsløbet

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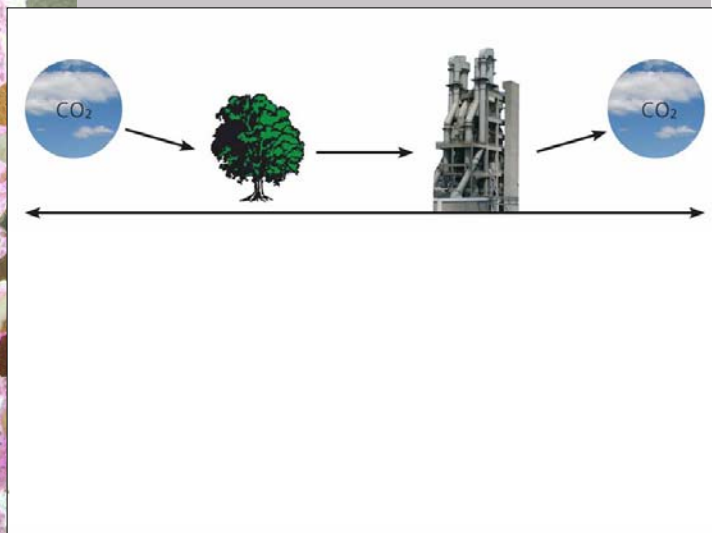


Baggrund

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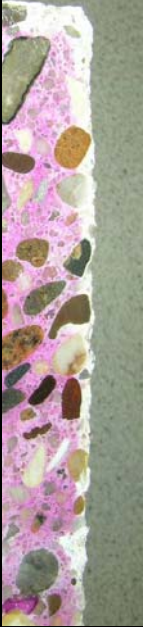
# CO<sub>2</sub>-kredsløbet

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Baggrund

Research and Development Centre

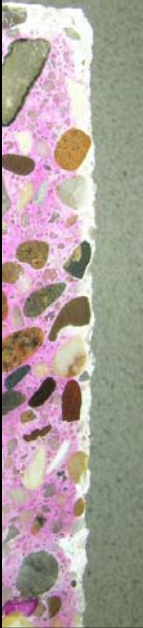


# CO<sub>2</sub> emission fra cementproduktion

aalborg portland  
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Baggrund

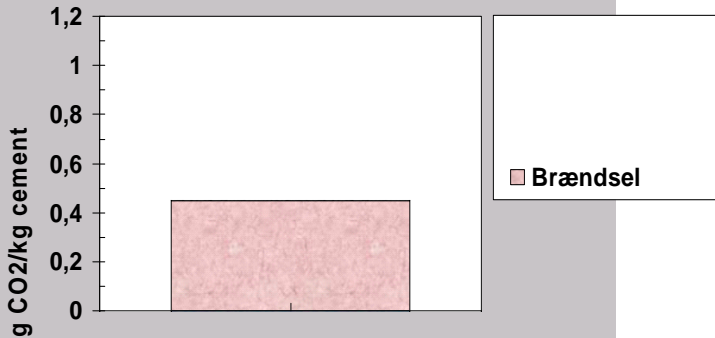
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# CO<sub>2</sub> emission fra cementproduktion

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kg CO<sub>2</sub>/kg cement



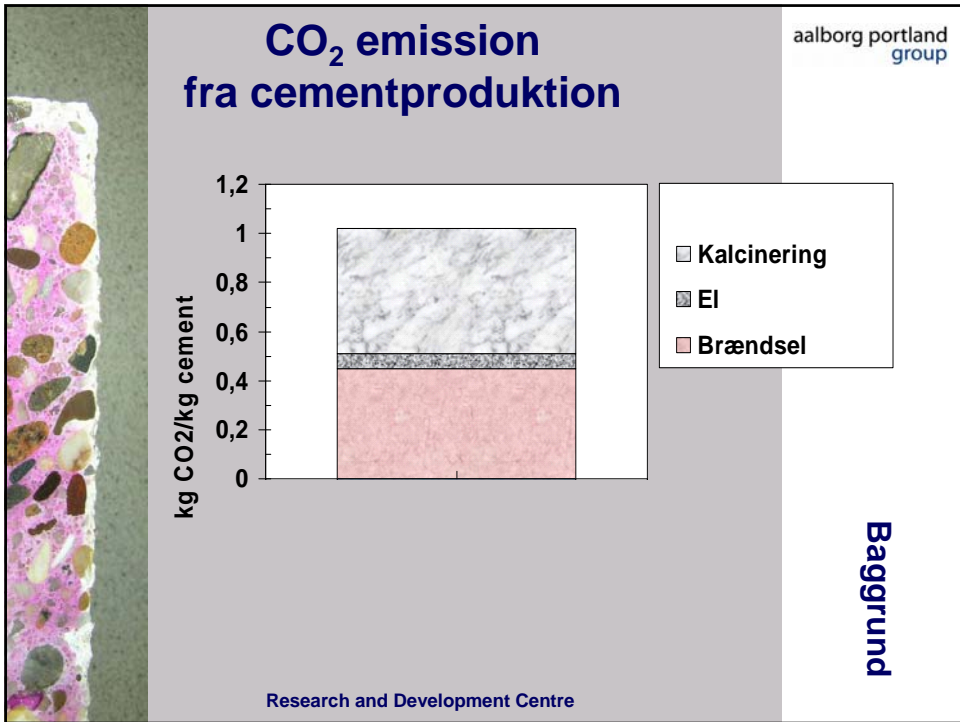
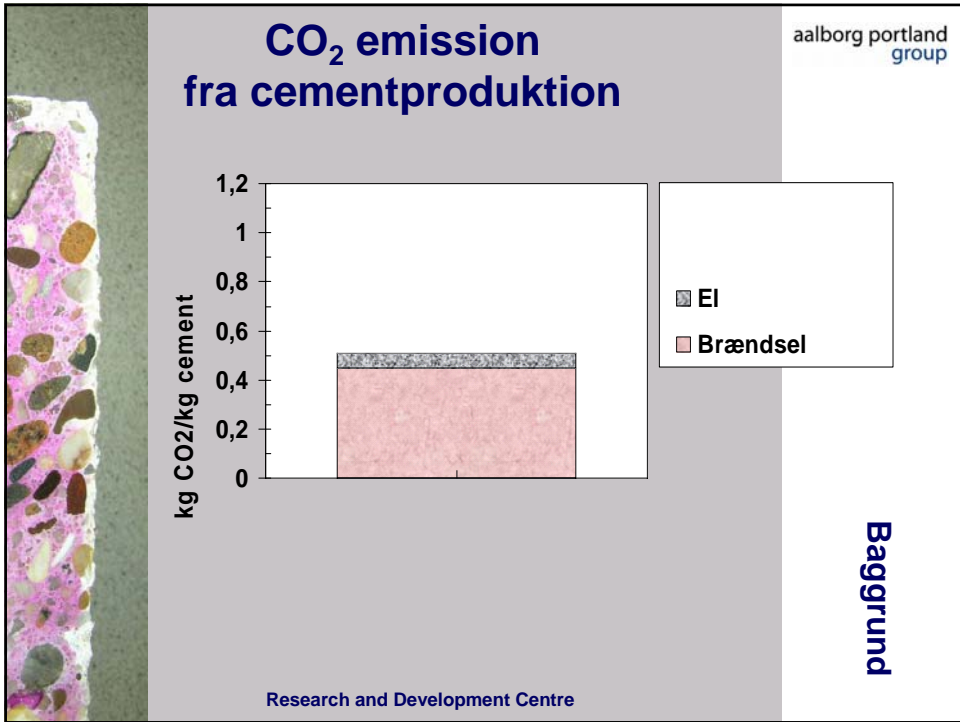
Category	kg CO <sub>2</sub> /kg cement
Brændsel	~0.45

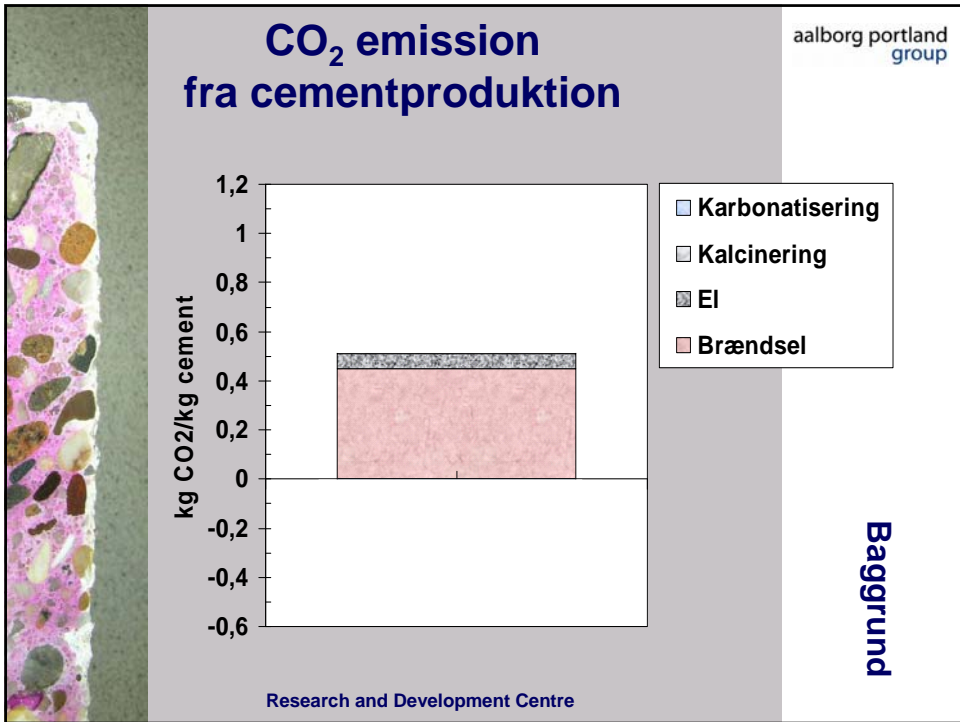
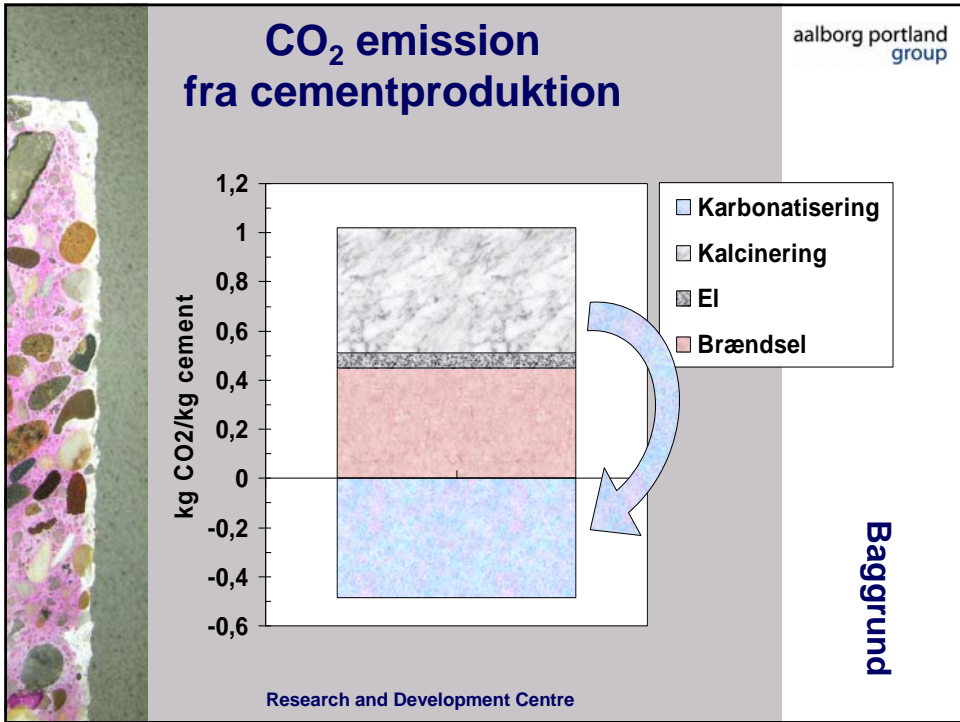
Brændsel

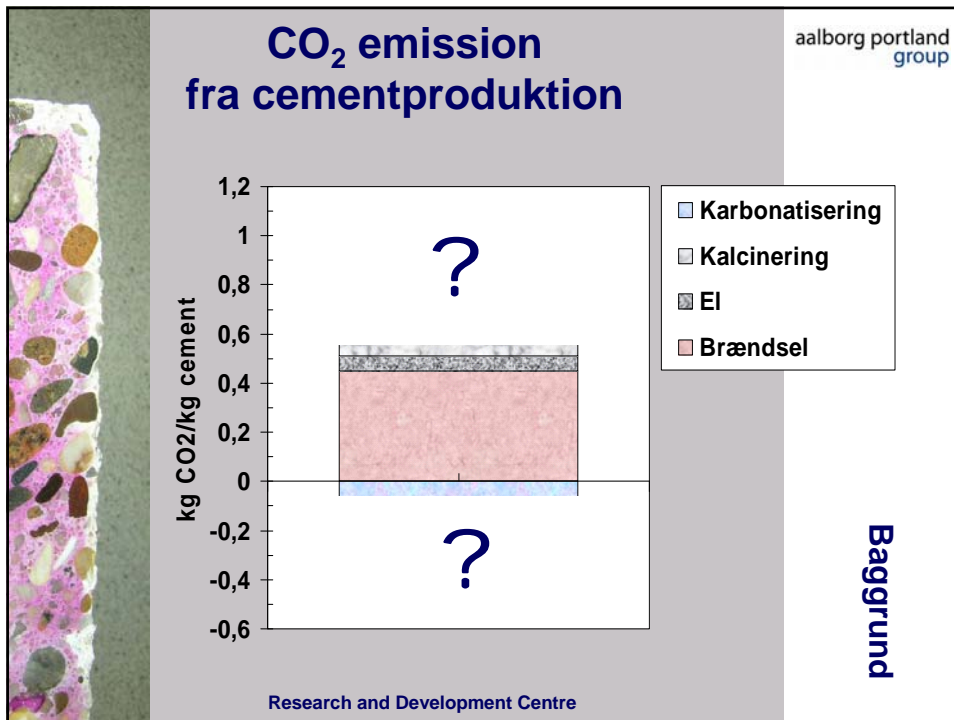
Baggrund

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## Mål

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Dokumentere miljøeffekten af betons karbonatisering, dvs. CO<sub>2</sub>-optag i de Nordiske lande.

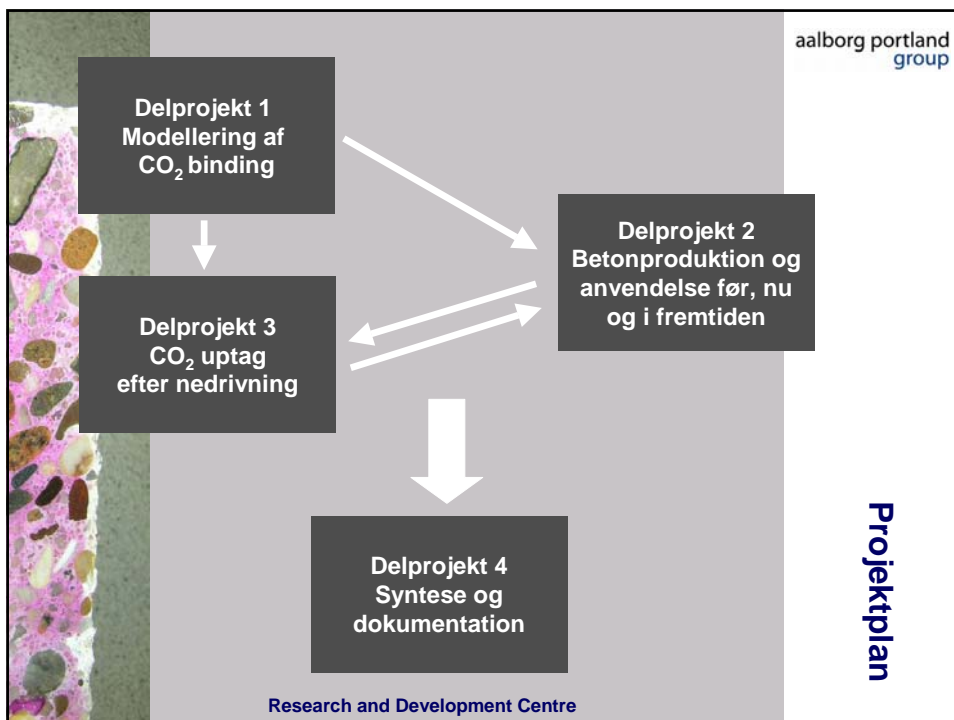
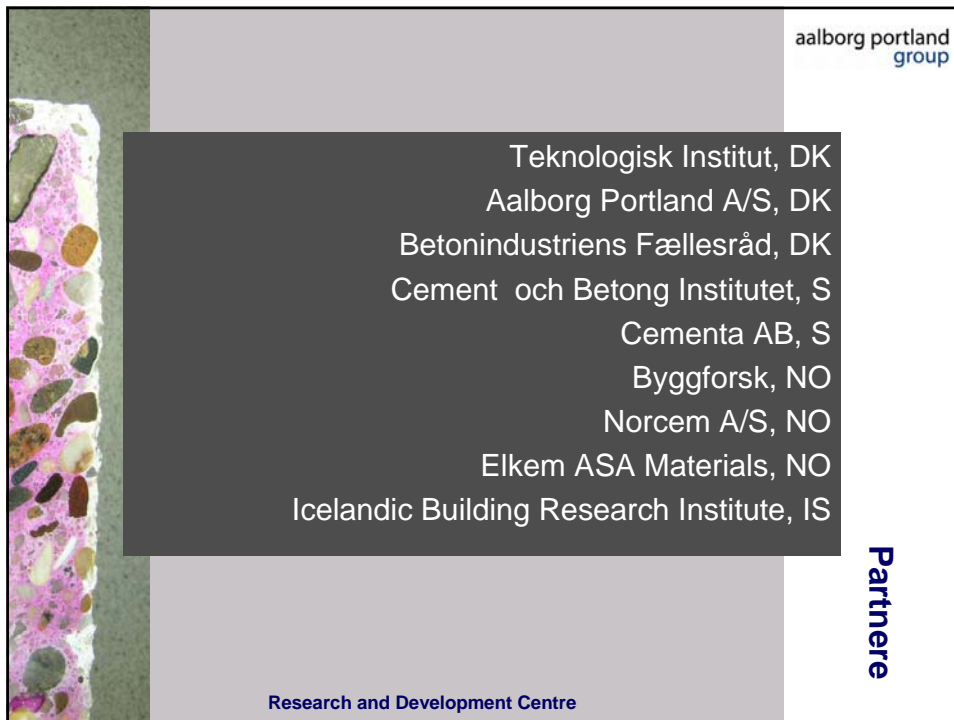
**Budget**  
2,6 mill. kr.

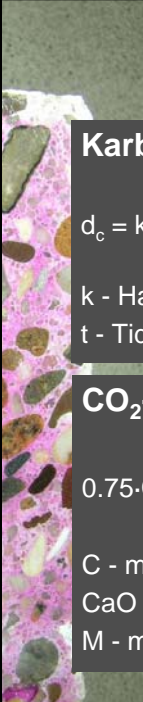
**Projektperiode**  
December 2003 – december 2005

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Mål







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## CO<sub>2</sub>-optag

**Karbonatiseringsdybde**

$$d_c = k \cdot (t)^{0.5}$$

k - Hastighedsfaktor  
t - Tid

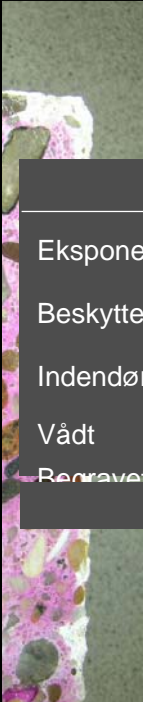
**CO<sub>2</sub>-optag**

$$0.75 \cdot C \cdot CaO \cdot (M_{CO_2} / M_{CaO}) \text{ (kg/m}^3\text{)}$$

C - masse af Portland-cement klinker pr. m<sup>3</sup> beton  
CaO – andel af CaO i cement-klinkerne (masse)  
M - molmasse af hhv. CO<sub>2</sub> og CaO

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Modeller



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## Hastighed af CO<sub>2</sub>-optag

	< 15 MPa	15-20 MPa	25-35 MPa	> 35 MPa
Eksponeret	5	2.5	1.5	1
Beskyttet	10	6	4	2.5
Indendørs	15	9	6	3.5
Vådt	2	1	0.75	0.5
Repareret	3	1.5	1	0.75

mm/year<sup>0.5</sup>

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Modeller




## Betonproduktion i Norden

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- Mængde beton produceret i 1950 og 2003
- Betontyper
- Gennemsnitlig tykkelse af hver betontype
- Eksponering

**Statistik**

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## Betonproduktion i Norden


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- Mængde beton produceret i 1950 og 2003
- Betontyper
- Gennemsnitlig tykkelse af hver betontype
- Eksponering

Ready-mixed concrete		Pre-cast elements		Pre-cast products	
	Thickness (mm)		Thickness (mm)		Thickness (mm)
Walls	180	Hollow-core slabs	300	Paving	60
Slabs	200	Other slabs	120	Blocks	160
Foundations	240	Roof	120	Elements	120
Civil eng. structures*	400	Walls	220	Pipes and others	60
		Facades	70+150		
		Columns/Beams	300x300		
		Other	150		

**Statistik**

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**Affald fra nedrivning**

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	Betonaffald (tons)
Norge	650.000-975.000
Danmark	800.000-1.200.000
Sverige	1.080.000-1.200.000
Island	52.000
Finland	630.000-720.000

**Genanvendelse af beton**

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**Genanvendelse af beton**

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- % af betonaffald, der genanvendes
- Partikelstørrelsesfordeling af nedknust beton
- Eksponering



**Genanvendelse af beton**

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## Genanvendelse af beton

- % af betonaffald, der genanvendes
- Partikelstørrelsesfordeling af nedknust beton
- Eksposering

Country	current (%)	by 2010 (%)
DK	~90	~90
NO	~30	~70
IS	0	0
SE	~60	~70

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Genanvendelse af beton

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## Betydning af partikelstørrelse

size (m)	surface area (m <sup>2</sup> )
0,001	~10.000
0,01	~3.000
0,1	~0.500
1	~0.100
10	~0.010

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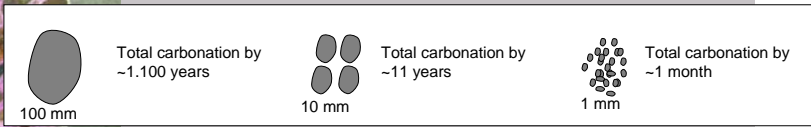
Genanvendelse af beton



## Beregnet CO<sub>2</sub>-optag i nedknust beton

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Particle sizes	%	Volume (m <sup>3</sup> )	Volume carbonated after 5 years (m <sup>3</sup> )
<1mm	21	140.252	<b>140.252</b>
1 -10mm	30	200.360	<b>200.360</b>
10-30mm	44	293.861	155.238
>30mm	5	33.393	7.056



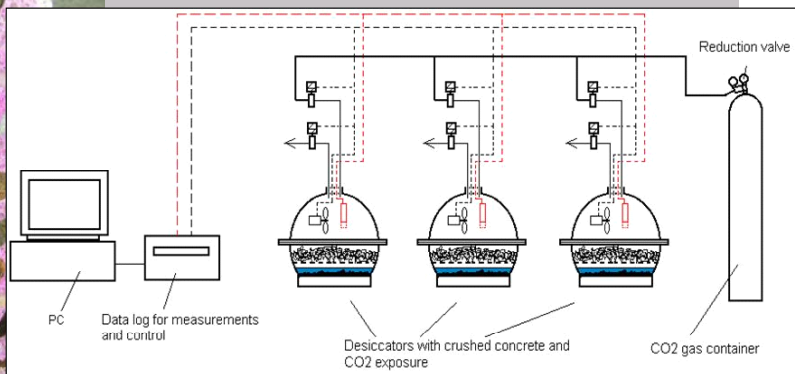
Beregning: **75%** karbonatiseret efter 5 år

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Genanvendelse af beton

## Accelereret prøvning

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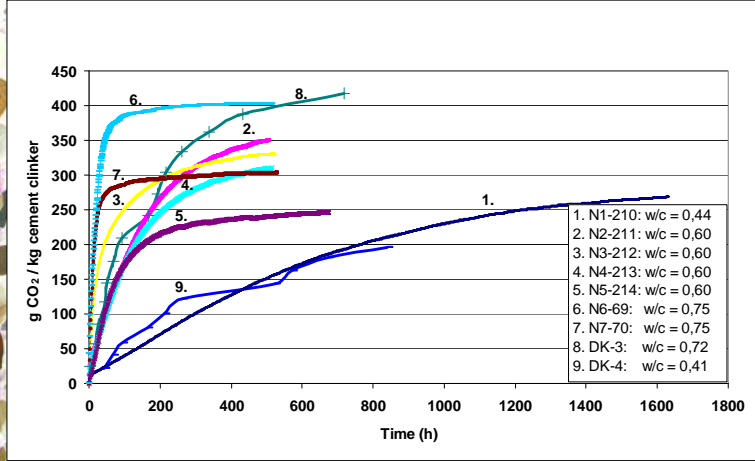


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Genanvendelse af beton

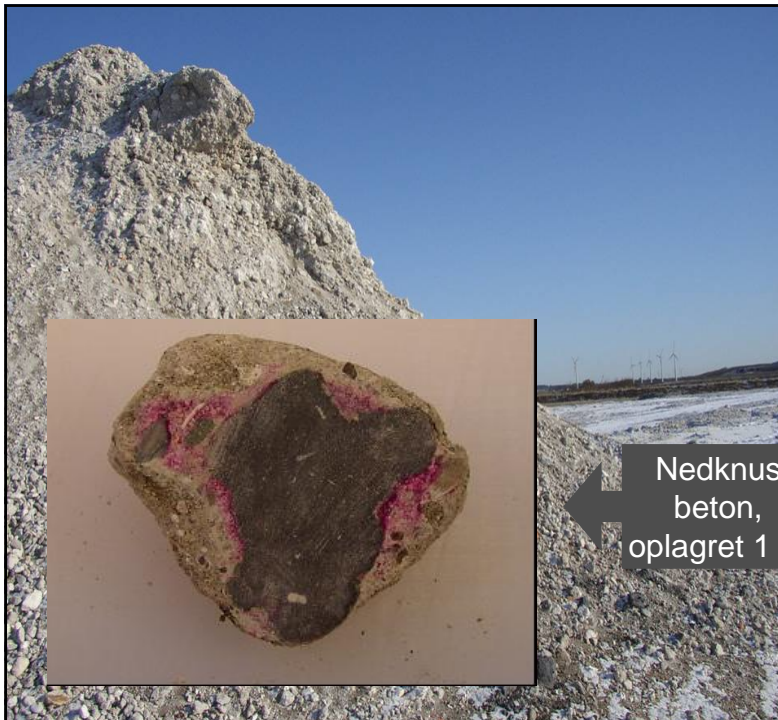
# Accelereret prøvning

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Genanvendelse af beton

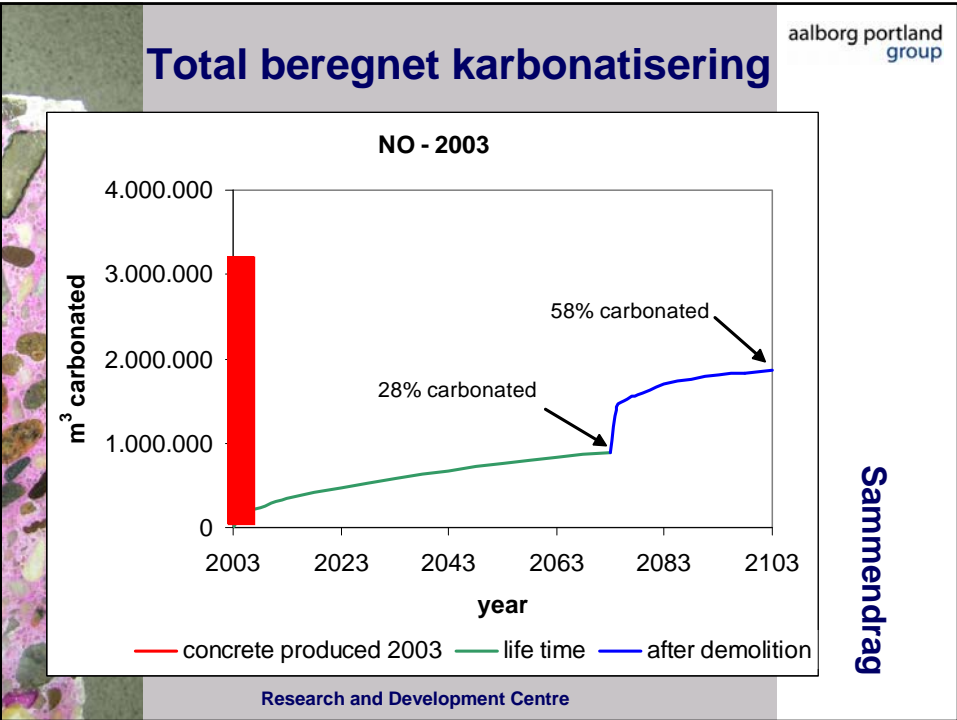
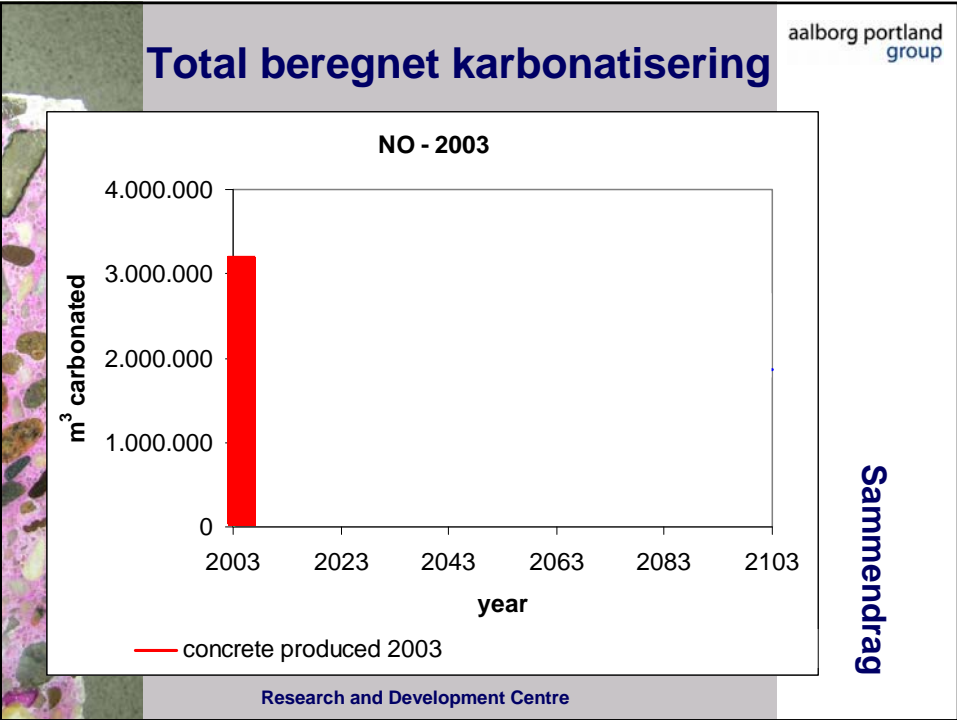
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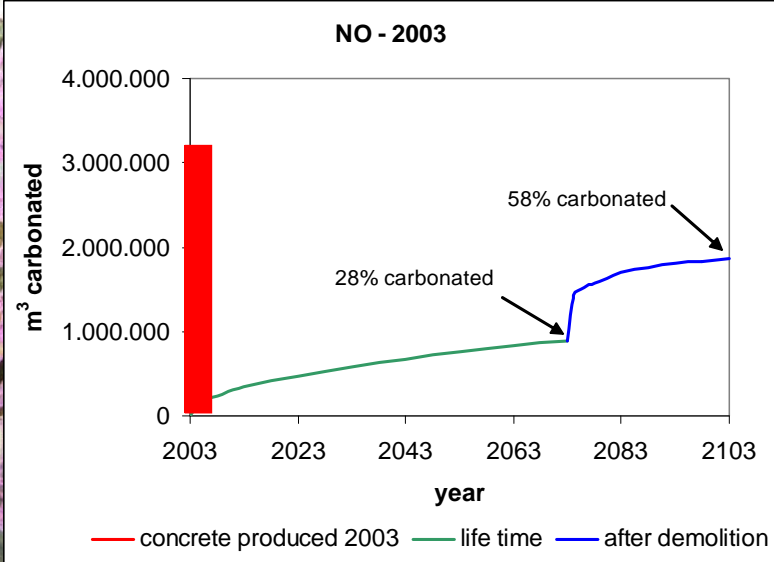
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Genanvendelse af beton

Nedkjust beton,  
oplagret 1 år



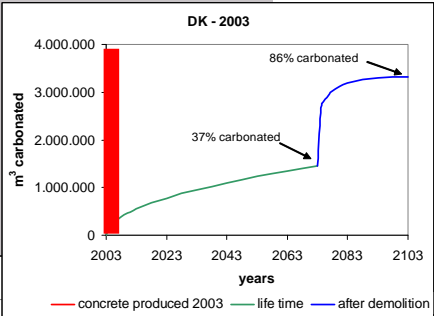
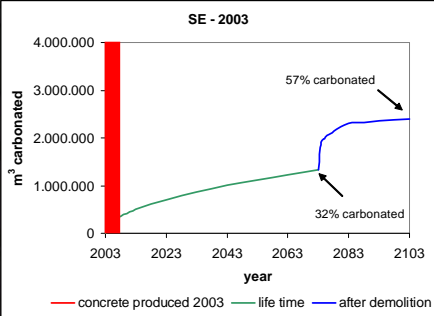
# Total beregnet karbonatisering



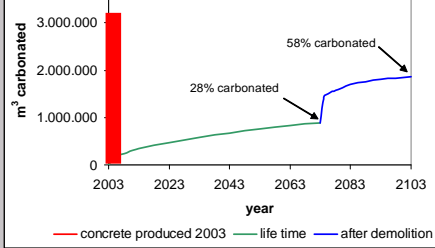
Sammendrag

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# Total beregnet karbonatisering



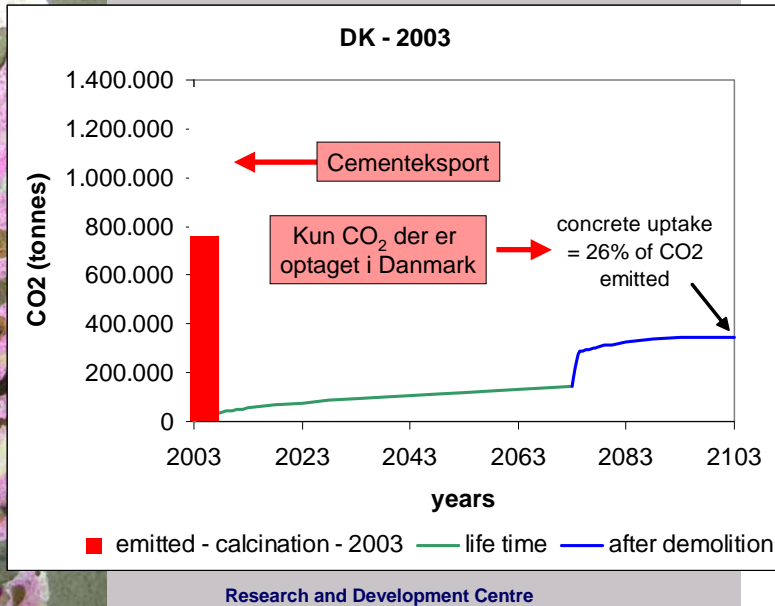
- 2003



Sammendrag

Research and Development Centre

## CO<sub>2</sub>-optag over 100 år



Sammendrag

## Hvad viser undersøgelsen?

- Betons CO<sub>2</sub> cyklus svarer til biobrændsler, med undtagelse af at kun en andel af CO<sub>2</sub> emissionen optages i løbet af de første 100 år

Konklusion





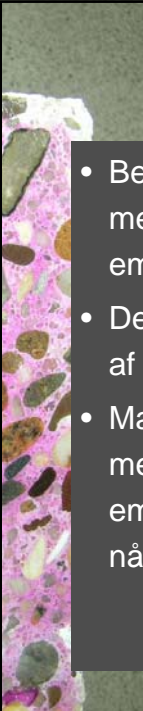
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## Hvad viser undersøgelsen?

- Betons CO<sub>2</sub> cyklus svarer til biobrændsler, med undtagelse af at kun en andel af CO<sub>2</sub> emissionen optages i løbet af de første 100 år
- Denne andel varierer fra land til land afhængig af hvorledes beton håndteres efter nedrivning

Konklusion

Research and Development Centre



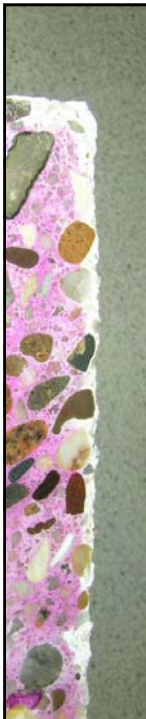
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## Hvad viser undersøgelsen?

- Betons CO<sub>2</sub> cyklus svarer til biobrændsler, med undtagelse af at kun en andel af CO<sub>2</sub> emissionen optages i løbet af de første 100 år
- Denne andel varierer fra land til land afhængig af hvorledes beton håndteres efter nedrivning
- Man bør derfor tage effekten af karbonatisering med i vurderingen af de samlede CO<sub>2</sub> emissioner fra cementproduktionen – specielt når betonen genanvendes efter nedknusning

Konklusion

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# Andre har tilsvarende ideer !

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**Research Project 12**  
**Concrete Carbonation**

**Project Objectives**  
To determine the potential of recycled concrete to act as a significant and economical method of active dioxide sequestration.

**Project Description**  
Manufacture of portland cement for concrete buildings and pavements involves production of large quantities of carbon dioxide (CO<sub>2</sub>), a greenhouse gas that contributes to global warming. Approximately half the CO<sub>2</sub> emitted during cement manufacture is due to consumption of fuel. Early on the high-temperature cement kiln and half is due to oxidation of carbon dioxide from raw materials such as limestone - a process called calcination. The research that centers in this kiln other calcination are highly reactive when mixed with water and form the chemical basis for hardening and strength formation in concrete. However, at ambient temperature and pressure, the calcination reaction can progress to reverse - a process called carbonation - as carbon dioxide from the atmosphere reacts with calcium and other minerals in hardened concrete to reform the original carbonate that was the raw material used to make cement. In normal concrete structures, the carbonation reaction is very slow. In fact, because it can lead to potential failure of the structure, design work to avoid or minimize carbonation by ensuring adequate concrete reinforcing steel, carefully monitoring water-cement ratios, or specifying admixtures that improve steel.

**Project Partners**  
New York State's Westchester County Highway Department

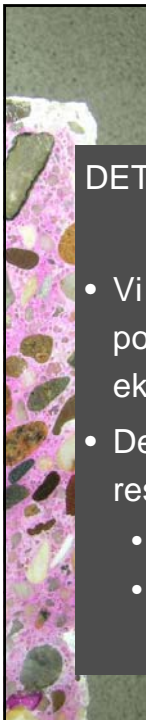
**Lead Products**  
Guidance to Federal and State agencies regarding the potential global warming benefits of concrete recycling and avoidance of new fuel consumption and to structure laws.

**Partner Information**  
The Recycled Materials Resource Center (RMRC), a cooperative agreement between the University of New Hampshire and the Federal Highway Administration, is a national center that promotes the appropriate use of recycled materials in the highway environment. The focus is on fielding some performance and environmental applications of using recycled materials.

For detailed quarterly progress reports for Project 12, as well as all RMRC-funded research projects, please see <http://www.rmrc.unh.edu/research/researchindex.asp>

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Konklusion



# Men.....

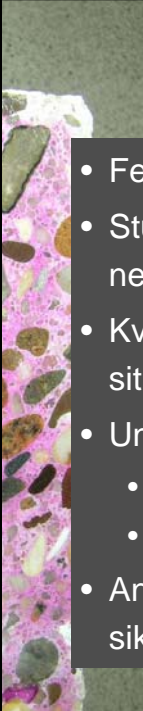
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## DETTE ER FORELØBIGE RESULTATER !

- Vi er sikre på, at CO<sub>2</sub>-optag i beton har en positiv miljøeffekt, men vi kender ikke det eksakte tal
- Det er nødvendigt at underbygge resultaterne:
  - Alle antagelser skal underbygges
  - Flere feltstudier af nedknust beton er nødvendige

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Konklusion



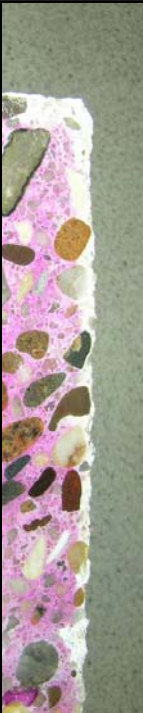
## CO<sub>2</sub>-optag ved genanvendelse

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- Feltstudier af genbrugsprocessen
- Studier af CO<sub>2</sub>-optag ved anvendelse af nedknust beton
- Kvantificering af CO<sub>2</sub>-optag i nuværende situation og potentiale ved nye procedurer
- Undersøgelse af andre miljøeffekter
  - NO<sub>x</sub>-optag
  - Udvaskning af tungmetaller
- Anvisning for genanvendelse af beton, der sikrer størst og hurtigst muligt CO<sub>2</sub>-optag

Opfølgning

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## Danmarks CO<sub>2</sub>-udledning

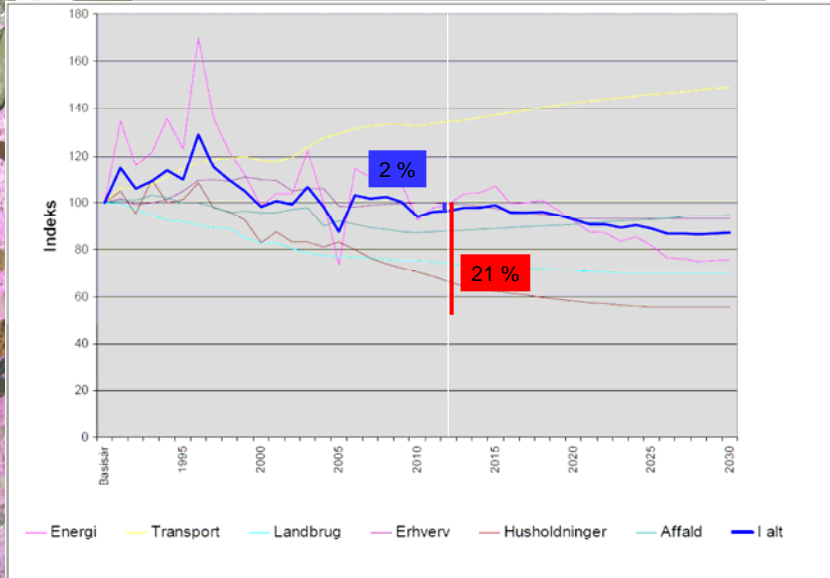
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Betyder det noget ?

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## Danmarks CO<sub>2</sub>-udledning

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Betyder det noget ?

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## Danmarks CO<sub>2</sub>-udledning

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Mio. Ton CO <sub>2</sub> -ækvivalenter	Basisår 1990/95 <sup>1</sup>	2004	2005 <sup>3</sup>	Pr. år 2008-12
CO <sub>2</sub> <sup>2</sup> (uden optag)	52,7	54,0	50,4	54,7
Metan (CH <sub>4</sub> )	5,7	5,8	5,6	5,5
Lattergas (N <sub>2</sub> O)	10,6	7,6	7,0	6,7
Industrigasser, HFC'er, PFC'er og SF <sub>6</sub>	0,3	0,8	0,8	0,9
Danmarks samlede udledning af drivhusgasser	69,3	68,2	63,9	67,8
Hvoraf eleksport udgør (- betyder sparet CO <sub>2</sub> ved import):	-6,3	6,9	-1,1	3,6
Kreditter fra optag af CO <sub>2</sub> i skov rejst siden 1990 jf. artikel 3.3 i Kyoto-protokollen				0,262
Kreditter fra optag af CO <sub>2</sub> i skov rejst før 1990 og jorder jf. artikel 3.4 i Kyoto-protokollen				2,0
Det juridisk bindende mål under EU's byrdefordeling (-21 %)				54,8

Betyder det noget ?

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## CO<sub>2</sub> optag i beton

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Ny skov siden 1990:

- 262.000 tons CO<sub>2</sub>/år

CO<sub>2</sub> optag i 1 mio. tons/år nedknust beton:

- 65.000 tons/CO<sub>2</sub>/år

CO<sub>2</sub> optag over 100 år:

- 350.000 tons CO<sub>2</sub>/år

Betyder det noget ?

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