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Benefits of Action

Towards an International Assessment of the Broader Implications of Climate Change Mitigation Measures

Report to the Environmental Advisory Council

Prepared by the Stockholm Environment Institute

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Contents

Preface and acknowledgment

This report has been prepared by the Stockholm Environment Institute (SEI) at the request of the Government Offices of Sweden. Anders Turesson has been the client's representative.

As part of the process, 11 separate written inputs on climate mitigation action and benefits were prepared by researchers at the Environmental Economics unit at the Department of Economics, Göteborg University. The inputs were prepared by Thomas Sterner, Olof Johansson-Stenman, Fredrik Carlsson, Åsa Löfgren, Gunnar Köhlin, Jessica Coria, Elina Lampi, Magnus Hennlock, Jorge Garcia and Anders Ekbom.

Separate background notes on particular topics were also prepared by research staff at SEI in Stockholm and York. The inputs were prepared by Johan Kuylenstierna, Lisa Emberson, Kevin Hicks, Karl Hallding, Magnus Benzie, John Whitelegg and Mike Ashmore, Steve Cinderby and Corrado Topi.

All of these inputs are presented as appendices to the report, and we would like to extend our sincere gratitude and appreciation to everybody who has been involved in preparing the background texts under a very tight time constraint.

Readers interested in more elaborate discussion on the topics addressed in the body of the report, are referred to the appendices, which provide a more thorough analysis of a selection of topics, as well as literature references.

In drafting the main text we have drawn on all the material mentioned above, without explicitly acknowledging particular contributions, arguments, data or evidence. A number of people have contributed to our work, but responsibility for any errors or omissions in the main text remains exclusively ours.

/ Oskar Wallgren and Måns Nilsson

Stockholm Environment Institute

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1. Introduction

There is a growing interest in what climate mitigation actions imply for wider society, both in terms of the economy and other social and political concerns. There have been a number of studies that estimate the "costs" of climate action, i.e. losses in growth and other economic outcomes that more stringent climate policy is surmised to generate. There are many who perceive measures and actions taken to mitigate climate change as costly for society, and against the national interest of countries around the world. National policy positions have often been underpinned by economic analysis and industrial interests that point to costs to society, and constraints to development, as the main implication of ambitious climate change action. As a result, the political will to make commitments within and outside the United Nations Framework Convention on Climate Change (UNFCCC) has been very limited, which has resulted in a relative stalemate in the development of the international policy framework.

However, the models used to represent climate mitigation action in economic terms simplify reality. These models also find it difficult to take into account the implications of long-term structural change (such as the effects of innovation), or implications that do not manifest themselves directly in economic flows. Along with the increasing interest in green growth, low-carbon development and eco-efficient economic strategies, there is a growing literature that examines these broader implications. This work shows that there is number of positive implications of climate mitigation policy that do not seem to reach the mainstream policy debate, but when looked at individually or taken together may very well shift the scales in favor of more far-reaching mitigation action.

However, the international climate policy debate still lacks systematic and comprehensive information about these potential positive outcomes. Furthermore, it is often these broader implications that speak more directly to national priorities and interests, be they public health, poverty reduction, innovation, employment or energy security, to name only a few. While the main argument for climate mitigation action may still be to reduce risks and avoid an unwanted future, the evidence of positive and tangible implications at a graspable scale, and within a future not too far off, has the potential to help overcome immediate implementation hurdles, financial constraints, and the shortcomings of political systems too often driven by short time horizons and election logics.

Sweden wishes to strengthen international efforts to mitigate climate change. Part of its strategy is to strengthen and extend analysis about the broader implications of ambitious climate action and low carbon development strategies, in order that these implications are more widely discussed in the international debate. By better understanding the multiple implications of climate mitigation action, nation states as well as specific actors (firms, land managers, local government, and cities) will be better positioned to make informed choices, to the benefit of themselves, their constituencies and the global environment. Implications other than those directly related to greenhouse gas (GHG) emissions need to be identified and where possible quantified.

Against this background, the Swedish government contracted the Stockholm Environment Institute (SEI) to carry out a pre-study for an international effort to amend existing analysis on the scope for efficient and equitable climate action with wider benefits. The purpose of the pre-study was to clarify the conditions and lay the groundwork for a major study in 2013–14. The main study would be carried out in collaboration with other countries, and develop new knowledge about the wider implications of climate mitigation action. The results from the pre-study are presented in this report.

The study considers the current knowledge base related to how different measures and actions for mitigating climate change can lead to social, economic and environmental impacts other than those linked to a changing climate. It also considers how robustly the various links between action and possible outcomes have been established. These links include areas where there is an established relationship with a clear evidence base (such as health impacts from reduced ancillary air pollution, or savings of energy costs from efficiency), ranging to areas for which there is a clear relationship but unclear or conflicting evidence (such as employment effects or energy security effects), and finally to areas where links are difficult to establish for methodological reasons, but for which there is still solid arguments for why links *should* exist (such as long-term innovation effects and quality of life)

Chapter 2 introduces key concepts. The evidence base for the study is presented in the appendices, while chapters 3–5 draw on and interpret this evidence. However, full references are only provided in the appendices. Chapter 6 then examines, as far as the current evidence base allows, how the link between action and implication varies depending on (a) different levels of development and (b) different levels of international cooperation. Chapter 7, finally, describes the recommended scope and approach of the main study, to be implemented over a two-year period.

Finally, it is worth emphasizing that, while the pre-study was originally intended to support efforts to "reframe" the international climate policy debate by pointing to wider benefits of climate change mitigation, it recognizes that it is crucial to present a balanced perspective of both risks and benefits.

2. Key concepts

The terms "action", "implication" and "benefit" can be interpreted and used in a number of different ways. This section describes our use of the main terminology and how we have categorized different elements of the core terms.

What do we mean by "implications"?

By implication, we mean all potential risks, costs and benefits from a particular action (see below), in the short as well as long term, and across the full width of society. The term may thus be both positive as negative. It is in principle possible to determine the net benefit (or net cost) by estimating the balance of the positive and negative implications, but whether a certain action generates overall net benefits may depend on the preferences of the parties involved and how they assign weights to different political or economic priorities.

For example, if a particular country invests in a larger share of biofuels in the energy sector, this may reduce the dependency on imported fossil fuels in that country (a positive implication) but may at the same time put more pressure on forest ecosystems in those countries in which biofuels are harvested, resulting in reduced ecosystem integrity (a negative implication). Whether the net implications motivate such a strategy will be determined by (a) the significance of the impact in the short and long term and (b) local and national preferences and priorities.

Straightforward economic valuations of all implications are not usually possible, owing to a lack of appropriate methodologies for costing things like political stability or energy security. This lack prevents the use of conventional or even extended cost-benefit assessment for weighing together all implications, despite the popularity of this approach in some circles.

In this report, we have assembled a relatively comprehensive gross set of implications (see Table 1. below). These are clustered into four different categories:

- Implications for people (health, quality of life, social inclusion, equality, poverty, livelihoods)
- Implications for resource systems (ecosystems, agricultural yields, forestry, fisheries)
- Implications for the economy (industrial renewal, innovation, employment, growth, financial stability)
- Implications for the state (fiscal effects, international stability, national political stability, energy security)

The pre-study has not examined all these aspects in full detail, but they are all touched upon to some degree in the appendices.

What do we mean by "action"?

Within the discipline of economics, analysis often focuses on different market-based policy instruments at the government's disposal, such as carbon taxation, emissions trading under quota schemes, subsidies, and (more rarely) non-market based instruments such as regulation or information-based instruments.

Within integrated assessment and mitigation scenarios, a more technical sector-based approach is widely used, examining different options for change in systems and sectors such as industry, services, transport, energy conversion, and buildings. For example, the Intergovernmental Panel on Climate Change (IPCC)[1] treats energy systems, transport, buildings, industry, land use and human settlements as separate sectors for which emissions trends are described and barriers and opportunities for action analyzed.

From a political science perspective, actions can also be discussed in terms of what actor(s) drive change, separating, for instance (a) individual actors (firms, land managers, local governments, cities) (b) national governments acting within their own territory (taxes, regulation, incentives, state owned enterprises) and (c) national governments acting together, either in formal and permanent constallations (e.g. the EU) or through bilateral or multilateral agreements (development assistance falls into this category). This perspective lends itself to a political economy analysis that considers the interests of specific actors (either economic or political).

In the table below we differentiate between three categories of action.

- Instruments imposed by governments (taxes, fees, regulation)
- Sector interventions (possibly driven by instruments, but also by other actions)
- Comprehensive economic/development strategies (low-carbon development strategies, green growth etc.)

It is uncommon to combine assessments of government instruments of a more generic nature with assessments of more specific measures and systems change in particular sectors, because to do so yokes together distinctly different disciplines. Still, this is a useful approach for communicating policy analysis to a broad audience.

[1] Specifically, IPCC Working Group III, which assesses pathways for mitigating climate change.

Additional concepts

When discussing how countries might be affected by climate change, and what action they can take, it is useful to distinguish between countries at different development levels. This report differentiates between low income countries, emerging economies, economies in transition, and developed countries. For the main study, it is recommended that a further breakdown is considered, which would include least developed countries (LDCs), other low income countries, lower middle income countries and upper middle income countries. It would also be useful, considering the centrality of the energy system in driving climate change and the importance of energy security as a potential risk/benefit, to consider differentiating between net exporters and net importers of fossil energy.

The Action-Implication matrix

Table 1 summarizes the scope and approach taken to implications (vertical) and actions (horizontal). Each cell represents a potential specific study of a particular causal link. In this pre-study, we have only been able to assemble evidence for a small selection of cells, either individual cells or a broader "cut" horizontally and vertically. In the scoping for the full study, this matrix can be used as a simple tool to help structure the discussion about appropriate focus and level of detail among the concerned stakeholders.

Table 1. Matrix for mapping implication against climate mitigation action

IMPLICATIONS	PEOPLE					RESOURCE SYSTEMS				ECONOMY					STATE			
ACTIONS	Health impacts via reduced air pollution	Health via lifestyles	Social inclusion and quality of life	Equality, justice and distribution	Poverty reduction (socioeconomic conditions, livelihoods, etc)	Agricultural productivity via changed practices	Agricultural productivity via reduced air pollution	Ecosystems function and biodiversity	Fisheries	Employment and job creation	Resource savings includ energy cost savings	Growth and Gross Value Added	Innovation and industrial renewal	Financial stability	International security, international relations, etc)	National political developments (democracy, stability, etc)	Resource security incl energy security	Fiscal revenue / budget implications
ECONOMY WIDE MITIGATION THROUGH INSTRUMENTS																		
Carbon tax																		
Emissions trading																		
Regulation																		
Subsidy removal																		
Refunded emissions payments																		
REDD																		
Information disclosure																		
Environment and energy labelling																		
SECTOR MITIGATION THROUGH SPECIFIC INTERVENTIONS																		
Forestry / REDD+																		
Transport systems																		
Urban infrastructure and planning																		
Low carbon modern energy investments																		
Agricultural practices																		
Energy use in buildings and processes																		
Consumption and food diets																		
PACKAGES / DEVELOPMENT STRATEGIES																		
Low-carbon development strategy																		
Green growth / green economy strategy																		

3. Mitigation action with potential near-term economic benefits

This section provides an overview of mitigation actions that are widely considered to have potential near-term economic benefits, but for which progress or uptake has to date not been sufficient. In particular, subsidy removal and carbon taxes are policy instruments with such immediate economic benefits. From the perspective of the energy sector, investments in transformation of energy systems and measures for energy efficiency are actions that could swiftly yield economic returns.

Removing fossil fuel subsidies

There is a wide range of policies in use that directly or indirectly support fossil-fuel production or consumption, both in developed and developing countries. Subsidies may be direct, or indirect: for example tax reductions, governments underwriting firms' financial risk, under-payment for government-supplied goods and services, and other interventions in markets affecting the relative price of fossil-related consumption and/or production. The most recent estimates (WEO 2012) from the International Energy Agency (IEA) suggest that globally fossil fuel subsidies may now exceed USD 600 billion per year.

Analyses by the Organisation for Economic Co-operation and Development (OECD) suggest that a phasing-out of fossil fuel subsidies in OECD countries could contribute to a 10% reduction in global greenhouse-gas emissions by 2050. Another study by IEA estimates that phasing out these subsidies by 2020 would result in a reduction in primary energy demand at the global level of almost 6% and a fall in carbon dioxide emissions by almost 7%, compared to business as usual. Research has suggested that by 2050 reductions of above 10% could be achieved. Removal of fossil fuel subsidies can therefore be seen as part of a significant climate policy package.

It is widely agreed that subsidy removal, as a climate policy, results in positive net benefits for the society. Fossil-fuel subsidies are not only costly to taxpayers, but are also lead to inefficient use of resources in society as well as questionable distributional effects. Several studies have tried to estimate the economic net benefits of removing fossil fuel subsidies and usually find positive global economic impacts. In several studies the estimates range from a global increase in GDP of 0.1% by 2010 up to 0.7% per year to 2050.

In the past decade the World Bank, OECD, and IEA, among others, have done a considerable amount of analysis of the economic impact of removing fossil fuel subsidies. This work has generally concluded that although for certain sectors there may be negative social impacts associated with fossil-fuel reform, these impacts could potentially be offset by allocating money saved on subsidies to the renewable energy sector and social programs.

Fuel taxes

Carbon taxes have often been put forward as the most efficient instrument to achieve long-term reductions in carbon emissions. The economic case for taxes from the perspective of cost-efficiency is well rehearsed and need not be repeated here. In many countries, carbon emissions from vehicles in the transport sector account for around a third of total emissions, and tend to grow at least at the same rate as income. It is thus vital to reign in these emissions from the viewpoint of climate. The long-term effect of applying high fuel taxes is very significant and arguably has done much more to limit carbon emissions than any other policy. High fuel taxes have reduced fuel use by at least 50% in countries where they have been implemented, such as in Europe and Japan; in fact they have lowered the fuel consumption (and thus carbon emissions) of the whole OECD by more than a third. However, there

have been concerns raised that the effects of rises in fuel tax are not equitably distributed across social groups. It has often been claimed that fuel taxes are regressive (i.e. that they disproportionally hit the poor), and there are very strong and vocal lobbies in most countries that try to prevent fuel tax rises, and even argue for subsidies instead. But evidence is growing that questions these claims about the regressive nature of fuel taxes. Recent research finds that fuel taxation would in fact be progressive in low income countries, where a majority of the world population lives. This applies to India, China, Indonesia and Africa. So, while fuel taxation has significant potential to mitigate climate change and create bring in money for governments, the risk of negative social impacts may have been overstated.

Energy saving action

Climate mitigation through improvements to the energy system, coupled with energy efficiency measures, would result in considerable cost savings, and investment in measures to boost resource efficiency can be achieved across all sectors of society. However, a lack of incentives, split incentives, and a range of non-economic barriers continue to block progress.

There are rather well developed approaches for performing bottom-up analysis of resource savings, in particular energy savings, for a certain jurisdiction (sector, city, country), which answer questions about how much can be saved by investing in, for example, better equipment, more efficient buildings, or modal shifts in transport. Pay back times and what are potential economic gains have received less attention, but the McKinsey Global Institute pioneered this work with their "climate cost curves", and in 2011 followed up with a similar approach for resource efficiency more broadly. At the city level, SEI together with University of Leeds and the Centre for Low Carbon Cities worked on "mini-Stern reviews", which carried out case studies on the cities of Leeds in the UK and Seattle in the US.

Concluding remark

In summary, both subsidy removal and fuel taxation are examples of climate mitigation action that combine cost-effective carbon emission reductions with potentially large positive near term effects for national governments. There is a strong evidence base that investments in low carbon development pathways, including fuel shifting and efficiency enhancements, will continue to provide opportunities for further savings and reduced energy imports within relatively short timeframes.

4. Low or moderate cost mitigation actions for which wider co-benefits can offset cost

Beyond climate mitigation actions with immediate economic returns there are both instruments and sector interventions that have low upfront costs for implementation, but which have been shown to generate a wide set of co-benefits. This section highlights how incentive-based instruments, refunded emission payments and carbon disclosure initiatives might lead to important co-benefits. Moving on to specific sector actions, we highlight improved air quality, partly through reduction of short lived climate pollutants (SLCPs) (affecting health, agriculture productivity, ecosystem health), land use improvements (REDD+, agricultural development and investments), urban planning and development, and energy system transformation aimed at lowering the dependence on imported fossil fuels (energy security).

Market-based instruments

It is well established in standard economic theory that market-based policy instruments such as emissions trading generate cost-effective emissions reductions. Another standard proposition is that

such instruments create more effective incentives to innovate and adapt new technology than do regulatory policies. However, the outcome of comparisons between different policy instruments and their respective effects on innovation depends on a number of contextual factors. Having said that, it is well established in the literature that permit programs create incentives to innovate and adopt technology, even if the effect and magnitude depends on the study at hand. However, the literature gives less insight into the use of emissions trading in countries with weak regulatory regimes (for example in less developed countries), though recent analysis suggests that in such contexts regimes with tradeable emission permits perform well compared with taxes targeting the same substances, which means it is a feasible policy alternative also from a developing country perspective.

Refunded emission payments (REPs) can be considered as a hybrid policy that consists of taxes on emissions, and refunds or subsidies to those companies that have paid tax, so that the state makes no net revenue. Practical experience from such schemes is limited to a few European countries (Sweden, Norway, France). REPs typically meet less political resistance than taxes. They provide regulators with a price-type policy that can be used in the case of firms or business interest have influence that could help them stop environmental taxes or other instruments that they consider too onerous. The fact that the instrument is cost neutral also means that it can be used for a subgroup of polluters without greatly affecting their competitiveness vis-à-vis those companies to which it is not applied. REPs contribute to investments in new technology and specific abatement technologies, and to "learning by doing" in the form of fine tuning new equipment and technology that further lowers emissions.

Information based instruments: carbon disclosure programs

Carbon disclosure programs are an example of an information-based policy instrument. A number of efforts have already been made that use its basic principles. A possibly significant co-benefit of informational approaches is that they increase local awareness of climate change. Disclosure can, in principle, help open up spaces for climate action. Although not always understood, negotiators depend greatly on the support of constituencies and the general public in their home countries. By the same token, pressure from foreign actors concerned about hidden CO_2 liabilities can help governments and communities to solve pressing local environmental problems. General equilibrium efficiency gains due to the correction of (local) environmental externalities represents a co-benefit of a carbon disclosure approaches. Notably, disclosure can be used as a substitute for conventional enforcement and ease constraints on local monitoring budgets.

Disclosure, by its nature, entails considerable stakeholder involvement. Once such a programme becomes institutionalised at the local level, a self-enforcing mechanism arises: systematic releases of information about polluters' environmental performance will expose them to public scrutiny, but also expose regulators. The general public may over time demand higher degrees of transparency. Thus spillover effects in the provision of other public goods such as health, education, infrastructure development are possible.

Links between air quality and climate forcing

In recent years there has also been a focus on how reducing the concentrations of short lived climate pollutants (SLCPs) can reduce the rate of global warming in the near term. SLCPs include a category of pollutants that have both air quality and climate change impacts. Activities to address atmospheric concentrations of SLCPs are being spearheaded by the Climate and Clean Air Coalition (CCAC). The focus is on emissions of black carbon (or soot), tropospheric ozone (formed from methane, CO, NOx and NMVOCs), methane (a GHG and precursor of ozone formation) and a subset of hydrofluorocarbons (HFCs), which only affect climate change and do not affect air quality. Key measures that would have maximum impact on near-term warming include introducing modern cook

stoves in parts of the developing world, reducing outdoor burning of agricultural residues, improved brick kiln designs, and reduced particulate emissions from diesel vehicles. Other measures include reducing methane from municipal landfill sites, coal mines, oil and gas production and from gas pipelines. Many of these provide economic returns from the use of methane as a fuel, and knowledge of the co-benefits can provide additional impetus for investment. These measures would provide substantial climate benefits and markedly reduce health impacts from particulate air pollution and ozone. Reduced ozone concentrations would also bring benefits for crop yields and for ecosystem services. (see below)

Improved air quality: health benefits

In many parts of the world the use of fossil fuels, both in electricity generation (coal) and transportation (diesel), negatively affects air quality. By reducing the use of such fuels (through both supply side and demand side action) co-benefits related to air quality can be expected in at least three key areas: health, agriculture and ecosystem function.

The biggest co-benefits from improved air quality in economic terms come from improved human health. A consistent and transferable analysis framework exists to quantify the health benefits of different policy scenarios. Analyses have been carried out to quantify relationships between the benefits for health (in terms of life years lost, adjusted for disability "DALY", and the number of avoided premature deaths), and the amount of CO_2 equivalents abated. Comparisons of the health benefits in developing and developed countries show that in general, developing countries would enjoy greater health benefits from better air (although often starting from a position where air quality is worse), although in many policy areas direct comparison is difficult. It should be acknowledged, though, that there are many uncertainties in the methods, of which estimating the change in exposure or dose at the scale of national populations is probably the most significant. Nevertheless, existing estimates cover only a limited number of health benefits, primarily linked to reduced mortality, and so may quite significantly underestimate the total health benefits.

Improved air quality: Agricultural productivity benefits

Poor air quality can have both direct and indirect impacts on agricultural productivity. Reducing pollutant emissions can improve the productivity of both crop and livestock systems. Direct impacts are related to air pollutants such as sulphur oxides (SO_x), nitrogen oxides (NO_x), ground level ozone (O_3), suspended particulate matter (SPM) and fluorides. Secondary impacts relate to air pollution deposition, which modifies the chemical nature of soils. The United Nations Environment Programme (UNEP) and the World Meteorological Organization made a joint assessment of the potential impacts of improved air quality. A package of 16 measures was identified that could yield the largest reductions in radiative forcing from short-lived substances by 2030. These combined measures were found to lead to worldwide benefits in crop yields (compared to a 2030 reference scenario) that ranged from a 1.3 % yield increase in rice to a 3.2% increase for soybeans. These benefits arose from a reduction in O_3 concentrations due to lower emissions of CH_4, NO_x and carbon monoxide. The largest benefits occurred in Asia. The economic gains for all four crops in all regions ranged between USD 4 to USD 33 billion, of which USD 2–32 billion were in Asia.

Improved air quality: ecosystem benefits

Ecosystems stand to gain significantly from reductions in air pollutants that result from mitigation action to cut both long- and short-term radiative forcers. In particular, atmospheric emissions of SO_2, NO_x, and O_3 precursors that are often emitted during fossil fuel combustion are associated with eutrophication, acidification, and various other types of ecosystem damage, such as changes in biodiversity and net primary productivity. Since non-agricultural ecosystems tend to be less

intensively managed and are much more diverse in terms of species composition, the implications of such changes in atmospheric composition, and therefore the benefits associated with emission reductions, are more difficult to estimate and confounded by interacting effects of multiple pollutants and other stressors.

Land use: REDD+

A well-established sector-related climate mitigation action on the landscape scale is REDD+.[2] International climate negotiations have been relatively successful on this action. The reason is not primarily that it is particularly promising for reducing emissions, but rather that there are a number of other benefits from reducing deforestation and degradation of forests and mangroves (blue carbon). While there are obvious environmental benefits, including biodiversity, these can come at a social cost. The large potential efficiency and market benefits that could arise from improved tenure and management of forests in developing countries are yet to be identified. REDD+ has the potential to deliver a wide range of positive effects, but more work is needed in a range of areas, in particular on sharing of co-benefits and distributional impacts; the effects on biodiversity, including successional stages of forest stands; effects on nutrient cycling; land tenure implications; and returns from various land uses (related to the increased demand for food, fiber, fodder and fuel).

Land use: investments strengthening agriculture

Likewise, investments in agriculture and parallel improvements in land management could generate a wide set of benefits, beyond the CO_2 emission reductions through improved and more efficient management of carbon and nitrogen flows in agricultural ecosystems, carbon sequestration in agro-forestry systems and soils, and avoidance or displacement of emissions. Action including improved tillage (conservation tillage, usually in combination with various mulching and green manure practices), agro-forestry, external application of fertilizer and manure, soil conservation terracing, and fallowing, produces a broad set of positive outcomes. These outcomes primarily include improved crop productivity and water quality, enhanced soil quality and soil biodiversity, and poverty reduction. In many respects these benefits are linked and implicitly produce other somewhat more intangible, and less researched, co-benefits, such as enhanced food security, increased resource efficiency, a strengthened asset base, and improved livelihoods. However, scientific evidence of these social impacts is much less frequent and largely absent in the literature.

Urban planning and development

Measures for urban planning and development aimed at increased spatial density and low-carbon transportation constitute a third set of actions with potentially important wider co-benefits. Under a policy scenario where national emission reduction strategies are implemented, aggregate mitigation costs can be reduced if economy-wide environmental policies are complemented by urban policies, such as congestion charges or increased spatial density. This is achieved as urban policies contribute to parallel policy objectives, such as lower local pollution (health benefits) and enhancing the attractiveness and competitiveness of cities. The link between urban density and city competitiveness and productivity has also been stressed in a recent ranking of world cities.

[2] The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries

Energy security

Finally, links between energy systems, resource scarcity and energy security point the way towards co-benefit from climate mitigation action that are growing in importance, but still remain overlooked in "standard" analysis.

The picture of how global energy markets are developing is blurry, with diverging narratives about prospects of unconventional oil and gas supplies on the one hand, and insatiable demand growth lead by emerging economies on the other. Given the fundamental uncertainties about global energy markets, particularly concerning oil, projections of "most likely" or "business as usual" futures is losing its relevance. Instead, policy needs to be informed by a broader appreciation of uncertainty.

Generally speaking there are many synergies between energy security and climate change mitigation. On a general level, enhanced energy security as the result of climate action is likely to reduce the overall vulnerability to shocks of national economies (particularly those who are import dependent), including energy price volatility and other supply disturbances (e.g. as the result of extreme weather, terrorism, military conflict, political crisis, etc.). Localized energy solutions (e.g. local biomass systems, small scale generation with feed in tariffs, etc.), complementing major state-backed utilities and large global energy companies, can change the wider national political-economy of energy, and most likely national – and potentially even global – governance more generally. At the sub-national level, properly designed policies could generate social outcomes, for example via decentralization and the creation of energy cooperatives, or by diminishing the role of large multinational corporations in local resource disputes, or state vs. local/ indigenous rights over land tenure. It is likely that these implications would be perceived as positive even though vested interests may stand to lose by such developments.

The added resilience offered by enhanced energy security could change the geo-political strategies of certain countries, for example to move away from securitizing certain critical supply chains or critical energy infrastructure (e.g. gas or oil pipelines). The consequences of this will not necessarily be positive in all cases and the importance of new supply chains, such as those for bio-fuels, rare earth metals, strategic technologies or transboundary water resources (for energy) may create new security tensions as an indirect result of low carbon energy transitions. Mitigation policies that provide incentives for renewables do have the potential to create new resource scarcity risks, such as pressure on land, water and food resources. However, overall, there are likely to be several positive effects for many countries if climate mitigation action reduces the role of fossil fuel resources in geopolitics, given the important *de facto* role of such resources in current geopolitical dynamics.

Concluding remark

The account provided above shows the wide range of co-benefits for which there is strong and verifiable evidence. Emissions trading, refunded emission payments and carbon disclosure can be implemented with low or moderate costs to the economy, but will drive development in a positive direction, not least since they encourage firms to adopt new technologies and business practices, that may in turn contribute to making them more competitive.

Benefits from improved air quality have long been known. Many countries stand to gain from embarking on development paths that create long term dependencies on fossil fuel combustion. In the transport sector in particular, a number of significant co-benefits occur at the same time if investments are made into public transportation and rail-based systems that alleviate road congestion, do not contribute to poor air quality and reduce the amount of traffic casualties.

Improved land use practices in forest, agro-forestry and agriculture systems have the potential to deliver emission reductions as well as significant co-benefits, not least for poor people with insecure livelihoods.

Finally, the close link between energy security, resource scarcity and climate mitigation action merits further analysis, and may very well be one that individual countries use as the main argument for amending energy strategies and embark on less fossil-intensive development paths.

5. Mitigation with near-term costs that may be offset by uncertain long-term benefits

The third category of issues is one for which empirical evidence will be scant, but around which there is likely to be strong political interest in the long term. This section discusses the role of policy that promotes innovation, industrial renewal and increased employment opportunities. The wider effects of climate change mitigation action on the economy are addressed, as well as the role that urban planning and development aimed at increased density and low-carbon transportation can play in increasing the competitiveness and attractiveness of city regions.

Innovation and industrial renewal

The issue of wider effects of mitigation action on the economy has received a lot of attention. The argument is often made that stringent carbon emissions legislation and policy hampers growth and may lead to carbon leakage. The argument is that stricter environmental regulation is likely to reduce the profitability of affected firms. This, in turn, is then associated with social costs of different kinds. According to this perspective, stricter environmental policy also tends to imply lower growth rates of the economy, related both to unemployment effects and to various other mechanisms. A contrasting perspective is offered by people arguing that stricter environmental regulation is likely to increase technological development, which will increase productivity and growth, implying that the conventional method implies an underestimate of the social benefits associated with environmental regulation. Recent developments in appliances, personal transport and buildings demonstrate that also regulatory policy can induce strong innovation pathways within specific technology systems.

What are the greater benefits of climate mitigation in inducing society moving towards a “knowledge-based economy”? Links between climate mitigation and innovation benefits are elusive and yet potentially very significant. There are impacts that we cannot really predict today, from for example, new and growing industries (energy services), new technologies being implemented (smart grids), and new values created in industries.

In general terms, although the evidence base to suggest that there are direct growth effects of climate mitigation is weak, it is also clear that a number of countries have successfully pursued both growth and strong climate mitigation at the same time. The Swedish experience shows that the link between economic growth and increased GHG emissions can be broken and that instead emission reductions can be combined with economic growth. The period 1990 – 2007 saw reductions in CO2 equivalent emissions of 9%, while at the same time the country experienced economic growth of 51%.

Innovation effects can be traced. Research on the effect of environmental policies on the number of patent applications for wind, solar, wave/tide, biomass, geothermal, and waste-to-energy technologies in a sample of 25 OECD countries found that environmental policies have had a significant role in determining patent applications.

The argument in favor of a stable and strong emissions price becomes stronger when we consider the interplay of technology and environmental market failures. There are a host of other impediments to a robust market for clean technology, such as for instance, financial, regulatory, and behavioral barriers, as well as knowledge and innovation spillovers. Ideally, an emission price should be supported by complementary policies to address barriers to technological development and deployment. However, in the absence of such complementary policies a strong and stable price could boost technological development helping to overcome some of the market failures on the technology markets.

Employment effects

Employment is a particularly salient topic. Here, it is important to note that unemployment in a society is not caused by the lack of meaningful work activities to undertake. For example, by comparing unemployment rates among countries there is no obvious pattern that more industrialized countries have a lower or higher unemployment rate than less industrialized, or technologically advanced, countries. Hence, the increase or decrease of employment in a particular sector says little about effects on overall unemployment; the latter is instead primarily affected by the functioning of certain institutions on the labour market, and the functioning of these institutions are most often not affected much by a certain strengthening (or weakening) of climate policy.

On a principal level it is however relevant to ask whether a move from "conventional" energy sectors to low carbon sectors in a structural change, implies higher new labour intensity. Payments are moved to wages and jobs for industrial and service workers (and then they spend it) instead of to fossil resource owners. Attempts have also been made, based on macro-economic modelling and optimization, to estimate net employment effects, related to the effects on the general equilibrium.

Competitive cities

There is a whole range of potential long term benefits from improved and climate-smart urban planning and transport infrastructure development aimed at creating increased density. Such measures have the potential to contribute to the competitiveness and attractiveness of city regions. Dense regions that offer urban lifestyle opportunities can attract investments and skilled labor. The evidence base in this field of research appears to be rather fragmented but nonetheless point to important social benefits such as city attractiveness for both investors and residents, quality of life, social inclusion and healthier lifestyles. All these aspects are inherently difficult to capture quantitatively and even more difficult to monetize.

Concluding remark

Looking back at the way countries or cities have developed, it is not evident that countries with stronger environmental regulation have necessarily fared worse (in terms of economic development, competitiveness or growth) than countries with lax rules. Nevertheless, for many reasons there will likely to be continued strong political interest in the question of growth and employment effects of different environmental policy options, and it seems worthwhile for the main study (see section 7) to shed more light on this particular question.

6. Discussion

Overall reflections

This study and its appendices assess the available knowledge base across a broad set of impact categories. The analysis suggests that there are, on balance, strong economic and political rationales to applying an ambitious climate mitigation agenda globally. These rationales go well beyond those that

are normally discussed. The evidence base for some of them is weak and will robust measurements will remain elusive, such as for growth, innovation and employment effects. However, it is worth emphasizing that other and more near term implications of climate mitigation (as described in sections 3 and 4) do strengthen the case for action, regardless of these more elusive benefits.

There are many policy areas that might not be considered as having obvious links to climate mitigation action, but where there are important co-benefits and synergies. One such example is dense urban/regional development. This enables more efficient transport and energy consumption. However, dense development in itself cannot be said to be "climate action". Another example is expansion of renewable energy, which increasingly serves as the most cost-effective supply option, in particular in rural areas, with costs of, for example, wind and solar PV continuously dropping.

It can be misleading to isolate specific policy instruments and their effects, although such studies are important for policy support in the short term. The structural transformation to a low carbon economy is a broader and long term societal change that needs to be assessed as a full system – and with a broad set of actions that coexist and interact. For example, recent in-depth analysis in the Global Energy Assessment shows that the cost of simultaneously addressing multiple societal objectives through systems change, including climate change, is significantly lower than addressing them one by one.

Impacts in different types of economies

The relationship between climate mitigation and its societal impacts differs depending on the level of development.

For the least developed countries, it is widely acknowledged that for a large share of their populations, basic access to energy services will need to be met before climate mitigation measures are considered. However, due to the lack of key infrastructures and associated "lock-in" effects, there are opportunities to "leapfrog" and steer investments, urbanization and transport strategies, to pursue low carbon energy sources, and to develop the domestic bioresource base for energy, food and material production to the benefit of both the economy and the climate. For this category of countries, key results of climate change mitigation action includes benefits such as health impacts from reduced indoor air pollution, energy security impacts from reduced fossil import dependency, and poverty impacts from new businesses providing and distributing energy services. Growth impacts from bio-resource expansion strategies, in particular in Subsaharan Africa, are anticipated but not yet proven.

For emerging economies, one of the primary concerns is energy costs and energy security. Climate actions towards low carbon energy investments and efficiency enhancements are already today crucial elements of development strategies in Brazil, China and India. At the same time, many of these economies are exploring oil, coal and gas domestically, offering additional opportunities for energy security that are not coherent with climate change policy.

For economies in transition, old and often fossil-based infrastructures permeate and reinforce a technology lock in. In Eastern Europe, climate mitigation, for instance through the emissions trading system, has in some cases implied a shift from coal to gas, further deepening dependency on Russian gas. However, new gas economy is shifting this playing field. While economies in transition have undergone massive efficiency enhancements since the 1990s, infrastructure investments are needed regardless of climate mitigation.

For developed economies, existing infrastructure, including urban sprawls and strong dependence on personal cars for transport, provide a particularly challenging context, as shifting to new infrastructure is very expensive. At the same time, impacts such as social inclusion, and other quality of life aspects

associated with redesigning cities, may constitute very large co-benefits. Although urban public transport systems are very complex, evidence suggests that, when taking into account a broader set of costs and benefits, there are strongly positive rates of return.

It is often assumed that the available arsenal of economic policy instruments is very limited in developing countries, due to the lack of institutions to implement and monitor compliance. However, the available evidence reviewed in this study suggests that this is a too pessimistic assumption. Considering levels of development is important when discussing economic and distributional implications because the degree to which different policy instruments are progressive or regressive will be different in high income and low income countries. For example, the research overview in the Appendix shows that transport fuel taxes tend to be strongly progressive in poor countries (as it is the rich that spend most on fuel) whereas in rich countries the picture is more mixed. Similarly, subsidy removals will have different distributional impacts depending on country development level.

Level of development and national context is however also important when it comes to state-focused implications such as international relations, national politics, and security. Understanding these impacts require national-level case studies for a selection of type countries. Low carbon development strategies offer opportunities for low income countries to strengthen their position in the international political system. Low income importers of energy can also reduce their import bill through pursuing domestic sources of energy. Political stability is often a key concern in both poor and emerging economies. In low income and emerging economies, attempts at fuel subsidy reform have caused social unrest and have proven politically difficult. It is important that communications are strengthened in relation to these reforms, to make it publicly understood that it is generally the rich households that benefit the most from fuel subsidies, and budget savings are geared towards sectors that truly benefit the poor, such as health and education.

Cooperation within and outside global agreements

The relationship between climate mitigation and its societal impacts also differs depending on the level of international cooperation. The evidence base assembled for this pre-study does not provide robust results on this issue, but some principal issues can be raised.

International cooperation will in many cases increase the opportunity space for stronger benefits. For instance, global deals with high levels of reliable financing should lessen the risk for poor countries to develop new energy and technology dependencies and hence improve energy security. Overall, the stronger the international cooperation, the easier it will be to harvest benefits and minimise costs of action. Technology, know-how and finance can be more easily transferred, reducing national costs, and efforts can be put in where they are most effective. Through cooperation and exchange, international relations improve and opportunities for exploiting synergies increase. However, the evidence base is still weak in this area. One possibility for the full study is to explore a linking of international climate cooperation with international trade cooperation.

In the absence of international agreement, the question of carbon leakage needs to be considered for greenhouse gas intensive industries that are subject to international competition (in particular heavy manufacturing, mining and raw materials industries). Carbon leakage has been thoroughly analyzed over the years (eg by OECD). The full study should not devote significant new analysis to this theme, but rather take stock of and interpret the existing knowledge base in light of recent developments. There are numerous ancillary trade and industrial policies possible to deal with carbon leakage.

In the absence of a global agreement, it is however still possible to significantly mitigate risks of carbon leakage. For instance, in recent years, a growing interest has emerged in smaller clubs of

countries. As the ten top energy-related carbon emitters represent 67% of the global emissions, this club does not need to become very big before it becomes very influential.

With a broader set of implications under consideration, experimental economic research on decision making can be probed to further advance the understanding of national positions and priorities and, entering the issue of group decision making and negotiation, the international community's ability to forge agreements.

7. Suggested scope and approach to main study

This section includes recommendations for components of the anticipated full international study during 2013 and 2014, including thoughts on methodology, focus, scale and level of ambition regarding quantification.

Overall approach

We propose a project that stretches over 2013 and 2014, with a first reporting deadline in September 2013, and final reporting during the second half of 2014.

The study would have a global focus with specific regional and national case studies. Similar to the Stern Review it would be set out in an accessible fashion and aimed at international policy analysts, policy-makers and investors rather than at the wider public or academic audiences.

The study should combine prospective (ex ante) analysis of future actions and mitigation pathways, using modeling tools, scenario analysis and impact assessment methodologies, with case study analysis and literature studies of actions in specific locations.

Given this rationale and the ambition to contribute to a positive dialogue on climate action, we propose a study with three main work packages:

WP1: Macro-level pathway analysis and knowledge consolidation, including original analysis paired with aggregation of existing results from low emissions development pathways.

WP2: In-depth case studies to illustrate how climate action has provided (or could provide) wider benefits to countries, regions, local communities and cities. The number of cases would depend on resource availability.

WP3: Science-policy dialogues on findings, experiences from implementation, and expectations on science to be held regularly over the life of the work, and with high-level political participation at one or two occasions.

All three work packages will proceed in parallel and are closely linked. The pathways analysis of WP1 sets the frame and the basis for the assessment. WP2 case studies will be selected on the basis of WP1 pathway patterns and recommendations from the first dialogues in WP3. WP1 and WP2 feed analytical results to WP3. WP3 outcomes are feeding back to and serve as recommendations and direction for WP1 and WP2.

Analytical approach

WP1: Climate mitigation pathways

WP1 should present the macro-level frame and "object of analysis". It should describe global emissions pathways compatible with a 2 degree target according to state of the art data and research. Combining different modeling tools including energy systems models and integrated assessment models with global equilibrium models (options include: PAGE, IMAGE, LEAP) a coherent set of low emissions scenarios will be assessed in terms of its benefits and risks. WP1 will disaggregate existing scenarios by sector and by region to provide a detailed and transparent account of the structural transformations associated with an ambitious climate policy and its implications across a range of impact categories.

Two or more variations of scenarios can be made, either building on dominant scenario packages developed by the global research community, or building on other uncertainties deemed of particular interest (options include: degree of international cooperation, rate of efficiency improvement, rate of renewable versus nuclear expansion, use of CCS, rate of economic development in different regions, rate of development of new fossil sources).

This pathway forms a type of low emissions development package that unfolds over time, which then is subject to an impact assessment at varying scales and levels (depending on what resources are made available to the study).

It is clear that some implications (such as health benefits from air pollution reductions) can be identified, quantified and given a monetary value (although uncertainties still loom large), whereas others (such as industrial innovation) may only be possible to identify and characterize in partly qualitative terms. Still, they naturally merit attention. The study would therefore deploy a combination of methods and tools at the macro-level, including new modeling as well as estimates of benefits transfers from previous studies.

WP2: Case studies of actions in selected nations and cities

Parallel to the analytical components above, a number of in-depth empirical case studies will be carried out. The case studies represent the main empirical evidence base and will be selected to be as representative as possible for different contexts such as levels of development and resource base.

Depending on scale and location, the issue focus will be different. Due consideration should be given to differentiating results between within-country income groups.

Rural cases – what actions and instruments are viable in, for instance, climate mitigation agriculture and forestry, and the production of bio-energy, but also in implementation of policy reform, such as subsidy removal. What are the potential implications on, for instance, livelihoods, productivity, poverty, quality of life and employment?

Urban cases – what actions and measures are viable in that particular city? What are the policies, investments and other actions necessary for a low emissions pathway, and what are the implications in terms of issues such as active travel, health, air pollution, income, savings, and social inclusion?

National cases – case studies into national level use of policy instruments such as market-based instruments, regulation, consumer and producer subsidy removal, and various sector actions, and their implications on impacts such as energy imports, security, international relations and political stability.

WP3: Science-policy dialogue

The study will be set up so that analysts and scientists co-produce knowledge through a series of science-policy dialogues and other forms of in-depth policy maker engagement. The purpose of these dialogues is to enable a policy interpretation and learning of the results of the assessment at the same time as they enable the direction and policy relevance of the analysis in WP1 and WP2. Through the policy advisory group (and supported by the project secretariat), a number of science-policy dialogues can be orchestrated. These should be seen as an integral part of the research approach, rather than just as a communication of results to policy-makers.

Real engagement to facilitate policy learning on these matters can take many different forms. Possibilities include to engage in the scenario generation through structured workshop methodologies, to carry out multi-criteria analysis techniques and to ask policy makers to rank the available evidence in terms of which has the potential for greatest influence on their decision making.

The dialogues should be tailored to quite different audiences: (1) developed countries that have large climate footprints and for which the primary challenge is to maintain growth and remain competitive despite having to reduce carbon emissions, (2) low income countries that presently have small footprints but where development paths have to be developed that avoid increasing fossil fuel dependence, and 3) emerging economies where the climate footprint and energy use is growing very fast and where the benefits of low emissions development options need to be better understood.

Value added

The following aspects of the suggested study represent significant added value compared to the state of the art and previous efforts in global climate policy assessments:

- It provides a more systematic and comprehensive understanding of mitigation measures and actions from different disciplines (including both conventional economic analysis of specific instruments and more socio-technical approaches of structural change in specific sectors or as broader packages / strategies).
- It provides a more systematic and comprehensive understanding of implications in society from taking mitigation action, and a clear mapping of what we know and what we do not. This is a novel approach.
- It highlights and advances the knowledge base of a number of poorly understood and under-researched impact areas, including international and national political implications, livelihoods / poverty effects and innovation effects.
- Its combination of top down, macro-scale scenario work with on the ground empirical case studies will gain new insight and a more nuanced understanding of implications of action.
- By focusing the synthesis on what particular categories of actors could do, paying appropriate attention to the real-work context they operate in, the study would span from theory to implementation.
- Most existing global climate policy assessments paint very broad strokes when it comes global implications and effects. This study, by contrast, will explicitly differentiate between results for countries of varying levels of development (least developed countries, developing

countries, emerging economies, economies in transition and developed countries). This approach will allow the study to speak specifically to national priorities and concerns in all types of countries.

Organization and timing

A secretariat for the main study should hold the necessary analytical skills and broad research experience to be able to manage contributing organizations and provide continuous feedback to ensure timely delivery of results of high scientific standards.

The timing of the main study depends to a large extent on the political process(es) that the study results are supposed to support. However, as a general indication, it is possible to follow these tentative schedules:

1. Mobilization phase (Jan. 2013 – Apr. 2013). Establishing the secretariat, getting human resources on board, setting the final ToR for the study, establishing the scientific steering group and policy advisory committee
2. Analytical phase I (May 2013 – Sep. 2013)
3. Mid-term report (Sep. 2013)
4. Analytical phase II (Oct. 2013 – May 2014)
5. Final report (Sep. 2014)
6. Dissemination and knowledge sharing phase (Sep. 2014–Dec. 2014)

It is envisaged that a full international study would be lead by a scientific steering group chaired by an internationally renowned economist or policy analyst. The scientific steering group should include academic expertise with a broad regional representation. The expertise required in this group should span, for example, development economics, public health, macro economics, innovation systems, and climate sciences. A coordinator working 50% of full-time is envisaged to support this group.

A policy advisory group should be formed with representatives from the lead governments (Sweden, UK, Norway, Colombia, South Korea, Indonesia, etc.).

A secretariat[3] for coordinating the study, which would report to and support the scientific steering group, needs to be established, including a programme coordinator (100%) (a senior economist / policy analyst), a programme assistant (50%) and a communications specialist (50%).

Coordinating lead authors (CLA) for different chapters (circa 10), and a team of contributors recruited from the international expert pool are also needed. The CLAs would need resources for a 50% position in addition to a contingency budget equivalent to an additional 50% post to procure specific pieces of analysis.

Based on this initial scoping, a tentative budget is presented below, adding up to a grand total of 2,600,000 Euros.

[3] It is recommended that the secretariat be located in Sweden, as it is the study's country of origin, and because of its "honest broker" tradition and strong global reputation on both climate change and development issues.

Indicative budget table (in EUR)

	2013	**2014**	**Total**
SSG coordinator	50,000	50,000	100,000
Secretariat	500,000	500,000	1,000,000
Analytical Chapters	500,000	500,000	1,000,000
TOTAL PERSONEL COST	**1,050,000**	**1,050,000**	**2,100,000**
Travel and meeting costs – research	100,000	50,000	150,000
Travel and meeting costs – policy dialogue	100,000	100,000	200,000
Publication cost		50,000	50,000
Distribution and dissemination		50,000	50,000
TOTAL EXPENDITURES	**200,000**	**250,000**	**450,000**
GRAND TOTAL	**1,250,000**	**1,350,000**	**2,600,000**

List of Appendices

Cross-sector policy instruments (Environmental Economics Unit, University of Gothenburg):

1. International climate agreements: Implications on justice and equity
2. Emission trading: efficiency and distributional effects
3. Subsidy removal: distributional effects and increased efficiency
4. Refunded Emission Payments: efficiency and incentives for adoption and diffusion of technologies

Sector policy instruments (Environmental Economics Unit, University of Gothenburg):

5. Fuel (carbon) tax on transports: efficient instrument with easily implementable tax base and positive distributional effects
6. Carbon tax on energy (industry): long-term incentives for renewable investments and innovations
7. Information disclosure (industry): increased transparency and public awareness.
8. REDD+: Ecosystem services and distributional implications
9. Agricultural investments: ecosystem services, sustainability and social effects

Impact areas (Environmental Economics Unit, University of Gothenburg):

10. General reflections concerning possibilities to measure growth and employment effects of climate mitigation
11. Comparison of taxes, permit trading and other instruments

Sector analyses (Stockholm Environment Institute)

12. National and international political and security dimensions
13. Air quality, resource savings, and transport sector co-benefits