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ESCAPE: ENERGY SECURITY & CLIMATE POLICY EVALUATION

Linking climate change and energy security policy in post-2012 climate strategies

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Abstract

Climate change and energy supply security policy are currently not integrated in most countries, despite possible synergies. The ESCAPE approach suggests that linking climate change policy with security of energy supply could improve climate change policy at both a national and international level. The report explores the interaction between policies of energy security and climate change and the options of inclusion of energy security issues into national and international post-2012 climate negotiations. It emphasises the importance of the US in this regard and takes a close look at US energy policy documents.

It appears that current US energy policy is not directed towards reducing its reliance on imported fossil fuel, even though the government has a strong preference for this. This study shows that measures to reduce import dependency are mostly synergetic with climate policy and gives some options that can be implemented. On an international level, linkages of energy security into post-2012 climate policy may be possible in sectoral bottom-up approaches or technology frameworks. As well, inclusion of a security of supply criterion in international emission trading instruments may provide potential benefits.

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SUMMARY

Negotiations on the design of a post-2012 international climate policy are supposed to start in 2005. However, given the current international context with widely diverging views on this issue, this new climate regime is not quite emerging yet - even though different options have been put forward. The active involvement of key world regions, particularly the US, is a key factor for a truly global post-2012 climate change policy scheme. Linking the supra-national benefits of combating climate change with national interest may provide more common ground between currently divided countries. The ESCAPE approach - Energy Security and ClimAte Policy Evaluation - suggests that linking climate change policy with security of energy supply may improve climate policy at both national and international level.

National level
Security of energy supply is a major policy issue in many world regions. Dependency on imported oil and gas is likely to increase sharply for the US, the EU and China. US energy policy relies heavily on oil for the next decades. In addition, it focuses on creating incentives for new technologies and leaves it up to the market which energy sources will increase shares in the energy mix. To this extent, the energy security position is not likely to be beneficially influenced by energy policy. This is in contrast to the government's strong preferences for reducing imported oil and gas dependency. Many measures that can be taken in order to enhance security of supply are synergetic with climate change measures, such as renewable electricity, biofuels, nuclear power, hydrogen fuel (from renewable sources or fossil-based with carbon dioxide capture and storage). This paper puts forward a number of options that reduce import dependency as well as GHG emissions.

International level
Security of supply issues have to date not been included in climate policy negotiations and is not mentioned in any post-2012 climate regime proposal. However, as this issue deals with national interest, it could be a means to address the difficult issue of collective action in climate negotiations. Therefore, we recommend that, where possible, security of supply interests be integrated in post-2012 climate policy strategies. This will appeal to all major world regions and therefore, can streamline this issue into climate negotiations to utilise synergies. This will create a broader basis for future climate policy, involving more stakeholders over a range of policy areas.

The advantage of energy security as a national interest is also an inhibiting factor for streamlining this issue into international climate regime in the form of global targets similar to the top-down approaches in currently proposed post-2012 frameworks. As the synergies between the two policy areas are mainly on a technological level, post-2012 regimes that include sectoral bottom-up elements or technology-based approaches would provide the most promising linking options. For example, groups of countries agreeing on approaches to combat both climate change and energy security threats may aim to link these into one convention. Due to the different nature of the problems, options for linking on a global scale appear to be less likely achievable.

Emission trading instruments are likely to be part of any post-2012 climate regime, even though the design of such a regime is not within sight given current international situation. Instruments such as the current Clean Development Mechanism and the EU Emissions Trading Scheme provide interesting options to develop links with energy security. For the CDM, a new type of CER (carbon credit) can be designed to include an energy security criterion. This would in general favour projects that reduce CO_2 over other greenhouse gases, as the former often entail a benefit for the host country energy security situation. This adds to the sustainable development component of CDM projects, which are often stronger in CO_2 reduction projects.

Regarding instruments such as the EU ETS, governments may reward companies that comply by reducing their emissions compared to those buying allowances on the market.

In general, linking energy security and climate policy on an international level entails some potential benefits as well as drawbacks. To start with, it appeals to basic national interests, opening up a new dimension in climate negotiations that serve in essence supra-national interests. Secondly, measures or projects that improve security of supply and thereby add to sustainable development, will be favoured over those that do not. Thirdly, by serving multiple objectives, cost of policy may be reduced. Finally, it will encourage sustainable technology innovation and implementation.

On the drawback side, the main issue is increased complexity of design of a post-2012 climate regime. A common strategy, e.g. on technology development and diffusion, for energy security as well as climate change needs to be established between a group of countries. Both reaching common ground between countries on these issues as well as designing the combined polices will require more rounds of negotiation and policy-making. Also, including an energy security criterion in carbon credits in emission trading, will add to complexity in markets that are in early stages of development.

1. INTRODUCTION

1.1 Background

Climate change policy is a complicated issue with environmental, economic and social elements that is further compounded by the atmosphere being a common pool resource. The global community is concerned that anthropogenic activities could alter the climate if the atmosphere is overly exploited and used as a global commons (Nilsson and Pitt, 2004). The Kyoto Protocol is a precautionary response by countries to avoid a potential 'tragedy of the commons' (Hardin, 1968) on a global scale. Addressing all the elements of the problem requires a globally integrated policy mix that recognises the different circumstances of each country and acknowledges that no one approach precludes other approaches from being utilised. However, recent years in international climate negotiations have clearly shown that designing an effective and acceptable policy mix is a difficult mission. New ways to recognise and integrate different countries' interests need to be found to establish the required policy framework.

1.2 ESCAPE: Objectives and approach

This report puts forward the Energy Security and Climate Policy Evaluation (ESCAPE) hypothesis. The ESCAPE approach suggests that linking climate change policy with energy security of supply could improve climate change policy at both the national and international level. This report has a two-fold aim:

1. Exploring to what extent energy security and climate change policy interact and can be linked on a national level.
2. Exploring what the options are for linking energy security concerns into post-2012 climate change negotiations on an international level.

The first part is to a large extent based on existing literature on the links between the two policy areas. In order to provide more detail on the policy level, a country case is taken. Because energy security appears to be a much more important issue than climate change mitigation for the US, we specifically analyse US energy policy and associated documents to assess where the possible synergies and trade-offs with GHG reduction are. Also, recommendations regarding the options to capture the synergies more effectively are made. This part is mainly qualitative. Then we make a short comparison with other important world regions. Based on the general analysis as well as the case study, conclusions on the interactions can be made.

For the second objective, we cannot draw on existing studies, as this idea is fairly new. As a result, the conclusions will be of a more explorative kind. A specific focus is on emission trading and the Kyoto flexible mechanisms, as these instruments may provide promising options for linkages. We make a preliminary quantitative analysis on the energy security impact of the current portfolio of the Clean Development Mechanism projects, and provide some explorative options of how the different emission trading instruments can be improved so as to include concerns of energy security. We note that the report is limited in its scope and has not examined in detail the geopolitical context or gone into detail about improvement of oil and gas supply routes.

The next chapter briefly discusses the framework for the discussion of climate policy after 2012 and gives a review of three earlier publications on the links between energy security and climate. Chapter 3 defines our scope of energy security and then analyses the effect of the US energy policy on climate policy and vice versa, and gives some options to improve the synergies. In Chapter 4, we explore the ESCAPE at the international level, after which Chapter 5 provides conclusions of this study.

2. POST-2012 CLIMATE POLICY

In 2005, countries will begin to discuss what actions to take after 2012 in responding to the climate change problem. As a common starting point, there is a general consensus and agreement amongst countries on the United Nations Framework Convention on Climate Change (UNFCCC) objective to:

'…stabilise greenhouse gas concentrations in the atmosphere at such levels that would prevent dangerous anthropogenic interference with the climate system'. (Article 2, UNFCCC, 1992)

2.1 Framework

There is already common ground with the US and other countries accepting that 'technology' will play a vital role in the long term, but a post-2012 architecture will need to reflect not only the role of technology but other elements as well. There are several important issues playing a role in post-2012.

Firstly, the basis of commitments is to be determined, which may be climate impacts, temperature increase or GHG concentration levels. Then the type of commitments can be discussed: fixed or indexed targets and timetables for countries, a sectoral approach and/or a technology-based approach are some options. 'Equity' of a climate deal refers to a fair sharing of the 'burden' to reduce emissions across countries, based on (among others) historical responsibility, current and future capabilities, and levels of development. In addition to mitigation of climate change, i.e. reduce GHG emissions, funds for adaptation to the seemingly inevitable impacts of climate change needs to be part of the negotiations. Technology and technology transfer is often identified as a key issue in climate policy, but its role remains unclear. Regarding participation, it is clear that for an effective climate policy, all significant emitters, notably the US and large developing countries, need to be included in the negotiations, which to date has proven extremely challenging.

As mentioned, it is essential to achieve a broad coalition of greenhouse gas emitting countries in order to put together an effective global climate policy after 2012. Several important countries, notably China and the US, have expressed their apprehensions about the Kyoto Protocol regime. Therefore, exploring options different from the Kyoto regime is necessary to achieve an acceptable way forward after 2012 in international climate policy. One area that countries have common ground is the goal to have energy security of supply.

Climate policy interacts with many other policy areas, such as air pollution, transport and mobility policy, urban planning, security of energy supply, land-use and poverty. The interaction can be synergistic in nature, or trade-offs may occur (RIVM, 2004). In other words, reducing greenhouse gas emissions may yield considerable benefits in other areas. Possibly even more significant is that policy measures in other areas may have a positive or negative impact on GHG reduction. Figure 2.1.1 illustrates the process and issues that will influence a post-2012 climate change international framework. The current framework for international climate policy is the Kyoto Protocol, which is the result of negotiations within the UN Framework Convention on Climate Change. The basic principles of climate policy after 2012 may be different from those of the Kyoto Protocol[1].

[1] The main principles of the Kyoto Protocol are: legally binding and absolute reduction targets for a basket of six greenhouse gases for industrialised countries, no targets for developing countries, emission trading between countries, no clear role of adaptation.

The dashed boxes make a distinction between three important groups of countries in the climate negotiations, based on ratification of the Kyoto Protocol and, for the countries that have ratified, industrialised or developing. In addition to preventing dangerous climate change, these groups have some common and different interests and goals, expressed in the ovals (without being complete). Energy security and air quality appear to be common interests for all countries, whereas GHG targets are currently only desired by most Kyoto industrialised countries. Aspects of a post-2012 climate policy will be driven by several economic, environmental, social and political factors. The conclusions of the IPCC Fourth Assessment Report, due to be issued in 2007, may also influence the negotiations. The horizontal arrow should not be regarded as a timeline, more as the general direction of the process towards a post-2012 climate policy framework.

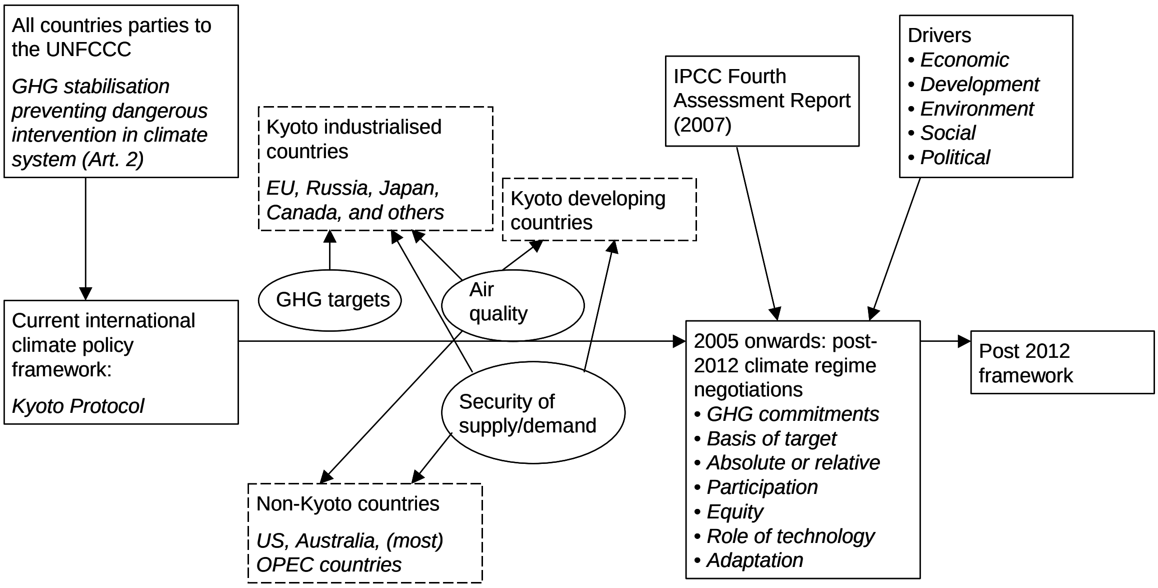

Figure 2.1.1 *Towards a post-2012 climate change policy framework*

The US is currently the world's biggest greenhouse gas emitter. Its current federal response to climate change consists of a target to reduce the emission intensity of the economy and identify technology solutions with a reliance on the market to decide the best option to implement those technology solutions (in the current strategy, the US is not aiming at any marketing of technologies; it is only focussing on research and development, not at market introduction). In contrast, the EU is focussing both on developing technologies - and on policy incentives to give the technologies a chance in the market. It has recently introduced an emissions trading system based on a cap and trade structure. This market intervention is aimed at encouraging industry to be innovative as well as learn how to manage their emissions within a carbon constraint.

Internationally, the only climate change agreement is the Kyoto Protocol. The Protocol is a legal instrument to respond to changes in scientific understanding and political will to realise the objectives of the Framework Convention. Under this Protocol, Annex I ('industrialised or developed') countries are obliged, through a legally binding agreement, to reduce their combined GHG emissions by 5.2% compared to 1990 levels in the first *'commitment period'* (2008-2012). The Protocol established the following market-based flexibility mechanisms to achieve commitment in an economically efficient manner:
1. Emissions Trading (ET)
2. Joint Implementation (JI)
3. Clean Development Mechanism (CDM).

The Protocol's entry into force on February 16, 2005 marks the legal relevance of the first commitment period, which will be 2008-2012. The US and Australia have decided not to ratify the Kyoto Protocol.

In view of the scope of this report it is useful to briefly discuss some of the main options that have been proposed as post-2012 regime options, with the distinction between top-down and bottom-up approaches. We note these options are limited to a certain type of climate regime, namely greenhouse gas targets on a global scale. Other options, such as technology cooperation or regional initiatives, are also possible (see earlier in this section).

In top-down approaches, greenhouse gas reduction paths are calculated based on certain (equity) assumptions. The most important are Contraction & convergence, in which global emissions are contracted to a 'safe' level and per capita emissions converge by a year (e.g. 2050) (Meyer, 2000), and the 'Brazilian proposal', according to which the emissions path is based on historical responsibility to temperature increase and implies larger commitments by Annex-I countries and gradual participation by developing countries. The Multi-stage approach (Den Elzen et al, 2002) entails participation in four stages with countries graduating from no commitments, intensity targets, stabilisation and finally reduction commitments, which would be determined by an indicator, e.g. per capita emissions or income.

Approaches with more bottom-up elements have also been put forward. The Global Triptych approach (Groenenberg, 2002) takes a sectoral approach and looks at domestic, industry and electricity (also agriculture and forestry) feeding into a national emissions target. This approach allows fewer reductions for more efficient countries, such as Japan and Europe. The Multi-Sector Convergence framework (Jansen et al, 2001) is also a sector-based approach, but seven sectors are distinguished and additional flexibility is provided by allowing for country-specific conditions such as economic structure, in adjusted targets. The national targets are binding and determined by convergence of per capita emissions, while the sector targets are not binding.

2.2 Existing work on supply security and climate

Egging and Van Oostvoorn

Linking supply security concerns and climate change is a fairly new concept. Egging and Van Oostvoorn (2004) provide an overview of the interactions between the two fields and the options to capture synergies. It is concluded that a range of synergies exists, which can be captured by implementing the right policies. There appears a weakness and fragmentation in how governments have separate policies for security of supply and climate change mitigation. Yet, both these policy areas will have a direct influence on technology choice by industry and emission reductions from the use of energy.

This study recommends that the two policies be linked more effectively, for which several international fora can be used. Involvement of oil and gas producing countries and companies is crucial to obtain a broader climate change community. Cleaner use of fossil fuels is an area of common ground. Application of various domestic renewable energy sources instead of importing fossil fuels has a range of co-benefits, such as possible improvement of balance of payments, employment and air quality, which can be emphasised more effectively.

IEA

The IEA (2004) carried out a quantitative scenario analysis to assess interaction of supply security policy and climate change, using three proxy measures:

- Geopolitical energy security (GES) - share of domestic supply in consumption of energy source and accessible market concentration for each energy source.
- Required back-up capacity in power generation.
- Start-up flexibility in power generation - possibility to anticipate adequately to short-term demand variability.

The US was one of four case countries besides the UK, Italy and Australia. The base case, taken from World Energy Outlook 2002, shows an 87% increase (worsening) in the proxy measure for GES in 2030 from current levels for the US. This is caused by a 37% increase in oil consumption, 50% in gas consumption, while the nuclear share will be decreasing.

Several policy options can be implemented to positively influence the proxy measures for the energy situation. Ten different energy scenarios were assessed on their impact on the proxy measures for energy security as well as on CO_2 reduction. The results are summarised in Table 2.1. In the table, positive figures indicate an improvement in the energy security situation for the US (% change compared to the baseline in 2030). For example, increased renewables to 15% results in a 1% improvement in the proxy measure for geopolitical energy security, but a decrease in proxy measures for power reliability. CO_2 emissions are reduced by 4%.

Table 2.1 *Summary of energy scenario results for US (% improvement in proxy measures, compared to baseline in 2030)*

Goal for 2030	Geopolitical energy security (GES) [%]	Power reliability		CO_2 reduction [%]
		Additional capacity [%]	Start-up flexibility [%]	
Renewables (non-hydro) to 15%	+1	-1	-6	+4
Nuclear: 15% (base case 13%)	+1	0	-5	+3
50% of 2030 gas-fired capacity to coal	-1	0	-25	-7
50% of 2030 coal-fired capacity to gas	0	0	+11	+4
15% biofuels transport	+13	na	na	+5
15% gas in transport	+11	na	na	0
Caspian oil supply +50%	+7	na	na	na
Caspian gas supply +50%	+/-0	na	na	na
Domestic fossil fuel +15%	+4	na	na	na
Energy efficiency +9%	+12	0	0	+9

na: not applicable
Source: IEA, 2004

It appears from this overview that policy aimed at the transport sector can be particularly useful for improving US geopolitical energy security. Also energy efficiency, domestic fuel production and oil from the Caspian Sea region may aid. Most of these are synergetic with CO_2 reduction.

Pew Center

The Pew Center (2003) carried out a scenario analysis along three story lines for 2035, both with and without climate policy and assessed the impacts on the economy, energy security and climate change. In the 'base' case where there are no strong incentives for new technologies because of a continual cheap supply of energy is a 50% rise in CO_2 emissions. The optimistic technology scenario ('Technology Triumphs') where there is a high penetration of hydrogen and energy efficient technologies and practices estimates a 15% rise in CO_2 emissions. This is due to a wide variety of policies, including fuel economy standards, renewable portfolio standards, air quality legislation, and continual public and private investment in clean technologies as well as responding to concerns of energy security and quality of life. The Turbulent world scenario translates into medium diffusion of technologies due to energy price fluctuations and concerns of energy security. Policymakers address supply disruptions with a variety of technologies and policies, of which only hydrogen and distributed generation prove successful in the longer term.

Biofuels (high transportation cost) and nuclear (security concerns and high capital cost) are not expected to play major role.[2] Hydrogen (both in transport and stationary power applications) and energy efficiency are important new technologies. To a lesser extent, distributed generation and combined heat and power increase their importance.

It is concluded that 'a smart investment path today provides a greater capacity to respond to surprises tomorrow. A portfolio of technology performance standards and market-oriented policies can stimulate investment, accelerate capital stock turnover, reduce carbon emissions, and enhance energy security across a wide range of possible energy futures.' (page x)

The report repeatedly mentions the co-benefits of several policy options: '…tough fuel economy standards designed to address energy security have the secondary effect of reducing GHG emissions' and '…the carbon constraint incidentally but significantly reduces oil imports.' (page ix)

[2] However, in a recent article in Petroleum Economist (2004) it was argued that, with 103 nuclear plants in operation supplying 20% of the US power, there has been a rethink in the use of nuclear. This is as a result of the need for stable electricity prices as well as the desire for emissions free power sources.

3. SECURITY OF ENERGY SUPPLY

This section briefly introduces the different aspects of energy security, to continue with a case study on the US energy policy and how it interacts with climate change, and vice versa. Some further options to enhance the synergies between the two areas are suggested.

The World Energy Assessment (2001, page 11) defines energy security as *the availability of energy at all times in various forms, in sufficient quantities, and at affordable prices.* The same report stated that energy supply of oil for many countries will rely more on imported oil, with OECD countries' share of imported oil growing from 56 percent in 1996 to 72 percent by 2010.

The IEA World Energy Outlook (IEA, 2004b) gives a forecast that fossil fuels will continue to dominate the energy mix until 2030, including large economies such as the EU, Japan, US and China. A growing concern among all countries is security of energy supply as well as finding technologies that replace or improve the efficiencies of fossil fuels.

3.1 Dimensions of energy security

Based on IEA definition[3] of energy security there are several elements that emerge. These include:

Diversification of energy sources
The more diverse is the mix of primary energy sources, the less vulnerable a country is when supply of one source is disrupted. Eight primary energy sources are often distinguished: coal, oil, gas, modern biomass, traditional biomass, nuclear, hydropower, and other renewables.

Reduce import dependency
There is a degree of risk of energy disruption when a country relies heavily on importing energy, in particular for oil, which comes for a large part from political unstable countries. Many countries maintain political ties with nations for energy security. Therefore, domestic energy supply is strongly favoured over imported energy (Clingendael, 2004).

Market concentration risk reduction
If there is only a limited number of countries supplying a particular energy source, these can influence the market to such an extent that undesirable impact on prices emerges. Also, risk of supply disruption increases.

Availability
A reliable energy infrastructure - for production as well as transport - is an essential part of an energy supply system. Oil, coal and gas are transported across large distances through ships or pipelines, while electricity needs a reliable grid network to be transmitted from source to end-user.

Affordable prices
It is crucial to have certainty over the mid to long-term energy prices, as these are a major factor to the end-use sectors and to the national economy. In addition, high short-term price increases (price-hikes) may also impact economic activities.

[3] Definitions of energy security vary to only a limited extent and often include similar elements.

Energy supply is clearly a complex system that involves many (market and non-market) stakeholders. The International Energy Agency (2004) states it is a government's task to design rules for the marketplace and to include externalities (security, climate) that are not accounted for in a free market.

Jansen et al (2004) have designed a set of indicators to quantify security of supply. The basic indicator is given by the Shannon diversity index for the portfolio of sources for primary energy sources. Another important indicator is the diversification of suppliers of primary energy. The indicators can be quantified so as to gain insight to a country's energy security situation, and how to improve this.

In the current study, we focus on the import dependency of countries as the most important aspect of energy security. This dimension is also of major importance for reducing import dependency that results in less price volatility, reduced transport requirement, and less market concentration for the country concerned. In addition, we take into account diversification of energy sources and diversification of energy supply routes. Quantification and interpretation of indicators of energy security is beyond the scope of this report.

3.2 US policy on security of supply

The US long-term strategy for energy supply security is based on maintaining an economy that is not limited by the availability of energy products on the market as well as a price that is affordable for industrial and private consumers. As stated by a White House spokesman Ari Fleischer at a briefing about whether the President would restrict the use of energy consumption by American consumers (Blanchard and Perkaus, 2004):

'…The President considers American's heavy use of energy a reflection of our economy, of the way of life that the American people have come to enjoy'.

The US economy energy use is based on 85% use of fossil fuels (DOE, 2004a). As a consequence of this heavy fossil use the US has policies built around protecting security of oil and gas supply.

The Energy Policy Act of 2003 (Senate Committee on Energy and Natural Resources, 2004) focuses on securing oil supplies, domestic and imports, and, to a lesser extent, on gas. These include enhancing political and economical ties with oil producing countries, filling of the Strategic Petroleum Reserve (SPV), promote construction of the Alaska natural gas pipeline, and regulations regarding LNG facilities. As a target by 2015, America aims to expand its recoverable oil reserves by 2.2 billion barrels and gas resources by 120 trillion cubic feet (3.4 trillion m^3). Table 3.1 summarises other policies undertaken by the US.

Table 3.1 *Energy policy details of the Energy Policy Act 2003*

Energy source	Policy priority	Goal
Energy efficiency	Standards for specific technologies, more funding for programmes and tax incentives (hybrid/fuel cell vehicles, residential solar energy, CHP)	20% improvement in federal energy efficiency in 20 years; and 20% reduction in energy demand for lighting by solid-state lighting.
Renewables	Tax incentives for residential wind and solar, and power production from wind, solar, biomass and landfill gas	By 2025, renewables (excl. hydro) reach 12 quadrillion Btu (13 EJ, a doubling from 2000 level)
Hydropower	Improve re-licensing process	
Clean coal	10-year Clean Power Initiative and tax incentives for investments up to 4 GW and power production ($ 200 million)	Demonstration of 52% efficiency fuel-flexible IGCC[4] by 2008; 2020 60% efficiency
Nuclear	Modify laws, and tax incentives for next-generation nuclear plants; feasibility study for new commercial plants	
Biodiesel/ethanol	Tax credits for alcohol fuels	5 billion gallons (23 billion litres) in 2012
Hydrogen	Hydrogen Fuel Initiative H-powered vehicles ($ 2 billion)	H_2-equivalent of 1 gallon of gas to $1.50 (0.27 €2004/l)
Nuclear fusion	R&D programme (ITER[5])	
GHG reduction	Carbon intensity target improvement	CO_2 intensity 18% improved by 2010; Demonstrate technologies that can reduce GHG by 70 MtC by 2012, and 117 by 2020 (3-4%) compared to business-as-usual

Source: Senate Committee on Energy and Natural Resources, 2004; DOE, 2003

In summary, most of the energy policy measures aim to enhance fossil fuel use and supply, in particular oil and gas. Limited policy effort is going into energy efficiency and enhancing the market shares of different types of renewable energy sources. Even though some technology policy is there as well as market incentives, diffusion of these energy sources over the next few decades is uncertain.

From the above, it appears that the US administration has limited goals to reduce their import dependency with the main focus on increasing biofuels. As well, diversification of primary energy sources is only a marginal policy goal. Diversification of supply routes appears to be addressed by enhancing political ties with several key oil and gas producing regions in the world and investing in oil and gas transportation routes.

The energy mix in 2025 is dominated by oil products (nearly 50%), the consumption of which is projected to rise steadily. To a lesser extent, natural gas and coal consumption will rise. Both energy sources are increasing their share in the electricity mix. Nuclear energy and hydropower output will stay at present level, therefore - with rising electricity consumption - their shares are going to drop slowly. Non-hydro renewable electricity is projected to increase marginally from 2 to 4% in 2025.

[4] Integrated Gasification Combined Cycle power plant.

[5] Formerly interpreted to stand for International Thermonuclear Experimental Reactor, although this usage has been discontinued (www.iter.org).

Figure 3.2.1 presents a future scenario of oil imports. In the next few decades, oil from the Persian Gulf and other OPEC countries will increase their share in US consumption, while US domestic production will slowly decline. Even though six Arabian OPEC countries (Saudi Arabia, Iraq, Iran, Kuwait, Qatar and the United Arab Emirates) currently supply about a quarter of imported oil, their importance will increase in the future, as more than two-thirds of the proven oil reserves are in this region (DOE, 2003).

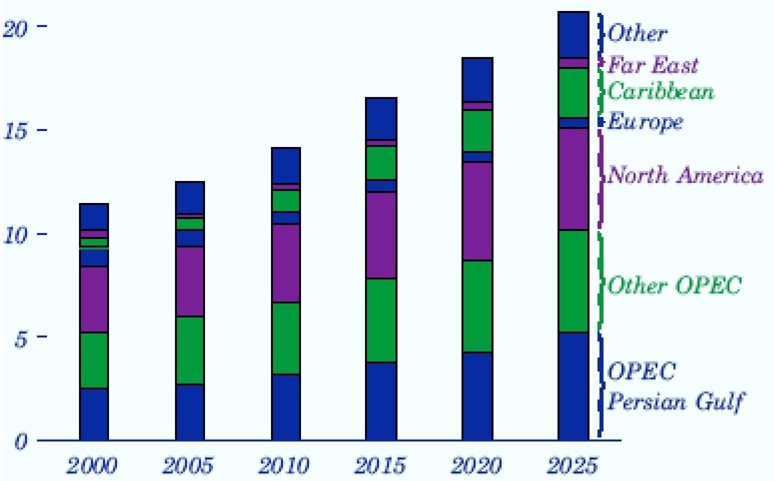

Figure 3.2.1 *US oil imports by source region*
Source: DOE, 2004a

Other world regions
Annex I gives a brief analysis of the energy situation in the European Union, China and Japan, in terms of import dependency projections for oil and gas. In the EU, import shares are likely to increase slowly to more than 80% for both oil and gas. For China, dependency on imports will increase sharply from 2010 onwards, while Japan, endowed with very limited domestic fossil fuel reserves, will rely on imports close to 100%.

In conclusion, all four world regions will see their import dependency[6] on both oil and gas increase or remain at a worrying level over the next decades.

3.3 Interaction of energy supply security and climate change

Table 3.2 gives an overview of how changes in the energy mix affects the energy security position of a country and GHG emissions. In the assessment, it is assumed that a less GHG intensive energy carrier replaces a more energy intensive one. Only in the case of oil and coal, expansion of current consumption is assumed.

[6] In terms of market concentration and dependency on politically instable nations.

Table 3.2 *Qualitative assessment of interaction between security of supply and climate change (GHG emissions) of energy policy measures in the US*

Energy option	SoS impact	GHG impact	Comments
Oil transport routes	-/+	-	Keeps import dependency but diversifies supply routes
Coal	0[7]	-	Continued use attractive to due to cheap domestic supplies; air pollution is concern
Clean coal technology	+	+/0	Promising for improving air quality; Several technologies already commercial (IGCC, supercritical PCC[8]); allows for continued coal use with improved efficiencies
CO_2 capture and storage	0[9]	+	Technology in demonstration phase; likely important option in mid-term; allows for coal use to be continued; synergy with hydrogen economy
Natural gas power	-	+	
Natural gas in transport sector	+/-	+[10]	Reduces oil dependency but increases gas imports; air quality co-benefits
Biofuels transport	+	+	Opportunity for US farmers; already strong subsidies in place as well as target
Biomass power	+	+	
Hydro	+	+	Most potential already harnessed
Other renewables	+	+	Wind particularly promising
Hydrogen[11] transport	+	+	Likely to be a major option in the long-term to reduce oil dependency
Nuclear fission	+	+	Currently projected to decrease slowly; terrorist attack sensitivity and waste disposal
Energy efficiency	+	+	Major cuts in energy intensity possible; current policy could be strengthened

Note: '+' Indicates an improvement, 'O' no significant impact, and '-' a negative impact

3.4 Influence of Security of Supply policy options on climate policy

The policy measures described in Section 3.2 that are (mainly) directed to energy security are here assessed on their climate change impact.

Enhancing oil supply

A major part of the US energy policy focuses on oil supply. This includes maintenance of the Strategic Petroleum Reserve, improving political relations with oil-producing countries, investing in pipelines as well as domestic production. The continued use of oil, mainly used in transport, is clearly not beneficial for climate change.

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7 US is likely to become a net coal importer in the next decade (DOE, 2004), but this will not significantly impact energy security. Most important countries from which coal is imported are Columbia, Venezuela and Canada.

8 Pulverised Coal Combustion.

9 CO_2 capture and storage would allow for continued use of coal with limited climate impact and so increase energy security compared to an equivalent of gas-fired power plants. On the other hand, it reduces the conversion efficiency of a power plant and thereby increasing the demand for (imported) coal. The '0' SoS impact can be disputed.

10 Particularly effective when replacing gasoline, less so in the case of diesel.

11 From coal gasification, with CO_2 capture and storage.

Enhancing natural gas supply
In the recent past, most new-built power plants were gas-fired. In the coming decades, also coal-fired power plants will be built, alongside gas-fired. To cater for the increasing gas demand, the US plans to strengthen political ties with major gas-producing countries (particularly the Caspian region), invest in infrastructure such as pipelines and LNG facilities, and expand domestic supply.

Whether increasing gas consumption will reduce GHG emissions, depends on the assumptions. If, for example, more gas-fired power stations instead of coal-fired will be built as a result of increased supplies, emissions will decrease compared to the baseline. This is also valid for a fuel switch from petrol to gas in transport. On the other hand, if the continued availability of relatively cheap natural gas prevents implementation of renewable electricity capacity, the gas supply measures are not synergetic with climate change policy in the long term.

Biofuels
Considerable financial incentives for biofuel crop production are already in place. This policy option has a large potential to reduce oil consumption and thereby, enhance US energy security. Increasing market share of biofuel in the transportation fuel mix is also clearly synergetic with climate policy.

Nuclear energy
Regarding the nuclear option, policy aims to modify laws and create tax incentives for next-generation plants. More nuclear energy is beneficial for GHG reduction, assuming it replaces fossil fuels.

Hydrogen
As hydrogen is an energy carrier rather than an energy source, it impact on energy security as well as climate change depends on how it is produced. However, if it replaces oil consumption in transportation - the main goal - it reduces the need to import oil and diversifies the energy sources, whether it is produced from natural gas, biomass or (renewable) electricity. Regarding GHG emissions, it will be beneficial provided it is produced from fossil fuels with CCS, biomass or CO_2 neutral electricity.

Conclusion
Current energy policy heavily focuses on enhancing future oil and gas imports from different regions in the world. This will not improve the energy security situation, in terms of import dependency of the US in the long term. To make things worse, over time, most of the oil will have to come from a limited number of Arabian OPEC countries. This will increase energy supply risk.

The main synergies between energy security and climate change are in the field of renewables, hydrogen, nuclear fission and energy efficiency. Policies to promote these are in place to some extent, but the Bush Administration has refrained from setting targets. The US has invested heavily in technology innovations with the US$1.7 billion Hydrogen Fuel Initiative and also a US$1 billion public-private project to develop a prototype electricity generation plant using hydrogen-powered turbines and carbon capture and storage. However, these technologies may take decades to develop and may not even be possible or commercially viable (Blanchard and Perkaus, 2004). For carbon capture and storage, implementation mainly depends on the price of CO_2.

It can be concluded that the US energy policy is not directed towards decreasing reliance on imported energy. However, if the policy would be to enhance self-reliance, most measures would be synergetic in nature with climate change mitigation.

3.5 US climate policy influence on security of supply

Intensity target
The US climate target is an 18% reduction in GHG emission intensity by 2012. It may be argued that this is nothing more than business-as-usual, but the government has put in place a set of policies (mainly) aimed at GHG reduction. The only real target relates to the use of biofuels, of which the domestic supply clearly enhances energy security. Every gallon of biofuel reduces an energy-equivalent amount of oil to be imported[12]. A second part of the policy aims to improve energy-efficiency in various end-use sectors. Reducing energy demand is also synergetic with energy security - it is the most basic approach towards supply security. Finally, tax incentives for renewable electricity production are in place. A greater share of renewables reduces the need to import gas (or coal) which would otherwise be used.

Clean coal and CO_2 capture and storage
The US is also investing in research on clean coal technologies and CO_2 capture and storage. Technologies such as (supercritical) pulverised coal combustion and integrated gasification combined cycle (IGCC) have the potential to increase conversion efficiency and substantially reduce CO_2 emissions as well as reduce emissions of other air pollutants. As the US is likely to become a net importer of coal within the next decade (DOE, 2004b), this will reduce import dependency. As well, clean coal technologies may allow for a longer use of coal and therefore reduce future demand for imported gas (in which case it may be argued that this policy is not beneficial for climate change).

Related to clean coal technologies is the investment in research and pilot projects on CO_2 capture and storage (CCS). This technology is seen by the US government as a promising option to reduce GHG emissions, while allowing for a continued use of coal for power generation. For this latter argument, this measure can be seen as enhancing power supply security. It should be taken into account however, that energy efficiency for a power plant with CCS currently decreases by up to 10%-point compared to plants without CCS (which figure may be improved through learning effect).

Hydrogen initiatives
The final important policy measure may turn out to be the most significant: hydrogen technology investment. The Bush Administration has allocated 2 billion dollars for programmes focussing on fuel cells in cars. Assuming that it is the goal to produce hydrogen from emission-free sources such as gasification with CCS, we have marked this policy as climate change policy. It is however largely driven by the wish to reduce oil imports from unstable nations. The hydrogen policy may therefore be the most synergetic of all, if hydrogen is produced in a CO_2-neutral way.

3.6 Other options to enhance synergies

The previous sections have indicated that several of the US energy policy goals are beneficial for both energy security and climate change. There are, however, several options that enhance the synergies between the two policy areas further. This section aims to give some examples for this.

[12] Based on a life-cycle approach taking into account production and processing of energy crops, savings will be less than 100%.

Extension of biofuel target

The current target for biofuels is 2% of transportation fuel in 2010. This compares to a EU (non-mandatory) goal of 5.75% in 2010[13]. The potential for growing crops for biofuel production in the US is large and could generate a new source of income for farmers. Therefore, if the current biofuel target would be extended, this would reduce both oil dependency (one of the main goals of the US energy policy) and CO_2 emissions. For example, a target of 5% - compared to the current goal of 2% - in 2015 lowers GHG emissions from the transport sector by approximately 50 $MtCO_2$-eq/yr and required oil imports by 0.5 million barrels/yr or 5%[14].

Target for renewable electricity

It appears that the current US government is in general reluctant to set targets for a certain technology. The general policy is to create market conditions that favour certain technologies, and then leave it up to the market which technologies increase their shares in the energy mix. As a result, diffusion of technologies such as renewable electricity production is promoted but there is no certainty as to the extent of deployment. It may be that an opportunity to reduce reliance on imported gas is missed. If, on the other hand, a target for renewable electricity would be set, it can be calculated that fewer coal or gas-fired power plants would be needed. For example, a goal of 10 GW wind power capacity in 2010 reduces annual power production of approximately 10 gas-fired power plants of 400 MW capacity each. This lowers GHG emissions by 7 $MtCO_2$-eq/yr and gas imports by 150 billion m^3 or 1% (assuming a marginal demand reduction means import reduction).

Energy efficiency

Improving energy efficiency is a basic approach to reduce demand for energy and thereby increase energy security. It inherently reduces greenhouse gas emissions from fossil fuels. The potential and number of options to increase energy efficiency are large, and a set of policies can be implemented to achieve this. Examples include standards for vehicle fuel economy (as recommended by the National Commission on Energy Policy (2004)), benchmarking industrial energy efficiency, tax incentives for efficient practices in households, industry or power production (e.g. co-generation) or technology standards for new appliances or industrial processes. Even though difficult to quantify, energy efficiency targets across the entire economy or defined for each sector may prove to be a very (cost-) effective way to reduce both import dependency and greenhouse gas emissions.

Nuclear power

It is currently projected that the nuclear share in the power mix will slowly decline to 14% (DOE, 2004). Even though economical and security issues are also important, it is technically feasible to build more power plants. If we assume 10 GW (10-20 plants) more nuclear capacity compared to current projections in 2020, this will reduce demand for imported coal and/or gas. If it replaces coal-based[15] power, import demand is reduced by 26 million tonnes/year and GHG emissions by 64 $MtCO_2$/yr. If it replaces gas-based power, import demand decreases by 1.6 billion m^3/yr and GHG emissions by 6.6 $MtCO_2$/yr.

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[13] However, this goal is not likely to be met.

[14] Every reduction of oil imports is a reduction at the margin, which is usually the most expensive or the most riskful. Therefore, every percent of import reduction is a significant gain.

[15] Coal-based power plants are often operating at the margin, in case the variable cost is higher than for gas-based power. However, replacement of gas-based power is also possible, if building nuclear plants replaces building of gas-fired power plants.

4. POST-2012 CLIMATE POLICY AND ENERGY SECURITY

The reliance of the global economy on fossil fuels, consumerism and increasing energy demands from a growing world population all contribute to the complexity of finding an acceptable post-2012 international climate change policy framework. In order to adequately address the problem of finding consensus internationally on climate change policy, it will require all significant emitters to take part. The proposition is put forward that linking energy security with climate change policy is a key element to a successful global response. As Palmer (1995, page 90) points out:

"No one country can solve the problem, although one country abstaining from corrective action could do great damage. It is a global problem that demands a global solution."

As discussed in the previous chapter, three of the major players and emitters are in the Kyoto Protocol, and the US also is participating in post-2012 climate negotiations. This section explores the possibilities of linking energy security with climate change policies in a post-2012 framework and with emission trading instruments.

4.1 Linking options in different climate regime types

Section 2.1 briefly points to issues regarding the design of a post-2012 climate regime and some options that have been proposed. The current section aims to explore possible linkages with energy security.

4.1.1 Integration into greenhouse gas reduction regimes?

Most well-known proposed post-2012 climate regime frameworks entail some form of greenhouse gas reduction target. Within this group of options, there is differentiation relating to participation, timetables, character of commitment, etc., but the principle of GHG targets is similar. These emission targets are determined following top-down principles, possibly in combination with bottom-up approaches.

The top-down element originates from the global nature of the climate change problem. As greenhouse gases mix very quickly in the global atmosphere, every country is responsible for the problem - even though current and historical contributions to global emissions vary greatly. On the other hand, the consequences are also felt across the globe. Therefore, an attractive principle of approaching the problem is to define 'carbon budgets' for countries or individuals based on climate impact assumptions and equity principles. Every country then may decide how to reach these targets.

Concerns of energy security on the other hand, are typically national or perhaps regional (in the case of the EU) issues. As opposed to a country's GHG emissions, a country's energy security situation is of minor impact to another country. It therefore does not make much sense to, e.g., design a global energy security regime, which lays down certain targets to individual countries and link this with climate targets. The only option is to point to the synergies regarding combating the two problems, but in essence this is also a national issue.

The bottom-up elements in some post-2012 regime options, such as the Triptych and the Multi-Sector Convergence framework, are of a sectoral nature and may provide some more linkage options. In these two approaches, the national economy is divided into sectors, such as power production, residential sector, industrial sector, etc. For each sector, an emission target is based upon sector-specific considerations and metrics. For instance, for the power sector, an emission target may be expressed in gCO_2-eq/kWh. This target may be valid for all countries in the regime, but it seems to make more sense to take country-specific circumstances such as technology and availability of resources into account, in order to differentiate national sector targets.

In these bottom-up approaches, several sectors appear to be very suitable to link up with improving the national energy security situation, notably power production, industry and transport. A common element in the approach of the two problems is technology. As elaborated in Section 3.2 and 3.4, the synergies are most clear on a technology level. Negotiations on which GHG targets for each sector are set on an international level may be easier when common concerns of energy security are addressed. If it is clear to participating countries that these targets have considerable ancillary benefits for their security of supply, likeliness of succeeding negotiations increases.

4.1.2 Technology framework

A climate change approach very different from the options outlined above, is focussing on technology rather than greenhouse gas emission targets. Even though there are no elaborate technology approaches put forward yet, it is worth exploring if linkages with energy security may be possible.

In a climate change technology framework, countries joined in an international convention may agree to (e.g.):

- allocation of RD&D budgets to specific climate-friendly technologies,
- cooperation between countries on RD&D of these technologies,
- targets and timetables for diffusion of technologies.

As on a technology level the synergies between climate change and energy security are quite straightforward, an agreement between countries with similar concerns regarding energy security appears to be an option. In this fashion, a common strategy in combating climate change and improving energy security between different countries emerges. This would have obvious merits, including cost-optimalisation, improved stakeholder support towards different policies and improved relations between countries.

The synergies between the two policy areas may provide more common ground between countries than is currently the case in negotiation about climate change only. Therefore, the ESCAPE approach may provide promising prospects. On the other hand, negotiations that are already complex in the current situation may become even more intricate when multiple issues are brought together.

4.2 Linking energy security and emission trading

The Kyoto Mechanisms CDM and JI and other emissions trading systems such as the EU ETS are likely to retain their importance and may need to be developed further (Sugiyama et al, 2004). This section therefore aims to initiate a discussion about the possibilities to link these trading systems with concerns of energy security.

4.2.1 Current situation regarding CDM/JI market

After several years of intensive discussion and development, the CDM market is now likely to emerge as a more influential factor in emission reductions. In 2004, several developments have occurred with the CDM, including the first two CDM project registrations, the first consolidated baseline methodologies approved and more than 200 projects reaching the stage that Project Design Documents are prepared[16]. Finally the Kyoto Protocol has come into force in early 2005.

Annex A gives an overview of the current state of the CDM as well as the JI market[17], regarding type of projects, host countries and buyers. All together, over 200 projects have requested comments on PDDs. The biggest GHG reductions are achieved by projects abating non-CO_2 gases, such as nitrous oxide, HFCs and methane, often reducing GHG by 1 up to 10 MtCO_2-eq/yr. Most projects though reduce CO_2, in less quantity, by implementing technologies such as renewables, energy efficiency measures or fuel switches. Popular host countries are India, Brazil and Mexico for CDM, and Romania and Bulgaria for JI. It should be noted that the JI market is in a much earlier stage of development, as no procedures for baseline methodologies have been agreed.

As most projects deal with energy related emissions, an effect on the energy security situation of the host country may be expected. In general, it can be said that all projects aiming at reducing CO_2 emission, except for sinks projects, are beneficial for the energy security situation of the host country, as they reduce dependency on (imported) fossil fuels. This of course counts most strongly for countries that are not abundant in domestic fossil fuel reserves, but even when this is not the case, diversifying energy sources is beneficial and as stated in Chapter 2 one of the important aspects of securing energy supply.

On the other hand, the larger projects targeting the other GHGs will not have a positive impact on energy security, for these involve end-of-pipe technologies or capturing of landfill gas. Exceptions here are utilisation of landfill gas and coalmine methane for power generation, but these account for only a minor part of the energy supply.

In order to gain some insight in the effect of the current CDM project portfolio on the energy security situation of non-Annex I countries in terms of import dependence, we carried out a simplified quantitative analysis. The 75 renewable electricity projects replace fossil-based power and it was assumed that power at the operating margin is based on natural gas. For the countries that are importers of natural gas, the projects would save over 600 million m^3 of natural gas imports each year. The methane capture projects have not been counted here, for their contribution to power production is relatively small.

Currently, only two projects involve production of biofuel. Together with two other projects that specifically replace oil in power production or industry, over 30,000 tons/yr of oil are saved, which are for the main part avoided imports. Most energy efficiency projects result in reduction of coal consumption, which for many countries, also entail a smaller need for imports. Finally, 9 projects aim to switch from fuels such as coal, oil or naphtha to natural gas or LPG. The impact on the import situation differs depending on the presence of national natural gas reserves or oil refineries.

[16] In this stage, stakeholders can also give comments which the validator of the PDD takes into account.

[17] This assessment includes projects for which a PDD is published.

4.2.2 EU Emission Trading Scheme

In January 2005, the biggest emission trading market designed to date commenced. Over 12,000 installations in the EU - covering nearly 50% of total EU CO_2 emissions - will fall under a cap-and-trade mechanism, allowing them to freely trade CO_2 emission rights. Even though it is in general not expected that the overall allocation of emission rights is very tight for the first three-year pilot trading period (Ecofys, 2004; Bakker, 2004), the establishment of a scheme this large is a major step forward in climate policy. Several countries, including Norway, Canada and Japan have expressed interest in linking their future emission trading systems to the EU ETS. In addition, initiatives to expand the system to cover other gases and emission sources (such as aviation) are being discussed. It is therefore likely that this system will play an increasingly important role in a post-2012 regime.

There is clearly a synergy with energy security in an industrial CO_2 emission trading systems. In most cases, measures that reduce energy CO_2 emissions will improve the energy security situation in the country it takes place. Fuel switch[18], energy efficiency measures or application of renewable energy all have a positive impact on reducing reliance on imported fossil fuel. In this regard however, it is from a national point of view always more advantageous to reduce emissions domestically, compared with the situation where a company buys emission rights from a foreign company. This is of course inherent to any emission trading system.

4.2.3 Options for linking energy security and emission trading

Like the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, there are several precedents promoting international cooperation. Several international agreements recognise the value of cooperation and developing partnerships to reduce emissions in a cost effective manner: the 1979 ECE Long-Range Transboundary Air Pollution Convention; the 1985 Vienna Convention for the Protection of the Ozone Layer; and the Montreal Protocol to the Ozone Convention are all examples of joint action between states (Kuik et al, 1994).

Given the importance of the Kyoto Mechanisms and the EU ETS, it is worthwhile exploring what possibilities exist to incorporate concerns of energy security into an emission trading system. In 2005, negotiations about the design of a post-2012 climate change policy response will begin. In an effort to advance the debate on the design of this system, we put forward the ESCAPE proposal to further examine the option of how to incorporate a criterion of energy security linked with JI and CDM projects as well as emissions trading. The other criteria for JI and CDM projects will remain: sustainable development, greenhouse gas emission reduction and economic efficiency (Pew Center, 2000).

The first step is to design a specific criterion for CDM and JI projects that deals with energy security. Apart from reduction of GHG emissions, which will remain the most important parameter, the effect on energy security will be taken into account. This could be quantified as reduction in required imported oil, coal or gas in units of energy. For example, power generation by a 20 MW wind farm may reduce annual demand for natural gas imports by 3 million cubic feet (0.08 million m^3). The host country or the investing party could give an additional financial credit to the project developer for each m^3 import saved. Another option is that the host country sells the credits for a lower price to take the energy security benefits into account.

Another option is to issue a special type of emission reduction credits that includes this criterion. Already several types of CERs exist, which are listed in appendix C. A new type can be added to this set of CERs. It is then likely that the new type of CER will be valued higher by buyers, compared to reduction units that do not improve energy security.

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[18] Unless it entails a switch to natural gas that needs to be imported.

Including this new type of projects will have an effect on the market in terms of selecting preferred technologies. It would allow (most) projects aimed at CO_2 reduction an advantage over most non-CO_2 projects, as the former often entail a benefit for the host country's energy security situation. This is an important advantage that also relates to one of the goals of e.g. the CDM, namely promoting sustainable development in the host countries.

An obvious drawback of adding an energy security type of carbon credits is that it will add to the complexity of the already intricate and slowly emerging international carbon market. A new type of credits would increase the amount of policy and regulations attached to the carbon market.

Regarding the EU ETS, which involves trading between companies instead of countries, a slightly different approach may be of interest. The power companies are particularly worthwhile to focus on, for these are in the business of energy supply and are closely involved in many strategic decisions regarding a country's future energy mix. Therefore, power companies that successfully reduce their CO_2 emissions will (often) reduce their reliance on (imported) fossil fuels and could be rewarded with an extra credit, if it is clear that they serve a national goal of energy security. Technologies such as energy efficiency, renewables and fuel switch are all useful in this regard. The reduction efforts can be rewarded by an extra credit issued by their national government that follows the CO_2 credits in €/tCO_2 or a credit related to reduction in required energy content of imported fuels.

An advantage of this approach will be that there is no issue of baseline determination, for this has effectively been carried out in the allocation of emission rights. As well, reporting of how the emission targets have been achieved is already contained in the ETS, for each affected installation will have to keep a transparent 'carbon account'. In this fashion, a company can give proof of their on-site emission reductions or bought emission allowances.

In considering application of an energy security criterion, interests of fossil-fuel-exporting countries need to be taken into account. Even though impact of current climate policy (i.e. Kyoto Protocol implementation) appears to small compared to other important factors (Van der Linden et al, 2004), OPEC countries tend to stress that their economies are hurt by climate policies. In the short to mid-term however, there may also be a synergy in the area of GHG reduction at the production of fossil fuel (Point Carbon, 2004). Cash flow to these countries as a result of implementation of CDM project aiming to reduce emissions at oil and gas production sites, can be seen as a compensation for reduction in export revenues.

5. EVALUATION AND CONCLUSION

The ESCAPE approach suggests that linking climate change policy with security of energy supply can improve climate change policy at both the national and international level. The report explores the interaction between policies of energy security and climate change and the options of inclusion of energy security issues into post-2012 climate negotiations. It emphasises the importance of the US in this regard and takes a close look on US energy policy documents.

National level

Security of energy supply is a major policy issue in many world regions. Dependency on imported oil and gas is likely to increase sharply for the US, the EU and China.

US energy policy relies heavily on oil for the next decades. In addition, it focuses on creating incentives for new technologies and leaves it up to the market which energy sources will increase their shares in the energy mix. To this extent, the energy security position is not likely to be beneficially influenced by current energy policy. This is in contrast to the strong preferences on reducing imported oil and gas dependency.

Many measures that can be taken in order to enhance security of supply are synergetic with climate change measures, such as renewable electricity, biofuels, nuclear power, hydrogen fuel (from renewable sources or fossil-based with carbon dioxide capture and storage). A number of options have been put forward that reduce import dependency as well as GHG emissions.

International level

The security of supply issue has to date not been included in climate policy negotiations and is also not mentioned in any post-2012 climate regime proposal. However, as this issue deals with national interest, it could be a means to address the difficult issue of collective action in climate negotiations.

Therefore, we recommend that security of supply interests be integrated in post-2012 climate policy strategies where possible. This will appeal to all major climate relevant world regions and therefore, can streamline this issue into climate negotiations to reap synergies. This will create a broader basis for future climate policy, involving more stakeholders and policy areas.

However, the advantage of energy security as a national interest is also an inhibiting factor for streamlining this issue into an international climate regime in the form of global targets similar to the top-down approaches in currently proposed post-2012 frameworks. As the synergies between the two policy areas are mainly on a technological level, post-2012 regimes that include sectoral bottom-up elements or technology-based approaches would provide the most promising linking options. For example, groups of countries agreeing on approaches to combat both climate change and energy security threats may aim to link the these into one convention. Due to the different nature of the problems, options for linking on a global scale appear to be less likely achieved.

Emission trading instruments are likely to be part of any post-2012 climate regime, even though the design of such a regime is not within sight given current international situation. Instruments such as the current Clean Development Mechanism and the EU Emissions Trading Scheme provide interesting options to link up with energy security. For the CDM, a new type of CER (carbon credit) can be designed to include an energy security criterion. This would in general favour projects that reduce CO_2 over other greenhouse gases, as the former often entail a benefit for the host country energy security situation. This adds to the sustainable development component of CDM projects, which are often stronger in CO_2 projects.

Regarding instruments such as the EU ETS, governments may reward companies that comply by reducing their emissions compared to those buying allowances on the market.

In general, linking energy security and climate policy on an international level entails some potential benefits as well as drawbacks. To start with, it appeals to basic national interests, opening up a new dimension in climate negotiations that serve in essence supra-national interests. Secondly, measures or projects that improve security of supply and thereby, add to sustainable development, are favoured over those that do not. Thirdly, by serving multiple objectives, cost of policy may be reduced. Finally, it will encourage sustainable technology innovation and implementation.

On the drawback side, the main issue is increased complexity of design of a post-2012 climate regime. A common strategy, e.g. on technology development and diffusion, for energy security as well as climate change needs to be established between a group of countries. Both reaching common ground between countries on these issues as well as designing the combined polices will require more rounds of negotiation and policy-making. Also, including an energy security criterion in carbon credits in emission trading, will also add to complexity in markets that are in early stages of development.

Recommendations
This report has emphasised the potential of the concept of linking security of supply with climate policy: the ESCAPE approach. To further explore how this can be put into practice, we recommend an assessment and exploration to further examine and analyse the option of including an energy security criterion into climate change mechanisms such as emissions trading, as well as the ways in which the concerns of energy security can be mainstreamed to enhance international cooperation and negotiations on climate change.

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APPENDIX A US ENERGY POLICY ANALYSIS ON ENERGY SECURITY AND CLIMATE INTERACTION

The Chairman of the Senate Energy and Natural Resources Committee, P.V. Domenici (in Economic Perspectives, May 2004) stated the US energy future goal as:

"A future where abundant, reliable, and affordable energy is produced with little impact on the environment and no dependence on the goodwill of hostile nations."

In addressing our vulnerability in the future, Secretary Abraham recently declared that the Department has 'an ambitious, long-term vision of a zero-emission future, free of reliance on imported energy' (DOE, 2003).

The approach to promote diffusion of clean technologies heavily relies on market-based instruments, with no mandatory targets, as shown by the following statement:

"The Administration believes it is not the role of the Federal government to choose the energy sources for the country. Instead, the role of the Federal government is to help the private sector develop technologies capable of providing a diverse supply of energy, and to allow the market to decide how much of each energy source is actually used (NEP, 2003)."

It also stresses the (potential) importance of hydrogen, particularly for transportation, for which several programmes have been initiated (such as FreedomCAR):

"Since most of our imported oil is used for transportation, these programs have the potential to substantially reduce, if not eliminate, our dependence on imported oil. Hydrogen can be produced from diverse domestic sources including coal, nuclear power, and renewable resources, (e.g., wind and solar)."

According to the US National Energy Report released in 2001, two of the principles and main components of US National Energy Policy are to develop a long-term comprehensive strategy that will advance new, environmentally friendly technologies as well as to increase energy supplies and encourage the use of cleaner and more efficient energy use. The Vice President of the US, Richard B. Cheney (2001: 10) stated in the report:

"Here we aim to continue a path of uninterrupted progress in many fields… New technologies are proving that we can save energy without sacrificing our standard of living. And we're going to encourage it in every way possible."

This philosophy is similar to many other countries' in identifying technologies and protecting the citizen's standard of living. As is a common desire to enhance and improve energy security of supply. A recent report on from the National Energy Commission (2004) had three key recommendations to enhance oil security:
- Increase and diversify world oil production and expand global network of strategic petroleum reserves.
- Reform and significantly strengthen vehicle efficiency standards.
- Provide $3 billion over ten years in manufacturer and consumer incentives for domestic production and purchase of efficient hybrid-electric and advanced diesel vehicles.

As a result of the energy-intensive way of living, the US energy consumption has been growing steadily at about 1.5%/yr over the last decade (NC3) and this growth-figure is projected to be sustained.

A.1 Historical and future energy demand

The Annual Energy Outlook is an annual update of the US energy scenarios. This section uses figures from the basic scenario in the latest version, the early release of AEO2005, unless mentioned otherwise.

The energy mix in 2025 is dominated by petroleum (nearly 50%), the consumption of which is projected to rise steadily. To a lesser extent, natural gas and coal consumption will rise. Both energy sources are increasing their share in the electricity mix. Nuclear energy and hydropower output will stay at present level, therefore - with rising electricity consumption - their shares are going to drop slowly. Non-hydro renewable electricity is projected to increase from 2 to 4% in 2025.

This energy mix results in 6.63 Gt CO_2-eq emissions in 2012 and 8.06 Gt CO_2-eq in 2025, up from 5.75 in 2002 (19% and 45% rise respectively. The price of oil is projected to rise from $25 per barrel in 2010 to $30 in 2025 (2002 prices). Coal prices stabilise at about $18 per short ton, while gas prices increase to $4.8 per tcf (thousand cubic feet) in 2025, up from $3.6 in 2010. Electricity prices will slowly decrease over the next five years, to stabilise or slowly increase afterwards at approximately 7 $ct/kWh.

AEO 2005 also publishes an alternative scenario: *The October oil futures case.* In this scenario it is particularly the price of oil that makes the difference: $6 higher in 2010 and $5 higher in 2025, compared to the basic scenario. This difference results in some changes in the energy mix: 2% decrease in oil consumption, 1% increase in gas consumption and 1% decrease in CO_2 emissions.

Table A.1 *Key scenario figures on US energy future*

	Unit	2002	2025
AEO 2005			
Prim energy consumption	[Quad. BTU[19]]	98.0	133.2
Oil consumption	[10^6 barrels/d]	19.71	27.9
Coal consumption	[Quad. BTU]	22.0	30.5
Natural gas consumption	[10^{12} ft^3 (10^9 m^3)]	23.0 (646)	30.5 (843)
Total renewable fuel consumption[20]	[Quad. BTU]	5.8	8.1
Final electricity consumption (2004)	[TWh]	3675	5485
AEO 2004			
Oil production IC's	[10^6 barrels/d]	23.4	24.2
Non-OPEC oil production	[10^6 barrels/d]	44.7	63.9
OPEC oil production	[10^6 barrels/d]	30	54
Oil production domestic	[10^6 barrels/d]	5.6	4.6
Petroleum supply domestic	[10^6 barrels/d]	9.2	8.6
Petroleum import share	[%]	54	70
Natural gas import share	[%]	24	38
Imported primary energy share	[%]	25	36
Coal-based capacity	[GW]		+112
Gas-based capacity	[GW]		+219
Nuclear capacity	[GW]	98.7	102.6
Coal-based electricity generation	[%]	50	52
Gas-based electricity production	[TWh]	682	1304
Generation by renewables	[TWh]	339	518
CO_2 emissions[21]	[Mt/yr]	5729	8142
GHG emissions	[MtCO_2 eq/yr]	6862	9839
GDP	[Billion $1996]	9440	18520
GHG intensity	[gCO_2eq/$96]	727	531

Source: DOE, 2004a, 2004b

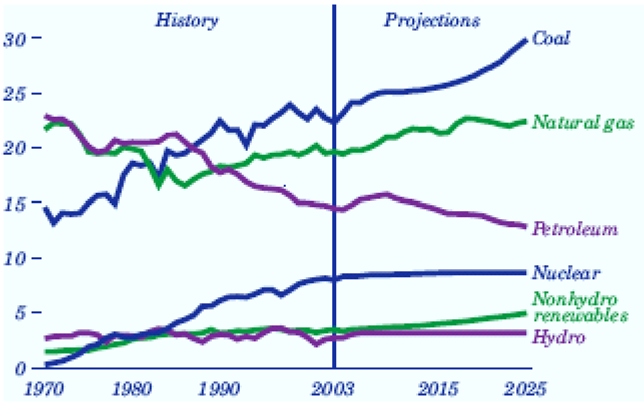

Figure A.1 shows how petroleum remains by far the largest primary energy source, its consumption rising faster than natural gas, coal and renewables. Nuclear and hydropower stay at a constant level.

[19] 1 quad. BTU = 10^{15} BTU = 1.05 EJ.

[20] Increase as a result of: state mandates for renewable electricity generation, higher natural gas prices and tax credits for renewable generation; 60% of this figure is for renewable electricity.

[21] The *AEO* projections do not include future policy actions or agreements that might be taken to reduce carbon dioxide emissions.

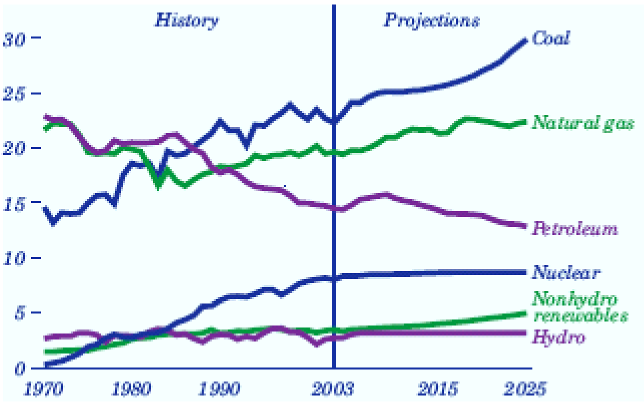

Figure A.1 *US energy consumption by fuel (quadrillion BTU)*
Source: DOE, 2004b

A.2. Oil and gas imports

Over 50% of current US oil consumption is imported. The imported share of oil and gas will increase with decreasing domestic production. There is currently about 25% of natural gas imported. The consumption growth is projected to outpace domestic production growth, leading to a required import share of 45%.

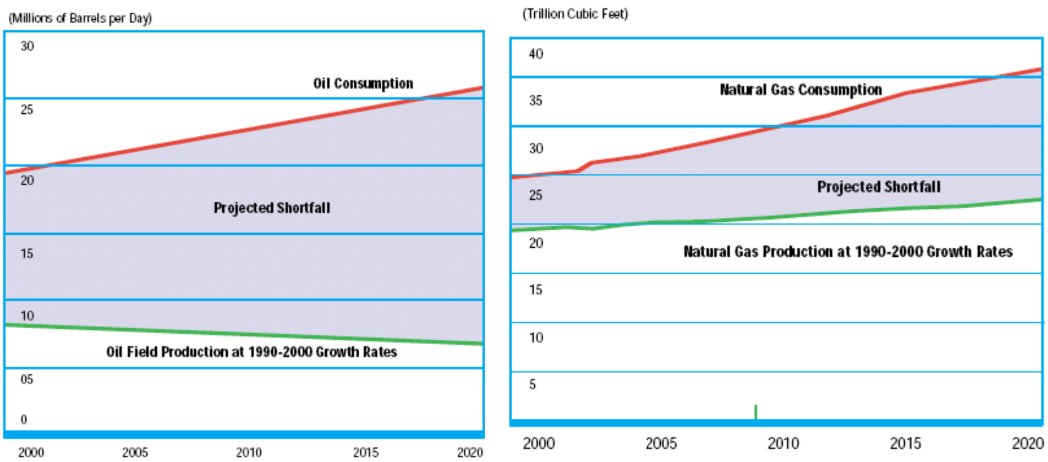

Figure A.2 *Consumption and required imports projections for oil and gas*
Source: DOE, 2004a

A.3. Electricity

A major challenge in the US will be to meet electricity demand in the next few decades. According to the National Energy Policy Report (2001) in the next two decades between 1,300 and 1,900 new electric plants will need to be built in the US. Most of those plants will be fuelled by natural gas although the options of coal and nuclear power are also being explored. The decision on what type of technology for these new plants will be a crucial factor in determining future greenhouse gas emissions.

In the next two decades the US expects to install over 300 GW of additional power capacity, or almost one power plant each week. Gas combined cycle will take a large share of the new capacity (more than 50% up to 2020), the remainder by coal and a small share by renewables. It is projected that average carbon dioxide emissions per kWh generated will decline by about 2% per year from 2002 to 2010 and remain at about that level through to 2025. Table A.2 shows that the electricity mix is expected to change towards more gas and coal with nuclear decreasing.

Table A.2 *Electricity mix in 2002 and 2025*

Primary Source	2002 [%]	2025 [%]
Coal	48	51
Natural gas	17	22
Nuclear	21	15
Renewables	11	10
Petroleum	4	3

Source: DOE, 2004a

A.4. Renewables

AEO2004 projects only a small increase in renewable electricity up to 2025, based on the assumption that the PTC (production tax credit) is not extended beyond 2003. However, the Energy Policy Act 2003 has already laid down a continued tax credit of 1.8 ct/kWh. It is not certain what period of time PTC will cover. With the details of this tax incentive, projections of renewable electricity production vary greatly. AEO2004 has made some scenarios regarding this, shown in Table A.3.

Table A.3 *Renewable electricity production scenarios*

	2003	2010				2025			
Projection	*Reference*	*Reference*	*3-year PTC*	*9-year PTC*	*9-year half PTC*	*Reference*	*3-year PTC*	*9-year PTC*	*9-year half PTC*
				Electric power sector net summer capacity (gigawatts)					
Municipal solid waste and landfill gas	*3.6*	*3.9*	*4.6*	*4.7*	*4.4*	*4.0*	*4.6*	*4.7*	*4.5*
Wood and other biomass	*1.9*	*2.2*	*2.1*	*4.4*	*3.2*	*3.7*	*4.6*	*13.7*	*8.1*
Wind	*6.5*	*8.0*	*15.9*	*40.3*	*23.4*	*16.0*	*23.8*	*65.4*	*38.8*
Total electric power industry	*936.9*	*931.7*	*937.5*	*958.1*	*943.3*	*1,169.9*	*1,176.7*	*1,221.0*	*1,191.7*
				Electric power sector generation (billion kilowatthours)					
Municipal solid waste and landfill gas	*25.6*	*28.1*	*33.7*	*34.5*	*32.3*	*28.5*	*33.9*	*34.7*	*32.4*
Wood and other biomass	*15.7*	*23.5*	*23.4*	*28.4*	*26.3*	*29.2*	*33.4*	*90.9*	*51.8*
Dedicated plants	*10.8*	*13.3*	*13.0*	*22.5*	*17.5*	*22.9*	*28.4*	*90.9*	*51.0*
Co-firing	*5.0*	*10.3*	*10.4*	*6.0*	*8.8*	*6.3*	*5.0*	*0.0*	*0.8*
Wind	*17.4*	*24.1*	*52.5*	*139.3*	*79.2*	*53.2*	*81.8*	*230.0*	*136.5*
Total electricity generation	*3,900.0*	*4,510.0*	*4,511.0*	*4,523.0*	*4,512.0*	*5,787.0*	*5,787.0*	*5,805.0*	*5,790.0*

Source: DOE, 2004a

If we assume extension of PTC of nine years, 180 TWh wind, 60 TWh biomass/wood, 60 TWh waste incineration, and 6 TWh landfill gas are added to the reference scenario. This adds up to over 300 TWh or 6%-point of extra non-hydro renewables in the total electricity mix, shown also in Figure A.3.

[TWh]

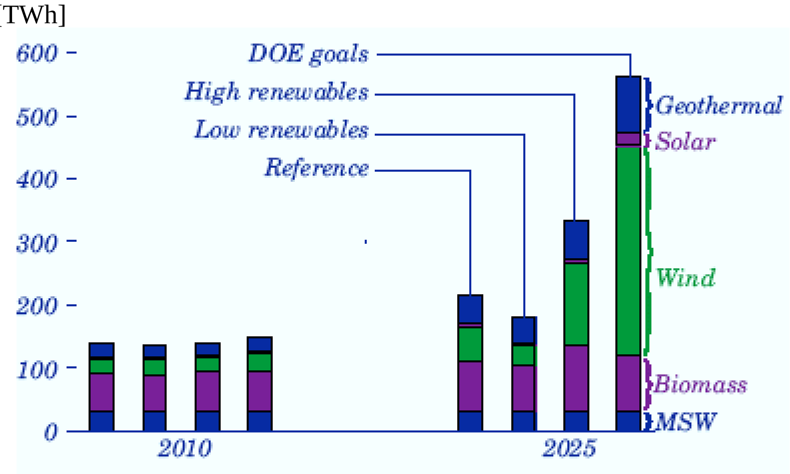

Figure A.3 *Renewables in 2025 under different assumptions*
Source: DOE, 2004a

APPENDIX B ENERGY SECURITY OUTLOOK FOR OTHER WORLD REGIONS

The concerns from the US of dependency on imported energy are common among many regions in the world. In this chapter, we briefly point out import dependency of the EU, Japan and China, which are also major players in climate negotiations.

EU

Primary energy consumption in the EU is projected to increase 16% from 2000 to 2025 (Egging 2004). Import dependency for oil is already high and is likely remain so - with 45% of import coming from the Middle East (European Commission, 2001). Over the mid term this also counts for gas and coal. It should be noted however, that imports from Norway account for approximately 25% of total gas imports (BP, 2004), this country not posing a serious ‘threat’ for energy security. In power production, the share renewables will increase slightly, while nuclear is projected to decrease. The transport sector relies for 98% on oil.

These figures appear to be in sharp contrast to the goal of being not dependent on external supply for 70% of its energy in 30 years’ time (European Commission, 2001). It seems more likely that the EU’s situation regarding dependency on import of fossil fuels will worsen substantially over the next decades.

China

With the economy booming these days, total energy use is projected to double to over 2000 Mtoe (53 EJ) by 2025. Coal remains to be the dominant energy carrier, but the oil share will rise. Nuclear energy use will grow but stays modest. The use of biomass stabilises in absolute terms, so its share in primary energy consumption decreases. Power generation relies for 75% on coal and 18% on hydro. The transport sector depends for 92% on petroleum, and the industrial sector depends for 2/3 on coal as fuel input.

The projected oil share increase will largely increase China’s dependency on external oil supplies (given its limited domestic oil reserves).

Japan

Japan’s economy is projected to grow steadily and, with that, energy consumption is going to rise 25% by 2025 (Egging and Van Oostvoorn, 2004). It has almost no domestic fossil fuel reserves and therefore, the country is and will remain entirely dependent on imports. The relatively large share of nuclear in the electricity mix (16%) is likely to decrease to 4% in 2030, while hydro and biomass take up a stable 4 and 1% respectively.

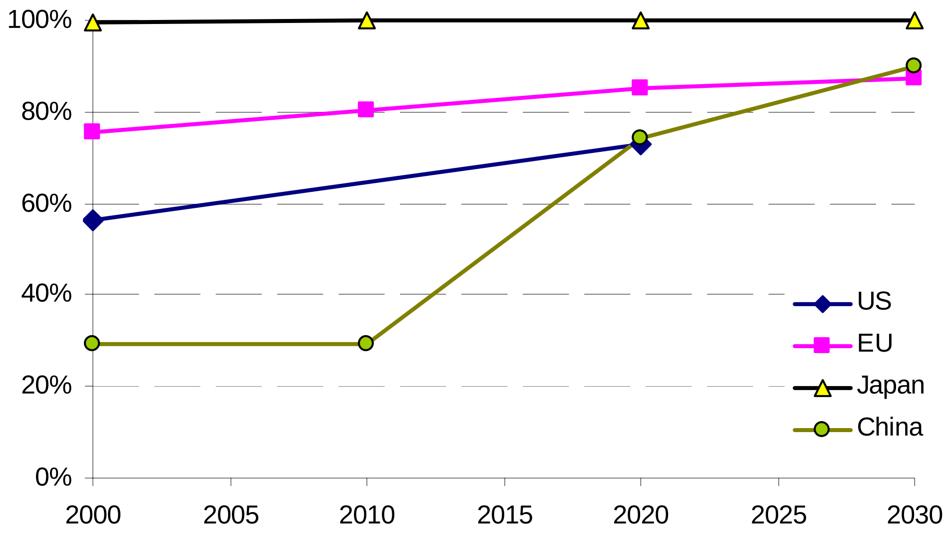

Figure B.1 *Dependency on imported oil: imports as percentage of total consumption*
Source: DOE, 2003; Uyterlinde et al, 2004

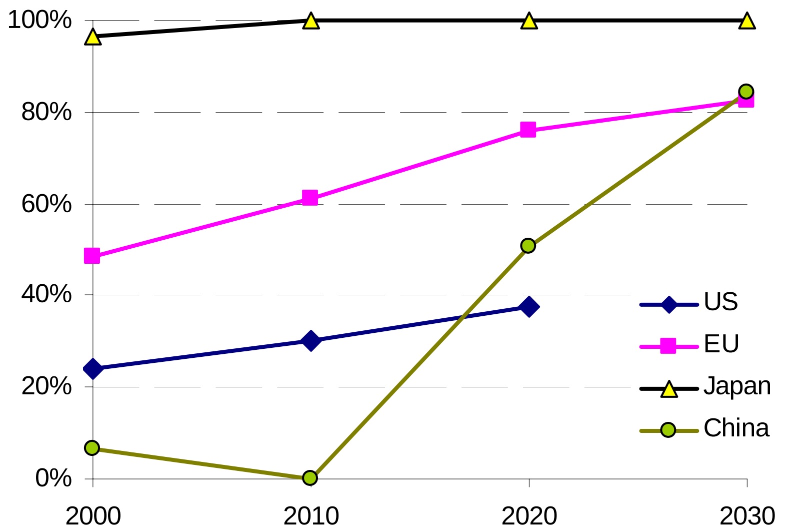

Figure B.2 *Gas import dependency: imports as share of total consumption*
Source: Uyterlinde et al, 2004; NEP, 2003

In conclusion, all four-world regions will see their import dependency on both oil and gas increase or remain at a worrying level over the next decades.

APPENDIX C CURRENT STATUS OF EMISSION MARKETS

This section gives an overview of JI and CDM projects and in particular assesses their potential as being a driver for China to reduce its projected greenhouse gas emissions and also improve its energy security situation.

The implementation of JI and CDM projects is becoming more common with many countries starting up their own individual JI and CDM programmes.

C.1. Joint Implementation initiatives

For Joint Implementation, 54 projects have been or are subjected to validation, amounting up to some 46 MtCO_2-eq. Romania and Bulgaria are dominating the project portfolio, both with 8 projects and approximately 10 MtCO_2-eq in reductions up to 2012. Hungary, the Czech Republic, Estonia and Russia are also important. Many Joint Implementation projects are implemented in countries that are not able to participate in the domestic Emissions Trading System of the European Union, such as Romania, Bulgaria and Russia.

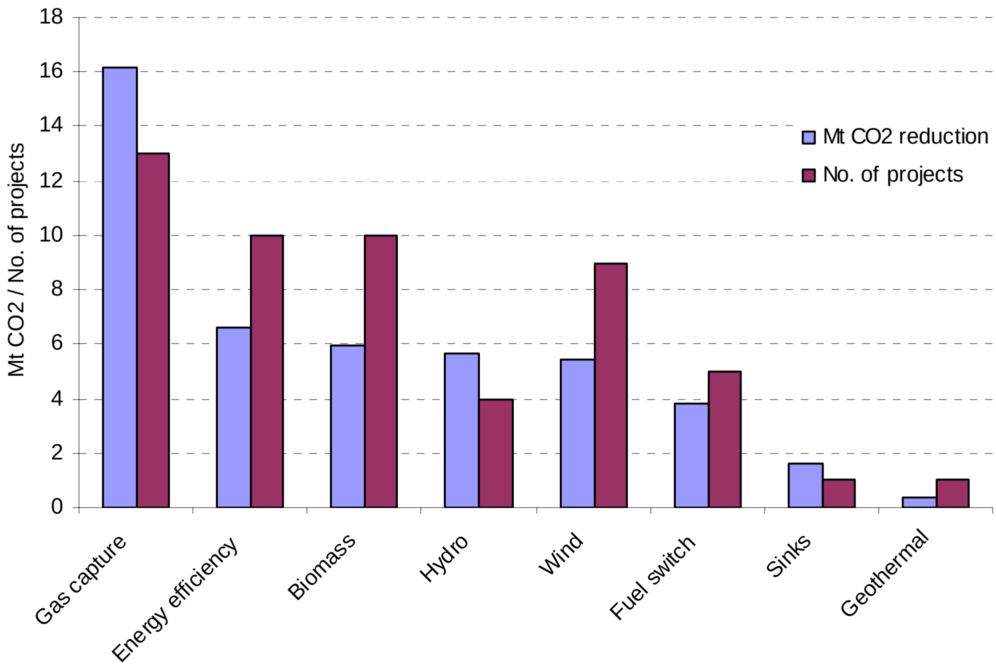

Figure C.1 *JI project portfolio, technology-wise*

The larger part of the current project portfolio contributes to improving the host country's energy security situation. Only the gas capture and, depending on national fossil fuel reserves, fuel switch projects, will not benefit energy security. In addition, most projects have co-benefits for air quality as well.

C.2. Clean Development Mechanism initiatives

The use of the CDM is increasing and its inclusion in the EU ETS as a means for companies to comply with their targets will increase this as an option.

Currently, for CDM alone, over 160 projects with GHG reductions amounting to more than 400 $MtCO_2$-eq (up to 2025) have been submitted to the CDM Executive Board for approval or published with a validator for stakeholder inputs. The majority of the reductions in greenhouse gases in CDM is taking place in Asia: ca. 51% of the emission reductions. Only 7% is in Africa.

Brazil is the most popular host country, with 25 projects and over 100 Mt CO_2-eq reduction. South Korea, with only two projects, is selling the second-largest quantity of emission reductions: over 80 $MtCO_2$-eq. India is also a large host country with the largest number of projects: 34.

In terms of technologies, for CDM, by far most reductions are achieved by gas capture: almost 230 $MtCO_2$-eq. This can be methane from landfills that is used for electricity, but also HFC_{23}, PFC or N_2O capture and destruction as in the two South Korean projects. Renewable electricity projects (hydropower, geothermal, bio-energy and wind energy) together total reductions of over 80 $MtCO_2$ of the total portfolio of CDM. The 27 energy efficiency projects are usually in the field of steel or cement industry, steam recovery or co-generation. The bio-fuel and transportation projects are relatively new in the project portfolio.

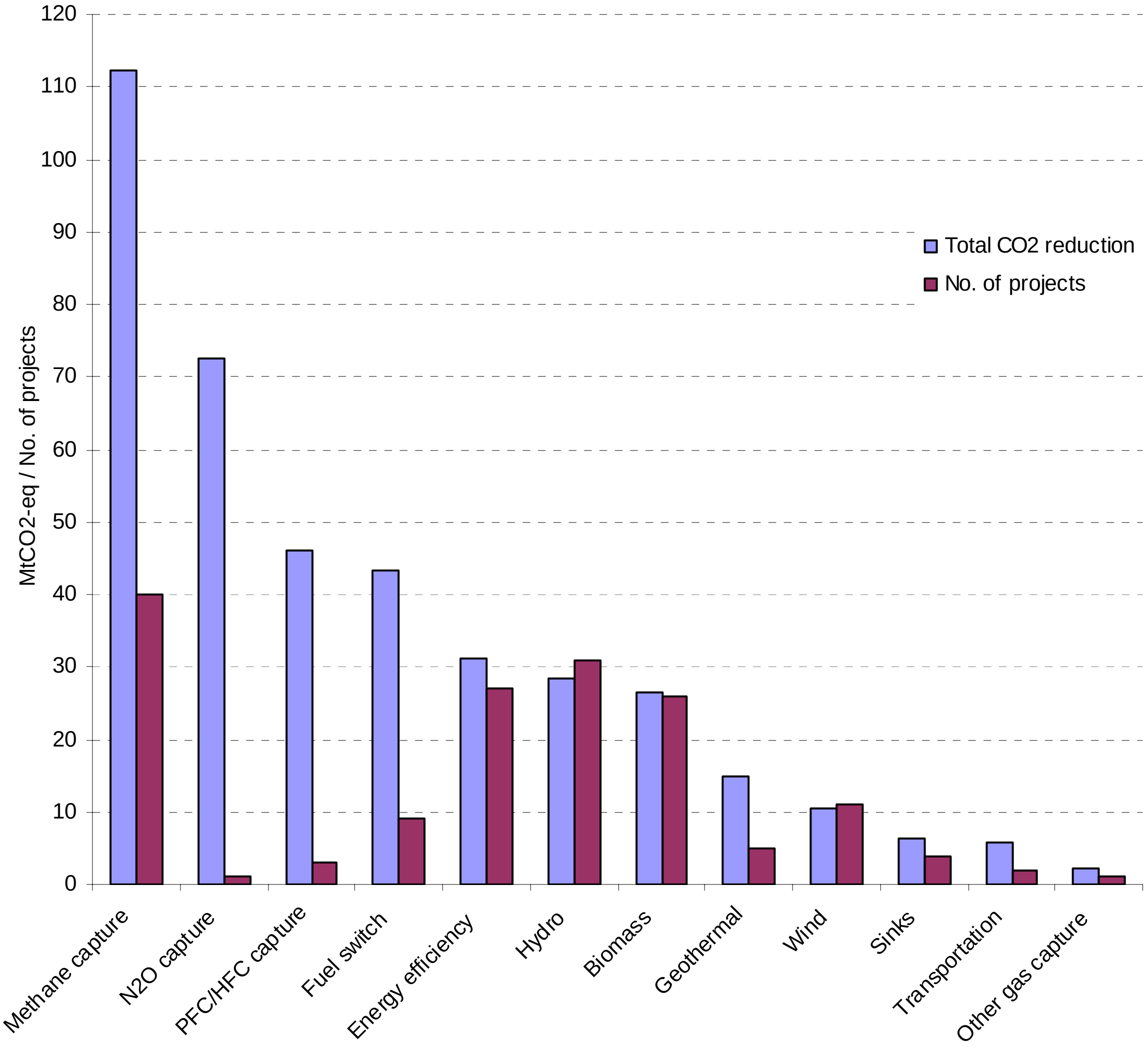

Figure C.2 *CDM project portfolio*

In terms of GHG reduction, the CDM project portfolio is dominated by gas capture projects such as N_2O, HFC and methane abatement, which do not contribute to a better energy security situation. If we look at the number of projects, however, it appears there are many projects concerning energy efficiency and renewables such as hydro, geothermal and wind energy. These yield considerable benefits in terms of reduction of reliance on imported energy for host the country.

C.3. The Fragmented Market

There are several types of GHG certificates with a number of issues associated with them including fungibility of certificates, prices, demand for certificates and consequences. IET and JI can begin from 2008 onwards and CDM from 2000. There are three types of currencies: AAUs, ERUs and CERs. There is however a differentiation of certificates within the CDM, e.g. technical projects versus biological sink projects. There are also regular versus small-scale projects, for which simplified baseline procedures have been designed in order to promote these projects. Projects that meet certain sustainability criteria are qualified as Gold Standard projects and can generate GS CERs.

In the case of sink CDM there are temporary CERs (t-CERs), which are only valid for one credit period (so a maximum of five years) or the Long-term CERs (L-CERs) which are bankable over a longer time period. There is also a number of emissions trading schemes developing their own certificates, e.g. the EU ETS and the European Union Allowances. There is also discussion of national compensation projects or (CNPs) from 2008. This is a kind of domestic JI but e.g. it would involve a company inside Germany doing a project with another German company. There are also verified emission reductions or (VERs). Table C.1 summarises the carbon credit currencies.

Table C.1 *Types of certificates*

Types of certificates	Abbreviations
Assigned Amount Units	AAUs
Emission Reduction Units	ERUs
Certified Emission Reduction Units	CERs
Small-scale Certified Emission Reduction Units	SC-CERs
Gold Standard Certified Emission Reduction Units	GS-CERs
Temporary Certified Emission Reduction Units	t-CERs
Long-term Certified Emission Reduction Units	L-CERs
European Union Allowances	EUAs
Compensation National Projects	CANs
Verified Emission Reduction Units	VERs