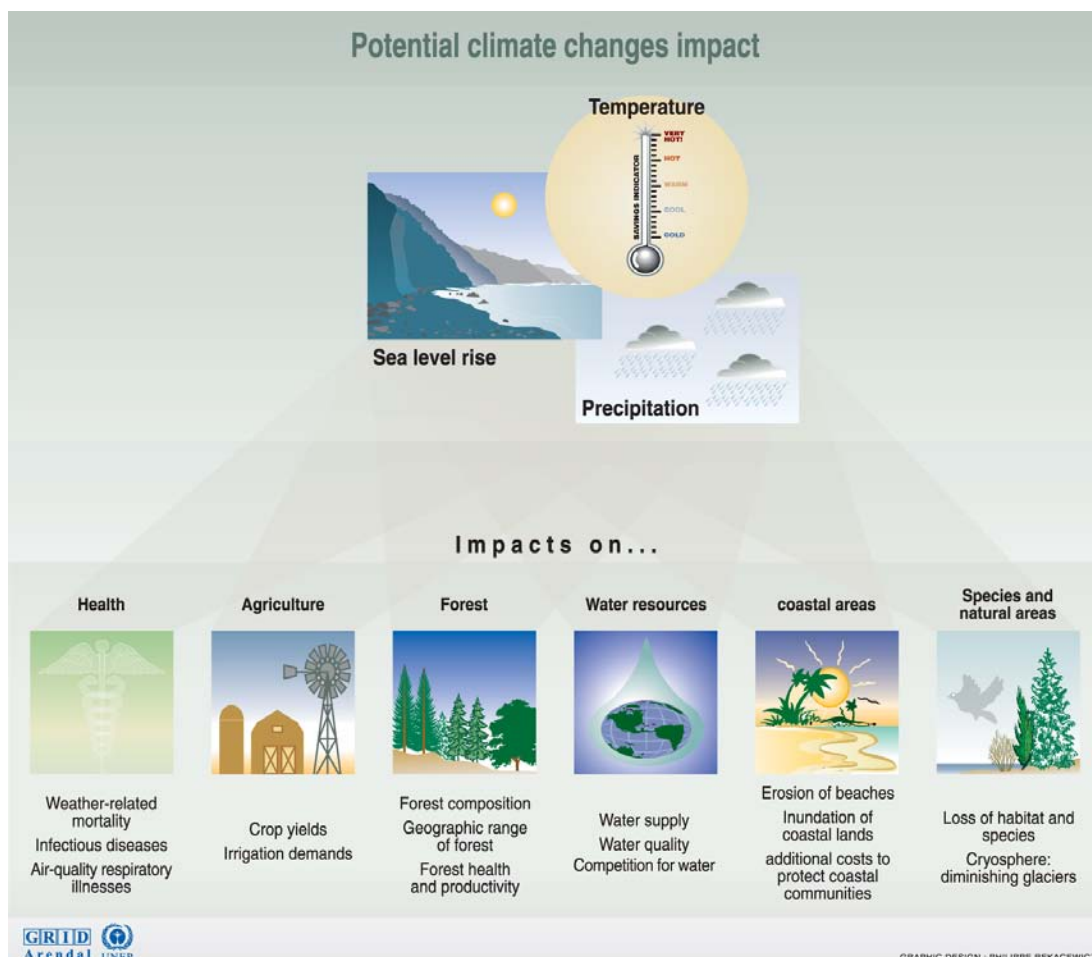


## An Attempt at an

Easy-to-Use, Hypertext-based Knowledge Base on Climate Change

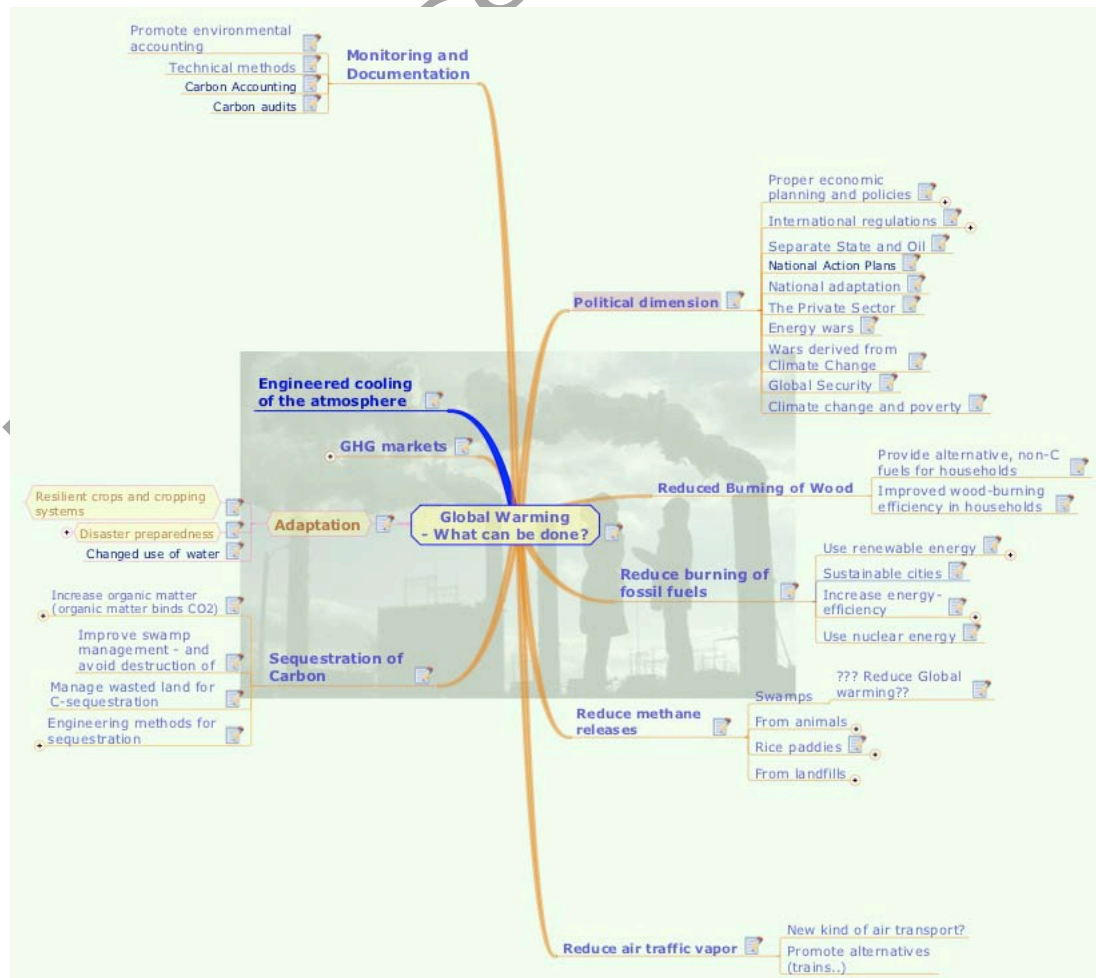
Part II

# Global Warming - What can be done?



Source: UNEP/GRID-Arendal. Potential climate change impacts

September 2009



This entire file is produced in the MindMap pictured above, using the software called Mindmanager. Interested readers may obtain the MindMap file, together with a free reader for the map, by sending an email to [sj@nordeco.dk](mailto:sj@nordeco.dk)

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## 1. Introduction

*This is an attempt to create a knowledge base on Global Warming for Nordeco and its clients and collaborators. The MindMap attempts to help with the overview, while the text generally provides first a 'key quote' or a description what an issue is about, and then goes on to refer to additional sources of information. If we have been able to identify sources that provide solid data, these are also listed, with some actual data.*

*This file should be read in conjunction with the one on Greenhouse Gasses, which attempts to provide info on which gases contribute to global warming as well as their sources and data on their volume.*

### **Key quotes:**

*'An initial 350 ppm CO<sub>2</sub> target may be achievable by phasing out coal use except where CO<sub>2</sub> is captured and adopting agricultural and forestry practices that sequester carbon. If the present overshoot of this target CO<sub>2</sub> is not brief, there is a possibility of seeding irreversible catastrophic effects.'* (James Hansen et al, Nov. 2008, 'Target Atmospheric CO<sub>2</sub>: Where Should Humanity Aim?', in press. Link may be found [here](#) )

*2. 'As yet, we humans manipulate materials and derive other energy services mostly using substantial temperature differences, in processes that use brute force rather than elegance, especially by burning fuel. Can human energy systems converge towards natural energy systems? The vision is appealing and exhilarating' (From the Book 'Keeping the Lights on', by [Walt Patterson](#), Earthscan 2007)*

*3. 'a simple conclusion: the benefits of strong and early action far outweigh the economic costs of not acting. Climate change will affect the basic elements of life for people around the world – access to water, food production, health, and the environment. Hundreds of millions of people could suffer hunger, water shortages and coastal flooding as the world warms. Using the results from formal economic models, the Review estimates that if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more. In contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year. The investment that takes place in the next 10-20 years will have a profound effect on the climate in the second half of this century and in the next. Our actions now and over the coming decades could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes. So prompt and strong action is clearly warranted. Because climate change is a global problem, the response to it must be international. It must be based on a shared vision of long-term goals and agreement on frameworks that will accelerate action over the next decade, and it must build on mutually reinforcing approaches at national, regional and*

international level. ([Stern review](#) - conclusion)

Homepages with **additional info** :

- [UNFCC](#) (United Nations Framework Agreement on Climate Change) Climate Change [Information Kit](#)
- [IPCC](#) (Intergovernmental Panel on Climate Change) – the mother lode of information.
- [Climate L](#), a homepage on climate change by International Institute for Sustainable Development, with useful links.
- [Sterns report and other papers](#) very clear, policy- oriented studies by an economist- team
- [EU](#) has a page on what can be done on climate change
- [New Scientist](#)
- [BBC](#) (quick overview, good pictures)
- The [Guardian](#), environment
- [WorldWatch](#) (collection of papers)
- [Greenpeace](#)
- [Natural Resources Defense Council](#) (short introduction and in-depth information and links)
- [Al Gore](#) (Al Gores Video)
- [World Land Trust](#) (has good briefs on possible actions against climate change)
- [IPCC's graphics](#)
- [Tiempo Climate](#) - a weekly magazine on climate and development
- A [journal](#), which focuses on mitigation and adaptation of climate change

Specific sites on **climate change and 'development'**

- The [Tearfund](#)
- [FAO on Climate Change and Agriculture](#)
- [IIED](#) (International Institute on Economics and Development) [collection of links](#).

Data on emissions can be [found at WRI](#).

**Definitions:**

- **Climate change (CC)** in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the UNFCCC, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.
- **Adaptation** can be defined as "any action that seeks to reduce the negative effects, or to capitalize on the positive effects, of climate change"
- **Mitigation** is an anthropogenic (human) intervention to reduce the sources of greenhouse gases or enhance their sinks.
- **Carbon sequestration** is defined as the capture and storage of carbon that would otherwise be emitted to or remain in the atmosphere.
- A **source** is any process or activity that releases a GHG or aerosol or precursor of a GHG into the atmosphere.
- A **sink** is a mechanism that removes a GHG or aerosol or precursor of a GHG from the atmosphere. (Extended explanation of a [Carbon sink](#) from Wikipedia)

A comprehensive glossary of most technical terms in CC can be found [here](#).

## 2. Political dimension

**Key quotes:** Three elements of policy are required for an effective response: carbon pricing, technology policy and energy efficiency. [Stern review](#)

Climate change is the greatest market failure the world has ever seen, and it interacts with other market imperfections. Three elements of policy are required for an effective global response. The first is the pricing of carbon, implemented through tax, trading or regulation. The second is policy to support innovation and the deployment of low- carbon technologies. And the third is action to remove barriers to energy efficiency, and to inform, educate and persuade individuals about what they can do to respond to climate change. [Stern review - conclusion](#)

The latest round of negotiations regarding the future of the United Nations Framework Convention on Climate Change (UNFCCC), the [14 Conference of the parties](#) in Poznan Poland, took place in December 2008.

The coming [COP15](#) in Copenhagen is expected to come up with a replacement for the Kyoto protocol. The key issues, according to Yvo de Boer UNs climate boss, the key issues are: 1. How much are the industrialized countries willing to reduce their emissions of greenhouse gases? 2. How much are major developing countries such as China and India willing to do to limit the growth of their emissions? 3. How is the help needed by developing countries to engage in reducing their emissions and adapting to the impacts of climate change going to

be financed? 4. How is that money going to be managed?

#### Additional Information:

- on overall economic considerations about acting vs. non-action on climate change: A [booklet](#) from OECD, (December 2008)

- On 'Ethical Frameworks and Intertemporal Equity':

**Quote:** '..questions such as 'what do individuals value', 'what should be their relation to decisions and decision- making', 'what is the decision- making process' and 'who are the decision- makers' arise immediately and strongly in the ethical analysis of climate change. These questions take us immediately to different perspectives on ethics. *Stern report, Annex 2A*

- On [integrating forestry and agriculture](#) in GHG reduction into economic planning

- On insurance companies' calculations on the [cost of CC](#).

**Quote:** 'Our research shows that even quite small increases in the intensity of such storms, as predicted by the latest climate science, could increase damage costs by at least two- thirds by the end of the century.'

The most extreme storms could become even more destructive, leading to losses greater than we have seen before. Insurance markets could become more volatile, as the costs of capital required to cover such events increased.

Many of the potential costs described in this report could be avoided by taking action now. Decisionmakers in government and elsewhere have a real opportunity to make rational choices for the future by taking account of the financial costs of climate change.'

From the [Association of British Insurers](#).

#### a. Dis-incentives for GHG producing technologies

Such as [taxes](#), levies, penalties etc...

#### b. Incentives for mitigation

##### What is it?

Policy instruments for mitigating climate change are needed (as the market will not do it, and regulation alone may also not be sufficient)

They may come in a host of different forms, from subsidies for R&D, to pricing policies that favor climate-friendly technologies, to support to education and training needed for climate change adaptation and mitigation etc.

##### Additional info

- EU's [action plan](#) for climate end renewable energy

- A [paper](#) on possible incentives in new global climate-agreements

- A list of possible [tax-related mechanisms](#) for promoting climate mitigation (from Trinidad and Tobago)

### C. Tax on Carbon

#### What is it?

The idea is simple: Put a tax on GHG emissions, and use (some of) the revenue to lower e.g. income tax or other expenditures for citizens.

It currently is being promoted in Canada ([video](#)) and Ireland, and is seen by many as a fair and more [effective](#) mechanism than 'Cap and Trade'

#### Additional Information

- A '[Carbon Tax Center](#)' by scientists and economists.
- The British paper/magazine 'The Economist' vigorously promotes Carbon Tax. One example [here](#) (subscribers only)
- France [intends to implement](#) a carbon tax from 2010.

### d. Climate change in overall economic planning

#### What is it:

National efforts to incorporate climate change mitigation and adaptation into economic planning and policies:

Additional Information: A plan from [Australia](#) (2008)

### e. International regulations

**Key quote:** Key elements of future international frameworks should include:

- *Emissions trading:* Expanding and linking the growing number of emissions trading schemes around the world is a powerful way to promote cost- effective reductions in emissions and to bring forward action in developing countries: strong targets in rich countries could drive flows amounting to tens of billions of dollars each year to support the transition to low- carbon development paths.
- *Technology cooperation:* Informal co- ordination as well as formal agreements can boost the effectiveness of investments in innovation around the world. Globally, support for energy R&D should at least double, and support for the deployment of new low- carbon technologies should increase up to five-fold. International cooperation on product standards is a powerful way to boost energy efficiency.
- *Action to reduce deforestation:* The loss of natural forests around the world contributes more to global emissions each year than the transport sector.

Curbing deforestation is a highly cost- effective way to reduce emissions; large scale international pilot programmes to explore the best ways to do this could get underway very quickly.

- *Adaptation:* The poorest countries are most vulnerable to climate change. It is essential that climate change be fully integrated into development policy, and that

rich countries honor their pledges to increase support through overseas development assistance. International funding should also support improved regional information on climate change impacts, and research into new crop varieties that will be more resilient to drought and flood. *Stern review*

#### f. Kyoto

##### What is it?

The Kyoto protocol is an International 'Cap and Trade Mechanism', setting Cap's (voluntary) for emission in wealthy countries (Annex 1 countries)

Issues about implementation of the current Clean Development Mechanism can be read [here](#).

(See also under [GHG markets](#) )

#### g. Separate State and Oil

**Substance:** Many governments are deeply dependent on oil revenues (Russia, Saudi Arabia, Brunei, Venezuela, Norway, etc..) and many governments and administrations consist of people with direct economic interests in continued oil production (e.g. USA) or with swing-door connections to power industries, automotive industries, aircraft producers or other fossil-fuel related industries.

It is imperative to break or push aside these interdependencies to obtain effective action on climate change.

Actually, oil is not even the worst GHG- source - coal is. So the word should be 'separate fossils and state'. That may not be any easier, but has a nice double meaning to it.

#### h. National Action Plans

##### Additional Information:

- New Zealand has an ambitious action plan for combating climate change in its [agriculture and forestry sectors](#).

#### i. National adaptation

An example of a national adaptation plan, from [Scotland](#)

## j. The Private Sector

### What is it?

Many companies and associations of companies express commitment towards CC Mitigation. Among those that encouraged the G7 meeting in June 2007 to take binding action were:

- Business Council for Sustainable Energy (Australia) Business Council for Sustainability Energy – e5 (Europe) Business Council for Sustainable Energy (UK) Business Council for Sustainable Energy (US) Carbon Disclosure Project Corporate Responsibility Interface Center - Verein für ethische Investoren e.V. (CRIC) European Carbon Investors and Services (ECIS) European Climate Forum (ECF) European Corporate Leaders Group on Climate Change (Cambridge Programme for Industry) European Insulation Manufacturers Association (EURIMA) European Technical Contractors Committee for the Construction Industry (CEETB) Global Roundtable on Climate Change (GROCC) Institutional Investors Group on Climate Change (IIGCC) Investor Network on Climate Risk (INCR) London Climate Change Services (LCCS) Munich Climate Insurance Initiative (MCII) „respect“ - organizing the Business Leaders Initiative on Climate Change (BLICC) and the Respect Table The Climate Group Underground Coal Gasification Partnership (UCG Partnership) U.S. Green Building Council (US GBC) Verband der Elektrizitätswirtschaft (VDEW) 3C - Combat Climate Change (Info from a [press release](#) by the group)

### Additional Information:

- An example from Mauritius show how some [industries adjust](#) to customer demands for sustainable production.
- A report (December 2008) surveying climate action in large US companies show a few positive examples and a lot of ['room for improvement'](#) .
- UN's environmental programme (its 'Finance Initiative) works with the insurance industry to provide finance and [insurance schemes](#) for renewable energy in developing countries.
- A programme for [Corporate Climate Response](#) exist in the USA.

## k. Energy wars

### What is it:

The struggles among corporations and governments to control sources of fossil fuels have led (and still lead) to many wars.

Thus, relying less on fossil fuels may reduce international tensions and conflicts

(nuclear power may however, increase conflicts).

**Additional info:**

- [here](#) (BBC)
- [here](#) (Multinational Monitor) and
- [here](#) (From the Book 'Blood and Oil')

### **l. Wars derived from Climate Change**

**What is it?**

UN [expects conflicts](#) as climate change makes life unbearable in some regions of the World.

The Military in the US is [preparing](#) for these situations.

A paper in [ScienceDaily](#) outlines possibilities for future wars.

### **m. Global Security**

**What is it?**

It is foreseen climate change may exacerbate some existing conflicts and create new ones.

**Additional information:**

- In the US the intelligence agencies are tasked with reviewing how Global Warming may threaten countries and regions that are of 'economic and political interest' to the USA. (A [news report](#), from Inter Press Service).

- A homepage with [links](#) to official USA reports on the issue.

- Pentagon sees a necessity (and opportunity) to [engage the military](#) in 'resolving' crises that originate from climate changes.

### **n. Climate change and poverty**

**Key quote:**

The linkages between vulnerability and poverty can be summarized as:

1. any added risk by climate change to current ways of securing well-being;
2. the particular strategies or adaptive capacity of poor people in the face of climate stresses;

3. the causes of vulnerability, or specific factors and conditions that make poor people vulnerable to climate stress.

(From an [analysis](#) by NORAD, (2007) titled 'Climate Change Adaptation and Poverty Reduction')

**Additional Info:**

- OECD has produced a [Declaration](#) on Integrating Climate Change Adaptation into Development Co- operation
- Overseas Development Institute has produced '[opinions](#)' on poverty reduction through agriculture, in light of expected climate changes

### 3.Reduced Burning of Wood

#### a. Provide alternative, non-C fuels for households

**Additional Information:**

A [web resource](#) on how communities in developing countries may use non-wood energy.

Another [web resource](#) on sustainable biofuel production in developing countries

#### b. Improved wood-burning efficiency in households

**What is it?**

Traditional stoves - or even open fires - are quite easily replaced with more efficient stoves, saving substantial inputs of firewood. Countless designs exist, the most easily adopted being those that can be made by local people, from local materials and with minimum investment.

As an additional benefit the reduction in smoke from the improved stoves reduces the considerable health risk from smoke indoors, associated with less developed mean of providing heat for cooking.

**Additional information:**

- a [general introduction](#) , with description (including photos and videos) of several types of stoves.
- a description of [how to produce](#) a portable stove from clay
- a YouTube [video](#) about stoves in Uganda
- a set of [posters](#) on how to produce one model of improved stove

### 4.Reduce burning of fossil fuels

**Key quote:** Emissions can be cut through increased energy efficiency; changes in demand, and through adoption of clean power, heat and transport technologies. The power sector around the world would need to be at least 60% decarbonised by 2050 for atmospheric concentrations to stabilize at or below 550ppm CO<sub>2</sub>, and deep emissions cuts will also be required in the transport

sector. (*Stern review*, conclusion)

Homepages with **additional info** :

- a Global initiative (called [REEGLE](#)) on energy efficiency and alternative energy
- a Danish initiative on '[Solar Cities](#)'
- UNDP has a page on [Energy for Sustainable Development](#)
- It is now (December 2008) official that oil output in the World will [peak in 2020](#) - far earlier than previously predicted.
- And the [militaries](#), that often go to wars to control fossil fuels, want to reduce their own consumption

#### **a. Use renewable energy**

**Key quote:** Technology policy should drive the large-scale development and use of a range of low-carbon and high-efficiency products. (*Stern review*)

Emissions can be cut through increased energy efficiency, changes in demand, and through adoption of clean power, heat and transport technologies. The power sector around the world would need to be at least 60% decarbonised by 2050 for atmospheric concentrations to stabilize at or below 550ppm CO<sub>2</sub>, and deep emissions cuts will also be required in the transport sector. (*Stern review conclusion*)

**Additional Information sources:**

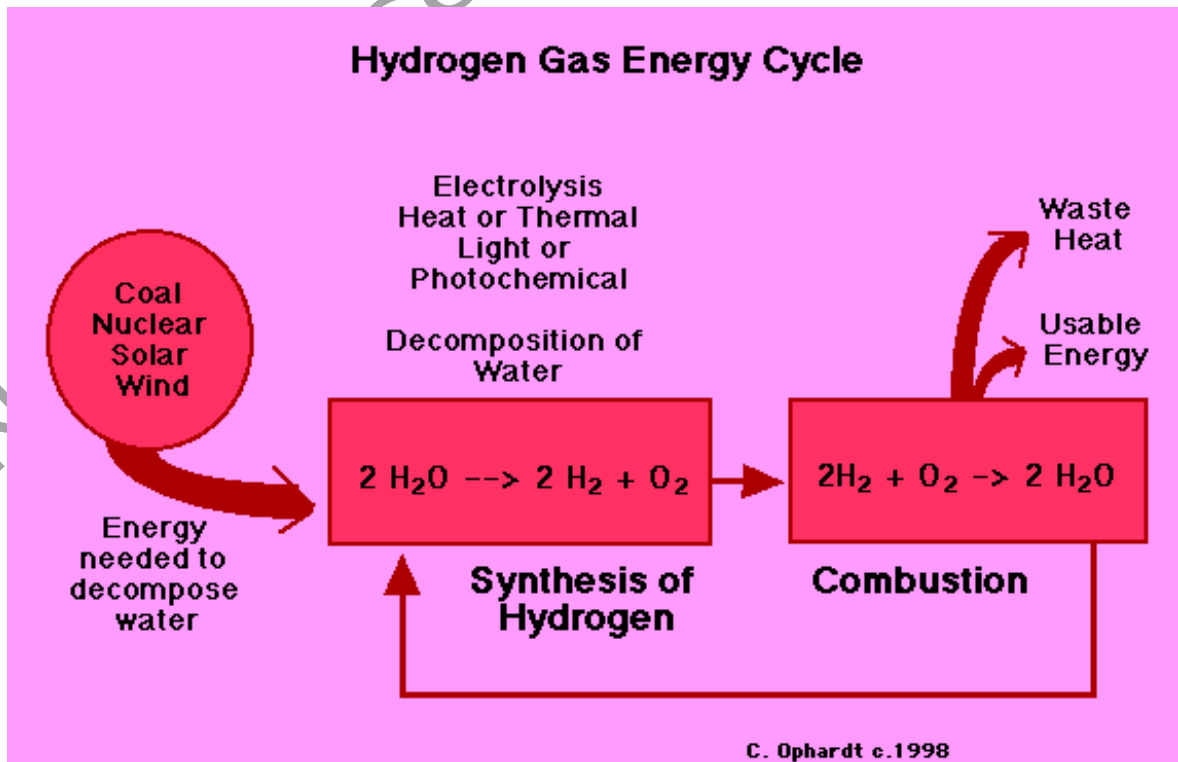
- General overview over [renewable energy sources](#)
- General overview of alternative energy (in Danish) from [Energistyrelsen](#)

#### *i. Hydrogen as energy carrier*

**What is it:**

In theory - and increasingly in practice - hydrogen may be used as energy carrier instead of hydrocarbons or carbon. Splitting the water molecule, which consists of one oxygen and two hydrogen atoms may generate hydrogen. Hydrogen can then be stored, transported and burned with oxygen, again forming water. If the source of hydrogen is also water, the cycle is complete. If further the hydrogen is obtained from water by using renewable energy, the cycle is truly sustainable.

Hydrogen may be used in a combustion engine, pretty much the same way as gasoline or diesel is used today or it may provide the fuel for a fuel cell (which generates electricity) or transform its energy content in other ways.



#### Additional info,

- A comprehensive [homepage with additional links](#)
- Some [videos](#), from Scientific American
- The [hydrogen community in Denmark](#)

#### *ii. Solar energy*

#### Key quote:

'The solar energy received each year by Earth is roughly equal to 10,000 times the total energy consumed by humanity. In other words, if we could only exploit 0,01% of this incoming solar energy for the profit of humankind, we could do without oil, coal, gas and uranium' (from a [homepage](#))

#### Definition and more info, [here](#)

- A basic [explanation](#), with useful links
- A similarly [simple explanation](#)
- A page with more advanced [explanations](#)
- An [international centre](#), offering courses and other info on solar energy

- An [overview site](#) from ScienceDaily
- An international [journal](#) , devoted to Solar Energy
- An example of a [solar power plant](#) in Spain
- An [article](#) in 'The Economist'
- And an [ambitious plan](#) for solar energy from the Sahara by large, centralized companies.

#### Data

- data for solar radiation are [available here](#).

#### *iii. Wind*

##### What is it?

Wind energy actually derives from the solar energy hitting the soil (and heating it differently in different places, causing pressure gradients, which the wind seek to eliminate).

It can now easily be exploited to produce electricity.

Excess wind energy (during heavy wind) may be exploited to produce hydrogen, from water.

- Several PowerPoint presentations from a [workshop](#) by the US Department of Energy
- An [example](#) from Denmark (in Danish)
- The [hydrogen community in Denmark](#)

#### *iv. Waves*

##### What is it?

Wave energy derives from the solar energy, through the actions of the wind.

##### Additional Info:

- From [Wikipedia](#)
- A page with [pictures and descriptions](#) of main technologies
- Portugal is leading the way [towards practical application](#)
- Denmark is [also active](#) .

#### v. *In space*

##### **What is it?**

Technical schemes are being put together, where huge collectors (mirrors) in space will [send solar-derived energy to Earth](#), frequently suggested through use of microwaves.

##### **Additional info:**

- an [article](#) about such work in Japan.
- another [article](#) about efforts in the USA
- a international [symposium](#) (September 2009)

#### b. Geothermal

##### **Additional info:**

- [Wikipedia](#)
- [Geothermal Education Office](#)

#### c. Biofuels

**What is it:** When the plant-derived (bio)fuel is burned in an engine, the CO<sub>2</sub> released is offset by the amount of the gas absorbed by the plants when they grew.

It is, in principle, approximately carbon neutral; though the energy needed to plant, tend, harvest, process and transport the finished product can make the equation (much) less favorable.

The scientific principle behind biofuels is the carbon cycle:

As they grow, plants absorb carbon dioxide (CO<sub>2</sub>)

The carbon (C) builds tissues and feeds the plant while the oxygen (O<sub>2</sub>) is released

When plant material is burned the carbon re- combines with oxygen.

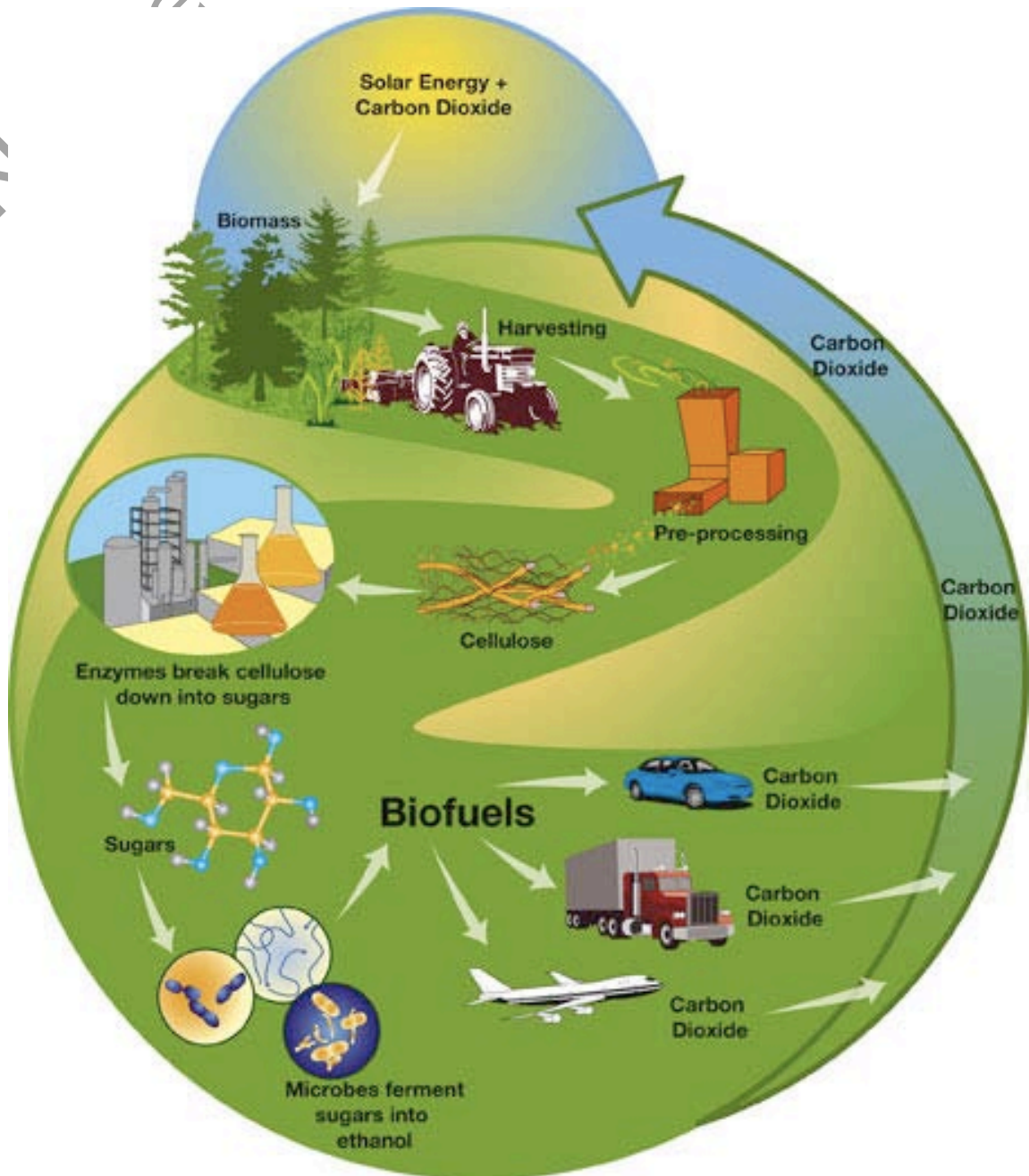
The resulting carbon dioxide is released back into the atmosphere. The contribution of biomass to the greenhouse effect is therefore far less than for traditional fossil fuels, which in a sense are biofuels, stored from past times.

The two main players in the market, bioethanol and biodiesel, are mainly made from crops such as cereals, soybean, rapeseed oil, sugar cane and palm oil., while smaller quantities are made from waste from abattoirs or from wood chips

While governments embrace what they see as a key player in a low- carbon future, there are concerns over some potential, unwanted consequences.

Demand for land to grow these crops could put pressure on valuable ecosystems

such as rainforests, and reduce the area available for subsistence food crops in developing countries.



### *The next generation*

Within a decade, current biofuel production methods could be replaced by "second generation" fuels. These will be produced from agricultural 'waste', e.g. straw, shells or other. The carbon-based molecules (celluloses and lignocelluloses) can be broken down, e.g. by enzymatic action, to molecules

usable in combustion engines or other motors.

Second generation fuel will have a smaller carbon footprint because the amount of energy- intensive fertilizers and fungicides will remain the same for a higher output of useable material.

*(The above is mainly taken from [BBC](#) )*

From the policy-makers' point of view, second- generation biofuels offer a number of advantages:

They allow the use of a much wider range of raw material, especially waste. This can significantly lower the cost of the feedstock.

The resulting fuels are high- quality and clean-burning, with potentially a much lower well- to- wheels CO<sub>2</sub>-profile than other liquid fuel options. The cultivation process (if any) could be less environmentally intensive than for ordinary agricultural crops. Lower intensity of cultivation will result in even lower greenhouse gas emissions from cultivation. They can be co-produced with electricity.

*The above is mainly taken from [here](#):*

The International Energy Agency released in December 2008 a paper on [prospects and challenges](#) for 2nd generation biofuels.

*Potential problems:*

Questions, problems and tradeoffs in the introduction of large- scale bioenergy production

– Land availability (short and long term), Land productivity, Plant species and species mixture, Environmental sustainability, Collection and transport, Social factors, Economic feasibility, Ancillary benefits, Fertilizer and pesticide requirements, N<sub>2</sub>O release from additional nitrogen, Nutrient cycling, Water requirements, Energy input/output balance, Impacts on biodiversity, Influence on soil and water quality, Contribution to runoff and soil erosion, Conflicts with food production, Level of subsidies required

From a [Journal Article](#), Sauerbeck 2001).

A journalist sums up [some current problems](#) with biofuels.

In view of the biofuel production's negative [impact on food security](#) , EU has [scrapped its goal](#) of 10% transport fuel from biofuels.

The EU is [promoting standards](#) for biofuels that may seek environmental and social sustainability. There is now (August 2008) a [draft standard](#) for certification.

**Additional info:**

- OECD has a [comprehensive](#) discussion of biofuels (Sept. 2007)

- EU has an [action plan on biomass](#) (2005), which regularly gets [updates](#).
- NovoZymes is [active in this field](#), i.e. with cooperation in China on 2nd generation biofuels.
- China has an ambitious [biofuel programme](#)
- Also Danisco has a [programme on 2nd generation biofuels](#), as has [Dong Energy](#).

In the production of '[Biochar](#)' (see elsewhere in this text), another type of biofuels is produced, in a potentially [Carbon-negative process](#) (Carbon is actively removed from the atmosphere), with other possible positive side effects; the 'waste' may be used to enrich soils or remove chemical pollution from soils.

In Brazil a [biofuel for airplanes](#) has been developed and produced.

#### *i. Engines on renewable energy*

### Combustion

**What is it:** [Hydrogen](#) may be used in a combustion engine (much like the one now sitting in our cars).

A BMW set a number of records with [such an engine](#).

### Fuel Cells

**What is it?**

- Wikipedia gives a [definition](#)

#### *ii. Hydropower*

**What is it?**

Hydropower eventually also derives from solar energy (as the heat from the sun evaporates water and transports it to the atmosphere, from which it precipitates).  
(From a [homepage](#))

The energy released when the water moves to lower elevations may be used in hydropower, either in large schemes or in microhydropower.

**Additional info:**

- A homepage on [micro-hydropower](#)

#### d. Sustainable cities

##### What is it?

A growing part of humanity lives in cities. A city acquires all its energy from the country surrounding it, and indeed from the world. An ever-increasing part of the global energy demand comes from cities. Hence efforts to reduce fossil fuel consumption are especially effective when directed towards cities.

##### Additional information

- a general [introductory/learning homepage](#) from the UK
- a homage for a [network](#) of some 30 cities striving to become sustainable
- an article on [zero- carbon cities](#) from 'Architectural Record
- a homepage from the [Danish association for city ecology](#)
- UN Habitat has a [programme](#) on sustainable cities
- Wikipedia on Dongtan, a [sustainable city being built](#) in China. 'Wired Magazine' has [more](#) about it. Recently it seems to have hit [hard times](#) .
- An article about Malmoe's [Western Harbour residential area](#)

#### e. Increase energy-efficiency

##### Additional info:

- a [workshop](#)\_(2007) on GHG mitigation in the energy sector

##### *i. Promote low-energy lighting*

##### What is it?

Huge amounts of energy may be spared if using lighting that is more efficient.

A prime candidate is [diodes or LED](#) .

##### *ii. Transport*

##### An example:

[Electrical cars](#) seem to be one development that may cut GHG emissions significantly more than the already-existing hybrids.

### *iii. Power Generation and Distribution*

#### New relations between the electricity grid and local producers?

##### What is it?

In the current way electrical grids are set up, there is enormous waste and frequently very little opportunity for decentralized energy producers to be connected. Decentralized power production, such as by windmills, fuel cells, biogas generators, and storage in e.g. rechargeable batteries in vehicles etc. may change the way the power grid functions. Away from large centralized networks with few providers to many, smaller, local providers. This, combined with modern management, could increase the efficacy of electricity distribution considerably. The catchword is 'Smart Grids'

##### Additional information:

- a brief [overview article](#)
- on [electric cars](#) and the grid
- See the book '[Keeping the lights on - towards sustainable electricity](#)' by Walt Patterson
- A [comprehensive paper](#)
- An EU [Homepage](#) on the subject

### *iv. Engines*

##### What is it?

Internal combustion engines have dominated the field since steam went out of use. They are highly [inefficient](#), only converting 18-25% of the chemical energy into kinetic (for movement) energy. They probably are on their way out, and more efficient designs will take over.

##### Additional information

One of the more efficient designs is

- [Stirling Engine](#)

The Stirling engine can now be used [with solar panels](#) and generator, to produce electricity from sunshine

### *v. Decrease energy use in buildings*

##### What is it?

Buildings use most of the energy consumed in the world. In cold climates heating

use a lot of energy and in hot climates, it is cooling. There are ample possibilities for reducing this energy use, and to get much of it from energy sources that do not produce GHG.

**Additional Information:**

- A [report](#) from UN Environmental Programme
- a press release about a municipal building that will be CO<sub>2</sub> [neutral](#)
- a report, suggesting investments in energy-conserving buildings as a [cost-effective way out](#) of the economic and environmental crisis in the US.

#### f. Use nuclear energy

Nuclear energy production does not (as such) release CO<sub>2</sub>. Construction and operation of nuclear power plants is however, [far from carbon neutral](#) .

It does however have many [unresolved problems](#)\_, (pointed out in a review by Massachusetts Institute of Technology)

- It is very [expensive](#)\_ (A citizens' network on Nuclear Energy), especially when external costs are considered
- It strengthens large, centralized (and very powerful) private or semi-public utility companies
- There is no sustainable solution to the waste problems
- Nuclear power infrastructure is vulnerable to natural disasters, wars and other attacks.
- A recent book (January 2009) [sums up](#) those problems

## 5.Reduce methane releases

### What is it?

Methane is released from organic matter that is decomposing without oxygen (anaerobic or anoxic conditions). This may be from soils, sediments below water (swamp gas), buried waste in landfills, animal manure or other organic matter.

In some of the forms, it is possible to cover the area, trap the methane and burn it, which in turn releases CO<sub>2</sub>. CO<sub>2</sub> is a much less potent GHG than methane (CH<sub>4</sub>).

Many of the early CDM project are about trapping methane from landfills, in China mainly.

#### a. Swamps

### What is it?

There is most likely a 'positive feedback' between global warming and increased thawing of some permafrost swamps e.g. in Siberia. If these thaw, they will in turn release much more methane, contributing to further global warming. Reducing global warming will reduce this risk.

### b. From animals

#### What is it?

Ruminants (such as cows, goats and sheep) release methane from their digestive tracts (they burp). The amount depends on their feeding and other factors (such as microbial flora in their stomachs).

Further, once the food is passed and become manure, it may produce methane if left to decompose (partially) without oxygen.

#### Manure

#### Recover methane - and use as fuel

#### Additional information

- From Colorado State University [homepage](#) on how to make biogas from manure

#### *i. Manage livestock better*

Additional info:

- A [question/answer page](#) from FAO provides some ideas
- A [similar page](#) from the US Environmental Protection Agency

#### Proper feeding

#### Key quote:

'Many factors influence methane emissions from cattle and include the following: level of feed intake, type of carbohydrate in the diet, feed processing, addition of lipids or ionophores to the diet, and alterations in the ruminal microflora. Manipulation of these factors can reduce methane emissions from cattle'. (From a [paper](#))

#### Additional info

- [A](#) news item from the US Academy of science on an additive that may reduce methane in ruminant flatulence.
- A [resource page](#) from the US EPA on how to assess impact of and manage ruminants for reduced methane

### c. Rice paddies

#### What is it?

In flooded rice fields (most rice fields are of this type) the water cover makes for oxygen free conditions in the soil a few millimeters below the surface. Under such anaerobic conditions organic matter (such as straw, root residues and others) are decomposed to methane. This GHG is released to the atmosphere through the water but also through the rice plant.

#### Promote SRI

**What is it?** : SRI (System of Rice Intensification) is a method for growing rice, which does not require constant flooding. It actually increases yields and drought-resistance of the crop, but requires better skills by the farmer. By avoiding constant flooding it also reduces methane release from the soils. It may well be combined with no- tillage.

**Additional info:** [Cornell University](#)

#### Promote dryland rice

#### Reduce chemical fertilizer use

#### Key quote:

'The long-term application of ammonium- ( $\text{NH}_4$ ) based fertilizer, but not nitrate- ( $\text{NO}_3$ ) based fertilizer, completely inhibited  $\text{CH}_4$  uptake, but the application for the same period of farmyard manure that contained more N than the fertilizer had no inhibitory effect'. (From a journal [paper](#), about a study from England)

### d. From landfills

#### What is it?

In landfills (mainly from cities) huge amounts of organic and other waste was - and in many cases still is – heaped in layers and often eventually covered with soil. This creates anoxic (oxygen-free) conditions. Thus, the organic matter, when broken down by microorganisms, is released as methane.

#### Cover the landfill, collect the methane

#### More info:

- A [brief overview](#) text.
- A page from the voluntary GHG market, about [landfill projects](#)

## 6.Reduce air traffic vapor

**What is it?:** Airplanes contribute to global warming in 2 ways - by releasing  $\text{CO}_2$  and by their 'contrails', the streak of water vapor/ice seen on the sky, after a jet

has passed. The latter is a problem because they 'insulate' the earth and thus increase temperature (they also reflect sunlight thus cooling - but the former effect is greater).

Additional [info](#).

New kind of air transport?

Promote alternatives (trains..)

## 7. Sequestration of Carbon

**What is it:** 'Sequestration' means binding of GHG in forms or locations where they do not reach the atmosphere. It could be in the form of organic compounds, sequestered by plants (trees, crops, algae or others), or chemically, by engineering means.

This latter is frequently called 'carbon capture and storage - CCS'

Capture and storage prevents newly produced CO<sub>2</sub> from reaching the atmosphere, while 'organic' sequestration actually *removes* CO<sub>2</sub> from the atmosphere.

### Key quotes:

1 : 'An initial 350 ppm CO<sub>2</sub> target may be achievable by phasing out coal use except where CO<sub>2</sub> is captured and adopting agricultural and forestry practices that *sequester* carbon. If the present overshoot of this target CO<sub>2</sub> is not brief, there is a possibility of seeding irreversible catastrophic effects.' (James Hansen et al, Nov. 2008, 'Target Atmospheric CO<sub>2</sub>: Where Should Humanity Aim?', in press. Link may be found [here](#) )

2: Even with very strong expansion of the use of renewable energy and other low carbon energy sources, fossil fuels could still make up over half of global energy supply in 2050. Coal will continue to be important in the energy mix around the world, including in fast- growing economies. Extensive carbon capture and storage will be necessary to allow the continued use of fossil fuels without damage to the atmosphere. (*Stern, review - conclusion*)

### Additional info:

- From [Wikipedia](#)

**Data:** The direct effects of land use and land-use change (including forest loss) led to a net emission of 1.7GtC/year in the 1980's and 1.6GtC/year in the 1980's. (Swingland (ed.) Capturing Carbon & Conserving Biodiversity, 2003 p. 195)

- An [overview paper](#) (pay) on potential in changing forestry and agricultural practices. (Science)

### a. Increase organic matter

(organic matter binds CO<sub>2</sub>)

**What is it?** : Synthesis of organic matter (sugars, other hydrocarbons, lipids (fat and oils) and protein) binds CO<sub>2</sub>. By felling forest and depleting soils of organic matter, enormous amounts of CO<sub>2</sub> have been and still are released to the atmosphere.

- **More info** on: Increased CO<sub>2</sub> sequestration in forestry and agriculture – [policy options](#) (article #9)
- UNDP has produced a report on [experiences and possibilities](#) in biomass projects in Europe and CIS
- A project ( [Bio-Rights](#) ) attempts at financing CO<sub>2</sub> sequestration in developing countries through provision of micro-credit to communities.

#### *i. Improve swamp management - and avoid destruction of swamps*

##### **What is it?**

Peat swamps store dead plant residues (mainly peat mosses). Because of acidic and often anoxic conditions the residues are not degraded. The swamps are thus an effective sink for CO<sub>2</sub>.

##### **Additional info:**

It has been estimated that Indonesia's peat swamps could earn the country 39 billion USD in [carbon credits](#) per year.

#### *ii. Sequestration through Sustainable Land Use practices*

##### **What is it:**

Agriculture and Forestry have the potential to actually remove CO<sub>2</sub> from the atmosphere and sequester it in living or dead organic matter. Proper land use can also dramatically reduce the emission of nitrous oxide and methane for farmed land.

##### **Additional Information:**

-EU intends to increase carbon sequestration in the terrestrial (land-based) ecosystems and farming, as part of its efforts to reach targets of the Kyoto protocol. (Source: [epaedia](#) )

-Se also New Zealand's Action Plan for land use under '[National Action Plans](#)

### *iii. Improved forest management*

#### **Key quotes :**

1: 'Large-scale international pilot programmes to explore the best ways to curb deforestation should be started very quickly.' (*Stern report*)

2: 'If carbon markets were harnessed, in many places forests would be worth far more standing than converted to low- value uses. Carbon finance funds could be used to help strengthen forest governance, support sustainable land use, and boost rural incomes'. From a World Bank [Report](#)

#### **Additional Information:**

At the Bali Meeting of the UNFCCC a new mechanism for financing the maintaining of forest and even reforestation was [set up](#) . It is called 'Reduced Emissions from Deforestation and Degradation' or REDD. The details of how this may work are being [piloted](#) (July 2008). Some of the funds for REDD will be [managed](#) by the World Bank.

In December 2008 a booklet providing overview over status of REDD procedures and regulations (proposals) was released ([The little REDD book](#) )

An [overview paper](#)\_:

The UN Forest Forum has adopted a [non- binding agreement](#)\_on how to manage forests for combating forest loss. Most forest-rich, developing nations have adopted it.

#### **Data:**

- Tropical deforestation accounts for about 20 percent of global CO<sub>2</sub> emissions (from a World Bank [report](#))
- It appears that [rising temperatures may reduce the growth](#)\_of tropical rainforests by as much as half.
- Potential carbon accumulation is 0.5 - 2.5 tC/ha/yr in dry tropical regions to 2.5 - 5.5 tC/ha/yr in humid tropical areas. These rates only include carbon accumulation in vegetation, not soil carbon, a factor that could elevate these ranges.

(Niles et al., in Swingland (ed.); Capturing Carbon & Conserving Biodiversity, p.73)

### *iv. Plant new forest and other trees*

#### **What is it?**

With money from CDM and volunteer schemes becoming available for 'Carbon Offset Schemes' a lot of business attention has been drawn to tree planting. This

inherently noble cause has also attracted some 'gold diggers', who do not care too much about the effects, either on the climate or on the local communities. A project called 'Sinkswatch' keep an eye on some of those.

#### Additional Info:

- A FAO [paper](#) on whether tree planting for C- sequestration may benefit the poor
- A [paper in Science](#) comparing, (favorably) in climate mitigation terms, forest retention versus replanting to biofuels.

v. *Replant forest*

vi. *Urban greening*

#### What is it?

A Japanese planner provides an [comprehensive introduction](#) .

#### Additional information:

- In Great Britain planning is underway on how to [avoid urban heat islands](#) , which will be one consequence of climate change, but also on how to plan in wider sense for climate-friendly cities.
- Mexico City has introduced a program of [rooftop gardens](#) on public buildings to help combat climate change

vii. *Retain existing forest*

#### What is it?

Forests store enormous amounts of carbon; [roughly half](#) of all terrestrial carbon. From the UNFCCC Bali meeting (December 2007) emerged a new focus on maintaining these forests and protect them from deforestation and degradation. This is currently (late 2009) evolving into the REDD mechanism

Additional information about this mechanism for Reduced Emissions from Deforestation and Degradation may be found:

- in an [overview](#) from a research institution (Woods Hole)
- from [Earthtrends](#) of the World Resources Institute (April 2008)

viii. *Enforce bans on forest burning*

ix. *Protect secondary and other degraded forest for regeneration*

#### What is it?

Poorer forest can re-grow and enrich. This will bind more carbon. This benefit is

aimed at by the second 'D' in REDD

*x. Manage forests towards providing biomass energy*

**What is it?**

Forests or agro-forests or trees in the open landscape may be managed towards producing biomass energy. This energy may be released as heat or gasses, to be used in e.g. power generation, thus replacing fossil fuels.

**b. Agriculture**

**Key quote:**

'Modern industrial agriculture of the "Green Revolution" contributes a great deal to climate change. It is the main source of the potent greenhouse gases nitrous oxide and methane; it is heavily dependent on the use of fossil fuels, and contributes to the loss of soil carbon to the atmosphere, especially through deforestation to make more land available for crops and plantations. Deforestation is predicted to accelerate as bio- energy crops are competing for land with food crops. But what makes our food system really unsustainable is the predominance of the globalized commodity trade that has resulted in the integration of the food supply chain and its concentration in the hands of a few transnational corporations. This greatly increases the carbon footprint and energy intensity of our food consumption, and at tremendous social and other environmental costs.'

'Greenhouse gas emissions were calculated to be 48-66 percent lower per hectare in organic farming systems in Europe, and were attributed to no input of chemical N fertilizers, less use of high energy consuming feedstuffs, low input of P, K mineral fertilizers, and elimination of pesticides, as characteristic of organic agriculture.'

(Both from an [overview paper](#).)

*i. Promote proper soil management*

**What is it:**

Soils contain varying amounts of organic matter - which contains C, derived from atmospheric CO<sub>2</sub>. Industrial agriculture leads to decreased organic matter content, while Low External Input Sustainable Agriculture (LEISA) leads to increased amounts. LEISA also increases yields and improves water retention in soil. The latter will be important for areas, where increasing temperatures will lead to increased evapo-transpiration (water loss) from soil and crops.

**Key quote:** 'Soil carbon is a major component of the terrestrial carbon cycle. The soils of the world contain more carbon than the combined total amounts occurring in vegetation and the atmosphere. Consequently, soils are a major reservoir of

carbon and an important sink. Because of the relatively long period of time that carbon spends within the soil and is thereby withheld from the atmosphere, it is often referred to as being sequestered. Increasing the capacity of soils to sequester C provides a partial, medium- term countermeasure to help ameliorate the increasing CO<sub>2</sub> levels in the atmosphere arising from fossil fuel burning and land clearing'. ([source](#))

**Another quote:** 'Soil organic matter of cropland increases only if either the additions can be enhanced or the decomposition rates be reduced. There are opportunities by which such improvements can be achieved. Taking the global historical loss of about 42 Gt former soil C from mineral soils as a reference, and assuming a practically feasible restoration by one half to two thirds, this would correspond to somewhere between 20 and 30 Gt C altogether, or to an average CO<sub>2</sub> offset of 0.4–0.6 Gt C yr<sup>-1</sup>. The drawback, however, is that this carbon-sink option is of limited duration only. The humus enrichment in crop soil always follows a saturation curve, approaching a new equilibrium level after not more than 50–100 years. (from an [overview paper](#))

#### **Additional info :**

- A [homepage](#) from an agricultural university

**Data:** Potential carbon sequestered by LEISA (Low External Input Sustainable Agriculture) amounted to an average of 0.35 t C/ha/year. (Pretty et al. 2006, [Source](#))

There is c. 1.402.317.000 ha of arable land in the World in 2003 ([source](#))

Soil organic matter is [about 58% carbon](#)

'Accordingly, if one wants to influence the soil organic matter level in existing farmland, there are two controls which need to be equally observed: One is the rate of organic inputs, the other one the rate of decomposition. Soil organic matter increases only if either the inputs can be enhanced or the decomposition rates be reduced. (Sauerbeck, 1992; Paustian et al., 1997, 1998). The working group which was responsible for identifying the agricultural CO<sub>2</sub> mitigation options in the 1996 IPCC 2nd Assessment Report has discussed the practical opportunities by which such input increases and/or decomposition decreases could be achieved (Table 7: Cole et al., 1996). Taking their assumed historical loss figure of about 43 Gt C from the world's mineral soils (excluding wetlands and histosols) as a reference, and assuming a practically achievable restoration by one half to two thirds, this would accumulate to somewhere between 20 and 30 Gt C altogether, or to an average CO<sub>2</sub> offset of 0.4–0.6Gt C yr<sup>-1</sup> worldwide (Paustian et al., 1998)'.

(From a [Journal Article](#), Sauerbeck 2001)

## Green manure

### **What is it?**

Use of plant species as living, 'green' manure usually helps build up soil carbon,

when the plant residues are either plowed under or drawn into the soil by soil animals, such as earthworms.

## Composting

### What is it?

Composting, even if it leads to breakdown of most organic matter, leaves certain more resistant carbon-based molecules that will be integrated into the soil, when the compost is applied.

Also the application of large amounts of compost builds up the pool of organic matter that was previously depleted. In this, much carbon is in transition (from organic matter to CO<sub>2</sub>) - but still removed from the atmosphere.

## No Tillage or Conservation Tillage

### What is it:

No tillage means the soil is not ploughed or otherwise turned by the end or beginning of a crop, as is the now usual practice. It has many benefits (among them water retention, nutrient retention, avoidance of erosion, conservation of microorganisms) but also requires more clever management.

By leaving the soil, the roots and microorganisms in the soil remain undisturbed and leaking and emission of GHG's are reduced.

**Additional info:** [here](#) and [here](#)

### Data :

For [northern soils](#): 'extensive research in nearby southwestern Saskatchewan (in Canada) shows that soils depleted of organic matter typically accumulate soil carbon at a rate of 0.1 tonne/ha/yr - when switching to no tillage'.

From [Spain](#): 'Conservation tillage systems appreciably improved the fertility level of the soil in the organic matter as compared to conventional tillage, increasing the organic matter of the profile 18 Mg/ ha' (Mg=Megagrams is the same as tonne).

## Improve range-land management

### What is it?

With proper management, rangelands (for grazing) may become net sinks of CO<sub>2</sub>

### Additional Information:

- A [scientific paper](#) (with easy-to-read summary)
- A general [overview](#) (from 2001)
- In the USA carbon from rangeland management is already [sold commercially](#) at carbon exchanges

## Promote use of Biochar/Black Earth

### What is it:

1. [Black Earth or Terra Preta](#) is an ancient technique of enriching soil through application of charcoal. Apparently the C- content of such soil can be much higher than in any other soil, and soil fertility is greatly increased.

2. the use of pyrolysis, a process in which biomass is burned at a high temperature in the absence of oxygen. The process yields both a charcoal by-product that can be used as a fertilizer, and bio- oil, which is a mix of oxygenated hydrocarbons that can be used to generate heat or electricity'.

**Key quote:** 'Many soils of the lowland humid tropics are thought to be too infertile to support sustainable agriculture. However, there is strong evidence that permanent or semi- permanent agriculture can itself create sustainably fertile soils known as 'Terra Preta' soils. These soils not only contain higher concentrations of nutrients such as nitrogen, phosphorus, potassium and calcium, but also greater amounts of stable soil organic matter. Frequent findings of charcoal and highly aromatic humic substances suggest that residues of incomplete combustion of organic material (black carbon) are a key factor in the persistence of soil organic matter in these soils. Our investigations showed that 'Terra Preta' soils contained up to 70 times more black carbon than the surrounding soils. Due to its polycyclic aromatic structure, black carbon is chemically and microbially stable and persists in the environment over centuries. Oxidation during this time produces carboxylic groups on the edges of the aromatic backbone, which increases its nutrient- holding capacity. We conclude that black carbon can act as a significant carbon sink and is a key factor for sustainable and fertile soils, especially in the humid tropics. (from a [paper](#)).'

**Another quote:** 'In a nutshell: Current approaches to replace fossil fuel with renewable energy at best reduce emissions, but are unable to reverse climate change. A new strategy obtains energy from gases produced by thermally degrading trees, shrubs, grasses, or organic wastes - very similar to charcoal making - in a process called pyrolysis. Charcoal or "bio-char" is left behind. The proposed approach to combine pyrolysis for energy production with bio-char additions to soil builds on its proven longevity and ability to retain cations better than other forms of carbon in the environment to actively draw carbon-dioxide from the atmosphere, regenerate degraded lands, and reduce environmental pollution. Precise knowledge of the longevity of bio- char and of the time and conditions to develop adsorptive properties is needed to evaluate its economic and environmental benefits. A full environmental risk assessment needs to be conducted to convincingly demonstrate the level of emissions and lack of any soil contamination associated with the technology.'

(From an article, by Lehmann - 2007, in *Frontiers in Ecology and the Environment*)

**Third quote:** 'The uptake by terrestrial processes can be increased significantly by management of the 60.6 Gt/yr of biomass C that is fixed by photosynthesis (i.e., net primary productivity), of which 59 Gt/yr is decomposed and 1.6 Gt/yr combusted. Biomass pyrolysis converts about 50% of the biomass C to char. Of the other 50% that is converted to bio-oil and bio-gas, the net energy production

is about 62% efficient. Thus, pyrolysis of 1 Gt of biomass C would provide energy equivalent to about 0.3 Gt of fossil C and could be used to offset that amount of fossil C, while sequestering 0.5 Gt as biochar.' From a [journal paper](#)

#### Additional information

- A nice [overview article](#) by Financial Times (200)
- Biochar is (December 2008) proposed to the UNFCCC (by the UN Convention to Combat Desertification) to be [included in CDM](#) (also post-2012)
- The same homepage as above has materials about what biochar is, how to produce it etc.
- A video from Australian [television](#)
- Some [videos](#) on YouTube
- A list of research institutions on biochar and manufacturers of equipment is found [here](#) .
- Description of a [household stove](#)
- A homepage provides list of and links to [scientific papers](#) and other information on biochar
- An [overview](#) article
- An [article](#) in ScienceDaily
- An [article](#) in Energy Bulletin about a global meeting discussing potential of biochar
- An [article](#) about application in agriculture (where biochar is called agrichar)
- A homepage giving [design](#) for simple production of biochar
- Another homepage, providing basic design for an [industrial method](#)

#### Promote agroforestry and trees in the agricultural landscape

##### What is it?

Many agricultural landscapes have been depleted of trees. They may be brought back, for reason related to climate change but also for improving soil fertility (by 'mining' nutrients from deeper soil layers and bringing some of these to the surface, through leaf-fall). Trees can also bring direct food to poor farmers.

##### Additional info:

- climate policies and incentives are [not \(yet\) in place](#) to [induce](#) farmers to plant trees.
- The international Centre For Agroforestry (ICRAF) [suggest](#) that trees on farms should be included in climate-funding.

### C. Wetlands

#### Manage peat bogs for C-sequestration

**Key quote.** The dead trees, plants, and moss in peat bogs undergo slow anaerobic decomposition below the surface of the bog. This process is slow enough that in many cases the bog grows rapidly and fixes more carbon from the atmosphere than is released. Over time, the peat grows deeper. Peat bogs hold approximately one-quarter of the carbon stored in land plants and soils ( [source](#) )

#### Additional info:

- on [maintaining](#) peat bogs, in Great Britain
- on [management](#) of peatlands for combatting climate change
- on [obtaining funds](#) for managing peat lands for climate change

#### i. Oceans

#### Key quote:

Oceans are natural CO<sub>2</sub> sinks, and represent the largest active carbon sink (*see also under CO<sub>2</sub> in the 'Greenhouse gas' file*) on Earth. This role as a sink for CO<sub>2</sub> is driven by two processes, the solubility pump and the biological pump. The former transfers CO<sub>2</sub> from the ocean's surface to its depths. Warm waters at the surface can hold much less CO<sub>2</sub> than can cold waters in the deep, while the latter is the sum of a series of biological processes that transport carbon (in organic and inorganic forms) from the surface euphotic zone to the ocean's interior. A small fraction of the organic carbon transported by the biological pump to the sea floor is buried in anoxic conditions under sediments and ultimately forms fossil fuels such as oil and natural gas.

At the present time, approximately one third of anthropogenic emissions are estimated to be entering the ocean. The solubility pump is the primary mechanism driving this, with the biological pump playing a negligible role.

Mainly from [Wikipedia](#) (look under 'Oceans')

One way to increase the carbon sequestration efficiency of the oceans is to add micrometre-sized iron particles called hematite or iron sulfate to the water. This has the effect of stimulating growth of plankton. Iron is an important nutrient for phytoplankton, usually made available via upwelling along the continental shelves, inflows from rivers and streams, as well as deposition of dust suspended in the atmosphere. Natural sources of ocean iron have been declining in recent decades, contributing to an overall decline in ocean productivity (NASA, 2003). Yet in the presence of iron nutrients plankton populations quickly grow, or 'bloom', expanding the base of biomass productivity throughout the region and removing significant quantities of CO<sub>2</sub> from the atmosphere via photosynthesis. (same source)

**Additional information:**

. The uptake of CO<sub>2</sub> in the oceans make them more acidic, in turn [harming many forms of life in the oceans](#).

- An idea is promoted to provide [fertilizers for algal growth](#) in areas of the ocean where nutrients are in short supply.

- But the idea may [backfire](#) and make global warming worse.

**Manage wasted land for C-sequestration**

Some info on management of reclaimed land for C-sequestration

- One article [here](#)

**d. Engineering methods for sequestration****What is it?**

Engineers come up with many ways of trapping CO<sub>2</sub> or other greenhouse gasses, as well as schemes to block out sunlight (partially). The latter is dealt with under '[Engineered cooling of the Earths Atmosphere](#)'

**Additional information**

- A brief [description](#) of some suggested technologies, and technical, legal and ethical issues surrounding this approach.

*i. CO<sub>2</sub>-bioreactor***What is this:?**

This is an experimental contraption, which leads air through some narrow tubes, in which algae grow. *May* be possible to scale up - maybe not.

**Additional info ,**

- on a [commercial product](#)
- and another commercial [company](#)

*ii. Capture and storage***What is it?**

The CO<sub>2</sub> is captured by various engineering tricks and stored, usually underground.

This is mainly applied in coal-fired power stations.

Now, there are serious plans of applying '[artificial trees](#)' to 'filter' CO<sub>2</sub> from the general atmosphere and store it underground, or use it as a fuel.

**Additional info:**

There is an [online magazine](#) committed to general capture and storage.

*iii. Chemical storage or filtering***What is it?**

A new group of chemicals seem able to store CO<sub>2</sub>, and filter it from gas or liquids. Still experimental ([article](#))

*iv. Electro-catalytic*

**What is it?:** This seems to be an experimental technology, with great promise - if it can be brought to work on large scale. It basically builds hydrocarbons from CO<sub>2</sub>, by an 'artificial' mechanism.

**Additional info,** [here](#) and [here](#)

## 8. Adaptation

**What is it?** 'Adaptation can be defined as "any action that seeks to reduce the negative effects, or to capitalize on the positive effects, of climate change".

It is applied to the most different fields, from road building (e.g. making the roads less vulnerable to floods) to agriculture (e.g. use of drought- resilient crops in areas that become drier). In general it applies principles and technologies already known in different fields of science, engineering and life sciences. The adaptive solutions will be known and applied in some geographical and social contexts, while possibly new to areas and institutions experiencing climate changes. It seems there is enormous potential in networking among practitioners to identify solutions and learn from each other. Many lessons from disaster preparedness may also be valuable in CC adaptation

**Additional info:**

- UNFCC has (November 2008) released [papers](#) on possible adaptation tools.
- Two homepages gives overview and examples of [community- based adaptations in developing countries\\_](#)(1) and ( 2\_).
- Another homepage provides exchange of [experiences](#)\_on CC adaptation in least developed countries
- A [photo series](#) on adaptation in Northern Brazilian farms to increased desertification

*i. Resilient crops and cropping systems*

**Additional info**

- FAO [workshop](#) on Africa
- An overview [presentation](#) on dryland farming and climate adapted varieties from ICRISAT

*ii. Disaster preparedness*

**What is it?**

With global warming frequency and severity of storms, floods, droughts etc. will increase in various ways according to the location. Existing methods and systems of disaster preparedness will be increasingly needed, also in areas, where they have hitherto not been applied.

UN states that already now, climate change is the [main driver for natural disasters](#) , and the frequency and seriousness keeps growing.

**Additional information:**

A [Guidance Package](#) from UN's organization for humanitarian assistance (OCHA).

A [collection](#) of manuals, tools and analyses from International Red Cross / Red Crescent.

*iii. Build strong communities, with disaster management capacities*

*iv. Improve water management*

**Additional info:**

A [World Water Week](#) discussed (August 2007) water and climate change

Maintain water bodies

Ensure quality of natural rivers

*v. Improved soil management*

**Substance:** Soils with increased content of organic matter will retain water better, thus mitigating effects of droughts.

## vi. Changed use of water

### What is it?

With water becoming scarcer in many areas (as a consequence of climate change) water needs to be used more diligently. There are ample [opportunities](#) (a magazine article)

## 9. GHG markets

### Key quote:

*'Climate change is the greatest market failure the world has ever seen, and it interacts with other market imperfections. Three elements of policy are required for an effective global response. The first is the pricing of carbon, implemented through tax, trading or regulation. The second is policy to support innovation and the deployment of low- carbon technologies. And the third is action to remove barriers to energy efficiency, and to inform, educate and persuade individuals about what they can do to respond to climate change. [Stern review - conclusion](#)'*

### Additional Information

- Stockholm Environmental Institute provides a [clear overview](#) over the markets and their relations to the Kyoto protocol.
- The Dag Hammarskjöld Foundation in Sweden has produced an issue of their Journal 'Development Dialogue', [critical of trading in greenhouse gasses](#).
- And a [humorous video](#) on the whole idea of paying somebody else to negate your sins.
- Often policies are put in place where trading is combined with ceilings. It is often called 'cap and trade'. Here is a [description](#) by Wikipedia.
- A report provides an [overview of carbon markets](#) in 2009

### a. Standards

### What is it?

This is about attempts to develop standards against which projects or products can be certified for their effects on the global climate

### Additional info:

- A US-based NGO has produced a [draft GHG- product standard](#).
- Another US-based group of collaborators from conservation NGO's and commercial companies have developed draft standards for [Climate. Community](#)

and Biodiversity' project design.

- WWF has produced a '[Gold Standard](#)' for CDM projects.
- A [standard for voluntary schemes](#) is being developed.

## b. Clean Development Mechanism - CDM

What is it?

- the CDM has its own [homepage](#) at UNFCC
- a [description](#) of the mechanism and its management is found here
- a fairly simple, graphic explanation of the current, (2008) CDM Mechanism may be [found](#) at IGES homepage
- Another homepage has more extensive, [capacity- building material](#) about the CDM
- A list of projects in Asia and guides on how to prepare projects in various Asian countries may be found at the [IGES home page](#)
- A [report on the future](#) of CDM and Joint Implementation has been produced (August 07) by the German Environment Ministry.
- Another report by 'Environmental Defense' also looks into the [future of CDM](#).
- A study has evaluated the current CDM and is presented in a [press article](#)

## c. Voluntary

What is it?

These are basically commercial entities selling 'carbon offsets' to individual consumers (e.g. air travelers)

Additional info

- Stockholm Environment Institute has developed a guide on [how to identify reputable voluntary schemes](#) and a report considering some of the issues to consider, when doing so.
- One [market analysis page](#) is here.
- A (commercial) overview over the status of Voluntary Markets (July 2007) may be found [here](#).
- An example of a (Portuguese) climate investment fund may be found [here](#).

### *i. Forests*

There is a homepage (in Spanish mainly) of [markets for forestry offsets](#)

### **d. Trade in Certified Emission Reductions**

What is it?

EU has a homepage describing the [Emission Trading Scheme](#)

[European Climate Exchange](#) is the actual trading place

The [Chicago Climate Exchange](#) covers mainly the North American market.

## **10. Engineered cooling of the atmosphere**

What is it?

As the globe is warming faster than even the worst predictions and action is slower than needed, some researchers suggest engineering ways of cooling the planet. They focus mainly on feeding the upper atmosphere with various chemical that reflects solar radiation.

While this may work in reducing overall temperatures, the effects on weather patterns may be extremely hard to predict and such technologies could do more harm than good.

Also, this simple cooling does [not address](#) other effects of GHG emission, such as the acidification of the oceans, which destroys ocean life.

**Additional information**

- Newsweek has an [overview article](#) (April 2009)
- Engineering Associations from 13 countries have formed '[Future Climate](#)'
- [Business interests](#) promote these technologies
- The Obama Administration is [considering](#) various such engineering 'silver bullets'.
- A study warns that these kinds of approaches could [cause severe draught](#)
- A scientist warns of other possible, [negative effects](#) .

## **11. Monitoring and Documentation**

### **a. Promote environmental accounting**

What is it?

A whole new branch of accounting is emerging, with the trading of carbon and its regulation in different forms. It connects to general environmental accounting and [corporate social responsibility](#).

**Additional Information:**

- Australia has an example of a [national carbon accounting system](#)
- An example of accounting for carbon [for private corporations](#), under development
- There exists a 'European Sustainability Reporting Association' ([ESRA](#)). They request international standards for reporting and auditing sustainability.
- PriceWaterhouseCoopers in DK (and probably in other countries as well) has a department for 'Climate Services'.

*i. Technical methods*

**Additional information:**

The '[Greenhouse Gas Management Institute](#)' provides information and on-line learning on how to measure and calculate GHG emissions.

An initiative called CARMA [provides](#) public transparency on CO<sub>2</sub> emissions from the power generation sector

*ii. Carbon Accounting*

**What is it?**

This is about national system to account for carbon, in relation to national action plans and commitments.

**Additional Information**

- Australia [has set up](#) a national carbon accounting system
- Canada has agreed on how to develop [national standards](#)
- ISO (The International Organization for Standards) has developed a [set of materials](#) for GHG emission accounting and verification

*iii. Carbon audits*

**What is it?**

With carbon accounting naturally comes carbon audits. The methods are however, still (2009) rudimentary.

**Additional info:**

- Wikipedia has (brief) definition
- An example of an Australian [company](#) doing carbon audits.