Effective Climate-Energy Solutions, Escape Routes and Peak Oil

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Abstract

Many well-intended climate-energy strategies are ineffective in the absence of serious environmental regulation. This holds, among others, for direct support of clean energy, voluntary energy conservation, technical standards on a limited set of products, unilateral stringent carbon pricing, and awaiting peak oil as a climate strategy. All of these suffer from "escape routes" that indirectly increase CO_2 emissions and thus make the original strategy ineffective. On the other hand, environmental regulation alone may lead to a myopia-bias, stimulating early dominance of cost-effective technologies and a focus on incremental innovations associated with such technologies rather than on radical innovations. Although adopting a partial viewpoint keeps the analysis simple, we urgently need a more inclusive systems perspective on climate solutions. This will allow the formulation of an effective climate policy package that addresses the various escape routes.

Keywords: Carbon leakage, climate policy, CO_2 pricing, CO_2 rebound, green paradox, peak oil, rebound policy, technological innovation.

1. Introduction

We humans are great at inventing strategies in an effort to avoid a serious climate policy. Examples of such strategies are voluntary energy conservation, carbon capture and storage, market support of clean energy, making public transport cheaper to stimulate less car use, and even awaiting the oil price response to peak oil. However, as will be argued below, none of these strategies is on its own capable of realizing a considerable emissions reduction over time because of the presence of various ‘escape routes’. The latter term is new as it is intended to cover all undesirable indirect effects of climate-energy strategies, notably carbon leakage, energy rebound, and fossil fuel market responses (including the “green paradox”).

This paper will take the existence of escape routes as a starting point for arguing that we should not be fooled by good intentions and that we cannot give up on the aim of reaching a stringent international climate agreement. The reason is that there just is no substitute for such an agreement because all suggested alternatives will be very ineffective without it. Note that the paper is not about the social and political feasibility of climate policies but about the effectiveness of policies once they are implemented. With this analysis I hope, however, to contribute to the social-political feasibility of an effective policy (package).

The remainder of the paper is organized as follows. Section 2 gives a schematic overview of the main climate-energy strategies and associated escape routes. Section 3 offers critical notes on market support of renewable energy. Section 4 discusses fossil fuel market responses to renewable energy subsidies. Section 5 considers the problems associated with awaiting peak oil as a climate strategy. Section 6 examines the differences in economic adjustment to peak oil and to climate policy. Section 7 broadens the discussion by considering rebound of climate strategies and possible “rebound policy”. Section 8 explains why in addition to environmental (greenhouse gas) regulation we need technology-specific policies. Section 9 returns to the question of whether, in view of all the evidence and arguments, we can solve climate change without a global treaty. Section 10 concludes.

2. An overview of energy-climate strategies and associated escape routes

Many climate-energy strategies that receive much support nowadays involve a number of escape routes. Table 1 illustrates some of these strategies and their escape routes. In addition, it provides information about the ideal circumstances under which escape is minimal and about the required policy responses to assure the environmental (climate) effectiveness of each strategy (if possible at all). For reasons of scarce space, not all of these strategies will be discussed here in equal detail. Note that some strategies are at a general level, such as 7-9, while others are of a more specific nature, like 2, 3 and 6. The remaining ones are somewhat in between general and specific. Certain strategies can be complemented by particular policies to close the escape routes (as much as possible). Other strategies simply do not have a solution in this sense, as is the case for strategies 3, 6 and – if one interprets the outcome precisely – 5. The details of some of the strategies and their problems in terms of escape routes will become clear in subsequent sections.

3. Market support of renewable energy

In the absence of a serious climate agreement and associated stringent national climate policies, some countries have chosen to subsidize clean energy rather than charge for dirty energy. Proponents of market subsidies or price guarantees for clean energy are found on the left and right side of the political spectrum. Left-wingers thus express their sympathy for clean energy and the environment, while right-wingers see these policies as a way to support private firms and avoid environmental taxes (or other forms of putting a price on the use of environmental or natural resources). One might think that by implementing such "cleaner technology" support we become less dependent on a post-Kyoto climate treaty for achieving a safe concentration of CO_2 in the atmosphere. Indeed, several participants in the climate debate, including politicians, scientists and NGOs, consider such a treaty as unnecessary because it is believed that individual countries can arrive quickly at a large-scale deployment of clean energy technologies through directly promoting them (e.g., Heskett, 2010). The term "bottom-up solutions" is often used in this context. However, such a belief is unfounded.

Technological policies, such as have been implemented with great force in Germany over the last decades, are no substitute for environmental regulation. Renewable energy support without a suitable complementary regulatory policy is an overly expensive and ineffective strategy to reduce CO_2 emissions (Frondel et al., 2008). To solve global warming and stimulate an adequate pace of environmental innovation we need to combine environmental and technology policies, which in turn will stimulate the required bottom-up solutions.

Of course it is possible that Germany achieved a "first mover advantage" through the provision of subsidies – via feed-in-tariffs – to expand the market for solar panels. Good for Germany, but it did and does not guarantee a solution to the global climate problem. In the period 2000-2010 Germany spent roughly €50 billion on market support. Who can guarantee that this money would not have been better spent on fundamental research on photovoltaic technology or even on international campaigns to build support for an effective climate treaty. If successful, this might have brought down the relative price of solar PV electricity (that is, relative to the prices of fossil fuel and nuclear electricity) more than the strategy of large-scale market support. This then would have altered the timing of emissions reduction, namely a little less initially and considerably more in the medium and long term. But as will be argued later, the story is more complex, and is not about a choice between the different options but combining them well.

Table 1. Possible climate-energy strategies (general and specific), escape routes and potential solutions and policy responses

Climate-energy strategy	*Escape route*	*Ideal situation to minimize escape/leakage*	*Policy response to assure minimal escape/leakage*
1. Direct market support of clean energy	More energy use in general (cheaper); and oil market response ("green paradox")	Fossil fuels need to be priced correctly	Carbon taxes or tradable carbon emission permits
2. Technological efficiency standards	Shift to technologies and energy uses not limited by technical standards	Standards on all (relevant) technologies, continuously updated for technical progress (which will require a huge LCA industry)	Government needs to monitor, control and update information about all technologies
3. Making public transport cheaper to stimulate less car use	More transport (more passengers, more trips, more kms) in general as it becomes cheaper; many people will just add public transport trips to their usual car trips	No solution, this strategy is a bad idea	No solution (alternative is carbon pricing in which case the cost of private car use rises more than that of public transport)
4. Awaiting the oil price response to peak oil (i.e. considerably higher oil prices)	Shift to coal and non-conventional fossil fuels (e.g., tar sands)	Coal and non-conventional fossil fuels need to be priced in accordance with their carbon content	Carbon taxes or tradable carbon emission permits
5. (Stimulating) voluntary action	Large rebound effects (notably re-spending of associated monetary savings on other energy-consuming goods or services)	Incentives to not shift to other activities that use much energy (and emit much CO_2)	Carbon pricing (but then behaviour is no longer "voluntary"); tradable carbon emission permits theoretically ideal approach as ceiling limits rebound and translates pressure on ceiling in an appropriate carbon price
6. Ecolabels	Do not affect behaviour of most people as average consumer cannot handle so much information; information needs continuously updating because of technological change (large LCA industry needed)	No solution, this strategy will always remain ineffective	No solution
7. Unilateral (single country) regulation of CO2 emissions	Carbon leakage due to relocation of dirty activities to regions/countries with laxer regulation and subsequent adaptation of trade patterns (notably importing CO_2 intensive goods that were previously produced domestically)	Consistent/identical regulatory policies in all countries	International climate agreement
8. Direct guidance of environmental innovation (support of fundamental research)	Innovative solutions and their development do not take into account all indirect effects in terms of CO_2 emissions because of lack of carbon price signal of products and services; moreover, diffusion of more CO_2-efficient technologies to new applications (rebound effect)	All products should signal their carbon content (i.e. direct and indirect CO_2 emissions) through their prices	Technological policy should be complemented by climate regulation (notably through carbon pricing)
9. Local solutions (cities, neighbourhoods)	Rebound to other regions through commerce, transport, trade and relocation	National and global limits/caps on CO_2 emissions needed, prices need to reflect carbon content so that local decisions automatically take all indirect effects into account and space use (beyond the local scale) can optimized from a CO_2 emissions perspective	Stringent national climate policy and international climate agreement
10. Nuclear energy and carbon capture and storage (CCS)	Oil market responses ("green paradox"); and does not solve CO_2 emission problem really (CCS) or creates other environmental risks (nuclear)	No solution	Political decision needed on whether the net benefits of these strategies are worth any additional risks

4. Fuel market responses to renewable energy market support

If we do not increase the price of fossil fuels but lower the price of clean energy by means of subsidies or price guarantees, such as feed-in tariffs, energy will just become cheaper and its use will be encouraged. This basic "economic law" seems to have been forgotten by many politicians and policy makers. An additional problem has been identified by Sinn (2008): a lower price of clean energy is an impetus for an accelerated depletion of fossil fuel reserves with the risk that the prices of fossil fuels decrease and as an indirect and unwanted effect their demand increases. This is known as the "green paradox". The accelerated depletion is a consequence of market competition and the threat of a cheaper and amply available clean alternative – a so-called backstop technology – due to which the value of oil, gas and coal reserves in the earth declines and their supply increases, which in turn lowers prices and stimulates demand. Ironically, the more effective is the direct support of renewable energy – and one needs to realize that it has not been very effective yet – the stronger will be its price-depressing effect on fossil fuels and the larger will be the subsequent indirect increase of fossil fuel deman. This will then diminish the success of the initial renewables' support policy. Since renewable energy sources mainly serve electricity generation, coal and gas markets will be most affected and oil markets to a lesser extent. Sinn (2008) concludes that climate policy needs to take the form of supply measures (e.g., taxes on fossil fuels) as these will be much more effective than energy demand measures like subsidies, price guarantees and moral suasion (in Section 8 we will see, however, that this is insufficient and that additional policies are needed).

The green paradox draws attention to the fact that we have forgotten to connect climate solutions with fossil fuel markets (van der Ploeg, 2011). Nevertheless, the main strategy for reducing CO_2 in the atmosphere is to cut back on fossil fuel use and supply, because the only alternatives, namely forestation and carbon capture and storage, offer limited capacity to curtail CO_2. The green paradox has a broader meaning however: even strategies like energy conservation through energy-efficient technologies and use of nuclear energy for electricity generation reduce demand for fossil fuels without taking into account subsequent supply responses. As a result of such leakage effects, one easily overestimates the contribution of these strategies to solving the problem of global warming. In fact, they all can be seen as strategies that avoid putting a price on CO_2 and thus fail to realize a higher price of all fossil fuels (gas, oil and coal) in proportion to their carbon content.

One might argue that the green paradox is merely theory because fossil fuel prices are driven by relatively short term interests and perceptions in fossil fuel markets. However, ultimately price trends will not be able to avoid the strong influence of the world reaching a peak in the production of conventional – generally easily accessible and relatively cheap – fossil fuels. Most experts agree that this peak for oil either has occurred or will occur between now and 2020 (though not necessarily for total liquid fuels as the supply of natural gas still increases). This has recently been supported by a Hubbert-type analysis (Galagher, 2011) and inspection of future prices in oil markets (de Almeida and Silva, 2009). For a recent evaluation of the evidence see Sorrell (2010). Once oil price are dominated by scarce supply[2], they become increasingly sensitive to what happens in renewable energy technologies and markets as this will immediately and noticeably affect oil scarcity patterns.

5. Awaiting peak oil as a climate strategy

While most climate policy debates neglect the connection between climate solutions and oil markets, a not uncommon opinion is that ever scarcer oil will help to solve climate problems. For instance, Grubb (2001, p.837) states: "Supply-side constraints will not solve the climate problem in themselves but they make the task a lot easier, if the opportunities are taken." However, this is not necessarily true, for a number of reasons. First, higher oil prices due to increasing scarcity do not reflect the climate-related external cost. So while they may signal resource scarcity, they will not accurately signal the external or social costs associated with CO_2 pollution. Second, coal will not follow the scarcity price pattern of oil. This then provides an incentive for a transition from oil to coal rather than away from CO_2 polluting fossil fuels in general. There are already some signs of this (see below). Third, scarce conventional oil also will (and already does) stimulate a shift to carbon-intensive, non-conventional liquid fuels, such as tar sands. Fourth, a belief in peak oil and its capacity to contribute to solving climate problems may hamper the support for a serious climate policy (Verbruggen and Al Marchohi, 2010). Apart from this, rising oil prices surely will not make it easier to implement serious climate policy on top, and one will need to explain citizens/voters very well that prices should reflect both resource scarcity and carbon content (i.e. climate externality). One should further realize that carbon pricing through taxes means that the revenues of these go back to (in fact, are 'owned by') all citizens, whereas scarcity premiums end up in the pockets of a few rich private individuals and companies who own or control oil resources.

Without a climate treaty, an upcoming peak in global oil production, as well as a rapidly rising demand for oil in countries like India and China, will just make an unintended transition to coal more likely. The current plan of Dutch energy companies to invest in new coal-fuelled electricity plants can be seen as an early (or late) warning. It is evidently undesirable from a climate standpoint, but makes economic sense. The prices of oil and gas will fluctuate because

[2] Non-conventional fossil fuels such as oil from tar sands put a cap on rising price trends. However, they will also be subject to a rising price trend as depletion occurs. In this sense the distinction between physical and economic depletion is relevant. The former refers to actually running out of a natural resource, while the latter denotes the prospect that while physical units of resource remain it becomes uneconomical to extract them.

of all kinds of market and political factors, but are likely to follow an upward trend due to increasing scarcity (peak oil and rising demand). Gas prices may rise less steeply because of more stable or even increasing supply (e.g., due to development of shale gas), but since oil and gas are (imperfect) substitutes their price difference cannot be too large. Renewable energy is still very expensive in many regions, depending on local climate and weather conditions. In view of this, the option coal is a logical choice from a business angle unless an international climate agreement can support CO_2 pricing worldwide. Dutch developments in the area of electricity production illustrate the risk of an unwanted transition to coal in the absence of such an agreement. This may not happen if coal production faces a peak in the near future. Accessible reserves providing cheap coal are limited while demand for coal is very quickly rising in developing counties, led by China. Nevertheless, poor quality of data on coal reserves makes any forecasts very uncertain (Kerr, 2009; Heinberg and Fridley, 2010).

Even though it may seem undesirable or even paradoxical to introduce a carbon price on top of already high energy prices there are various arguments why we should not await higher scarcity prices of oil and gas in international markets but instead start seriously pricing the CO_2 content of all energy sources as soon as possible. One argument is that in this way we would be able to keep part of the scarcity premium on oil prices in western oil-using countries instead of helping already exuberantly rich oil sheiks in Arabic states to accumulate more wealth. This (opportunistic) argument seems to have been totally disregarded by western countries. The reasoning here is that through a carbon tax (as one possible way to price CO_2) the profit margin on oil will go down, so that the scarcity price of oil incurred by the producer falls and in effect part of the huge profits from oil supply will shift to oil demanding countries.[3] One should realize that this shift of money will appear in the form of tax revenues, which will allow other than CO_2 taxes, notably labour taxes and possibly also capital taxes, to go down. In other words, higher prices of fossil fuels and of energy-intensive products and services will be compensated by higher after-tax labour incomes. This is consistent with the motivation for the CO_2 tax which is regulation, not financing, meaning that any CO_2 tax revenues have to go back to the tax payer to make sure that the total tax pressure does not increase.[4]

[3] For the oil exporters this would mean an argument against ratifying any climate agreement which supports carbon pricing. However, the major contribution to emissions reduction has to come from countries other than the oil exporters. This means that if the latter do not ratify the agreement it can still be effective in environmental terms (i.e. reduction of CO_2 emissions).

[4] One may also mention here the double-dividend argument, which says that environmental tax revenues allow for lower taxes on labour which then will reduce distortions in labour markets, in turn stimulating employment (e.g., de Mooij, 1999). The empirical importance of this theoretical argument has been heavily debated. This issue is not so important, however, as the existence of two dividends is not needed to support a shift from labour to environmental taxes. One welfare dividend of environmental regulation

The intended regulatory effect of CO_2 pricing is that relative prices will change such that energy and energy-intensive products and services become more expensive and other products relatively cheaper. Many politicians and voters are still unwilling to accept this inevitable aspect of any effective climate policy. They should realize, however, that the welfare impact of such a policy is not necessarily (very) negative in the short run (van den Bergh, 2010). And it is positive in the long run because avoiding climate change will mean circumventing extreme climate events with unknown consequences for the economy and welfare.

Another reason to not await a further rising of oil market prices but introduce stringent CO_2 pricing is that this avoids undesirable consequences of peak oil on oil-importing countries. Friedrichs (2010) mentions three broad categories of such consequences, namely predatory militarism, totalitarian retrenchment and socio-economic adaptation. He argues that precise impacts are likely to depend on the political, economic and even military power conditions characterizing a country. He hypothesises that economic adjustment will be more smooth and likely in a societal situation with strong community values (family, friend and neighbourhood networks) and subsistence lifestyles. As most western countries are instead characterized by individualism, industrialism and mass consumerism they will be less resilient to the impact of peak oil, making the other two undesirable trajectories more likely here. As opposed, the socio-economic adaptation trajectory is arguably the most likely outcome of a stringent climate policy. This is discussed in more detail in the next section.

6. Differences in economic adjustment to peak oil and climate policy

The nature of economic adjustment may differ between climate policy and peak oil scenarios. Under the first, economic adaptation will be dominated by market processes as prices of goods and services change in line with their carbon content (over the total life cycle of production). Some regard this as undesirable for ideological reasons, and in this context even defy the use of market-based instruments for CO_2 pricing like carbon taxes and tradable permits for CO_2 emissions. But it is not unlikely that our modern western society's resilience is best guaranteed by solutions that are consistent with markets rather than deny their usefulness or even try to ameliorate their role and influence. Price regulation will contribute to a smooth adaptation as it will stimulate a multitude of responses in the economy, involving input substitution and technical change within each sector, adjustment of the sector structure, and changes in the composition of consumption. Because of this, price regulation is able to maximally distribute

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is sufficient to support its implementation. In addition, environmental tax revenues might be used to lower capital taxes to compensate for firms' profits falling during a transition to a low-carbon economy.

the economic pain of cutting CO_2 emissions in the economy.[5] Any other type of policy or no policy will in comparison look like a shock therapy.

As opposed, under a peak oil scenario economic adaptation is likely to involve not only market processes but also important shifts in power. Friedrichs (2010) expects a redistribution of power and wealth from oil importers to oil exporters, and from private to state-controlled companies. One may expect under severe climate regulation the opposite to occur: less power and wealth for oil exporters, and less dominance of state-controlled oil companies. All in all, climate policy seems a much less risky climate strategy than awaiting peak oil to exert its effects on markets, prices and societies. Friedrichs implicitly supports this (p. 4567): "In the event of peak oil, we should not expect either immediate collapse or a smooth transition. People do not give up their lifestyle easily. We should expect painful adaptation processes that may last for a century or more." and "…ultimately Europeans could hardly avoid a transition to a more community-based lifestyle. Despite the present affluence of Western European societies (or precisely because of it), this would be extremely painful and last for several generations."

A final consideration is that higher oil prices reflecting resource scarcity in the absence of carbon pricing would make the extraction of unconventional oil more economically profitable. This would result in moving large-scale into lower quality fossil fuel energy sources. These, however, generate more CO_2 emissions per unit of useful energy.

By the way, those who do not agree to the peak oil tale should of course be in favour of a serious climate policy – at least, if they are concerned about human-induced climate change – as in their world view oil market prices will not rise to the extent that they contribute to a solution to the climate problem.

7. Rebound of climate strategies and 'rebound policy'

There is broad support in both politics and academia for stimulating energy conservation by providing information (moral suasion) or setting technological standards, and surprisingly less support for letting higher energy prices, due to CO_2 pricing, encourage energy conservation. However, if we do not succeed in raising prices of all dirty types of energy then energy conservation aimed at reducing greenhouse gases will be less effective than possible, because of energy or CO_2 (or more generally GHG) leakages. The common term here is rebound, the unanticipated increases in energy consumption associated with cost-effective energy efficiency

[5] This is not to deny that there will be distributional effects, but this holds for any policy instrument. One may design price instruments to minimize unwanted distribution effects (e.g., block-pricing) or implement additional policies (like reducing marginal income taxes for lower incomes). A simple prioritization of instruments on the basis of distributional effects is not feasible (Rose and Kverndokk, 1999; Fullerton, 2009). Further advantages of pricing instruments are discussed by Nordhaus (2007).

improvements (Sorrell, 2009). Rebound can be regarded as the result of (in principle) avoidable indirect and unintended effects arising because a system is not well or not completely regulated in terms of energy and environmental impacts of behaviour. The green paradox can actually be seen as a sub-case of rebound, although the literatures on these are independent so far (green paradox is mainly discussed among economists, and rebound among energy analysts). Rebound of clean energy is evidently less a problem, that is, in a world of 100% energy provision by renewable sources we would not have to worry about it. Of course, no form of energy is perfectly clean, so that even here rebound may be something to be concerned about. Nevertheless, rebound currently applies mainly to dirty energy, which generates CO_2 over its lifecycle. We therefore might speak better of "CO_2 rebound", reflecting strategies aimed at reducing CO_2 emissions which have as an unintended indirect effect an increase of emissions elsewhere.

Rebound can be understood as a response to relieving a limit on a scarce resource (energy) through conservation or efficiency improvements. This in turn invites expansion of human activities and associated energy use until the relieved limit is reached. Examples of rebound include more intensive use of more energy-efficient equipment, the purchase of heavier or faster machines with more energy-using functions or devices (e.g., cars with air conditioning), spending financial savings due to energy conservation on energy-intensive goods or services (e.g., holidays involving flights), and diffusion of more energy-efficient technologies to new applications (e.g., information technology). Jevons (1865) was the first to point out the risk of rebound. He suggested that technical improvements in steam engines, resulting in an increased efficiency of coal use, ultimately would stimulate an increase in the consumption of coal at a national scale due to diffusion of more efficient engines to new applications (and even new industries). The notion of "Jevons paradox" is now used to indicate 100% or more rebound, that is, energy conservation that is entirely ineffective or even counter-productive. Some authors argue that economic-technological history is largely characterized by Jevons paradox. Tainter (2011), for example, argues that solutions to environmental and other problems humans face generally take the form of an increase in the complexity of technologies, organizations, institutions and public regulation, which in turn increases demand for energy. In other words, the believed solution magnifies the problem. It is difficult to be sure about this, as causality is uncertain and system boundaries in space and time are virtually unlimited, meaning that one will never be able to assess all rebound effects of a certain change in an energy-using system. Nevertheless, there are studies which claim to have found more than 100% rebound, usually based on general equilibrium analysis that captures all important economy-wide effects (Hanley et al., 2009).

To reduce CO_2 rebound one should make dirty energy more expensive. Although this is a textbook lesson for economists, many non-economists still have not well understood this. To be certain that rebound – especially in terms of impacts on CO_2 emissions – is minimal, one should impose a hard limit on CO_2 emissions and link this to a variable CO_2 price. This implies a system of tradable CO_2 emission rights as an effective "rebound policy" (van den Bergh, 2011a). If the prices for all types of dirty energy are in line with their carbon content there will be no escape routes, i.e. we no longer will have to worry about the green paradox and rebound. This means we need to move away from wishful thinking that energy conservation can be voluntary, cheap and at the same time effective. Standards on some subset of technologies invites rebound too as it means an incomplete (as well as inefficient) control of CO_2 emissions in complex economy. Instead, imposing standards on all technologies present in the economy is not just infeasible but highly impractical as all existing standards have to be updated regularly as new technologies are constantly appearing. Instead, conservation is best triggered by higher energy prices. Information provision and standards on energy use or CO_2 emissions may possibly fulfil a complementary role.

Finally, climate policy through CO_2 pricing will have the effect of guiding innovation patterns. For example, oil companies and the car industry will be discouraged to invest large scale in further development of carbon-intensive activities. This includes R&D on more powerful gasoline cars, technologies for efficient exploration of unconventional fossil fuel deposits, and synfuel developments (Grubb, 2001). Altered relative prices of dirty and clean cars will shift funds towards research on innovation of the latter.

8. More than environmental regulation

The foregoing is an extended argument for regulation in climate policy. Nevertheless, alone, that is, without technology-specific policy, it is insufficient. The reason is that it will encourage the choice of currently cost-effective technological options, to the detriment of environmental technologies that will perform better in the long term. In other words, environmental regulation alone will suffer from a myopia bias. Economic studies anyway show that we should not expect a too large contribution from technological innovation to reducing CO_2 emissions in the short to medium term (van den Bergh, 2011b). This is partly due to the slow process of innovation, from invention to large-scale market application. The bulk of emission reductions over the medium term must instead come from changes in behaviour using existing technology, driven by price increases of fossil fuels. Nevertheless, after 2040 a large-scale transition to renewable energy is only possible through breakthroughs in technology research. Pricing of CO_2 will stimulate both the necessarily medium-term behavioural change and innovation for a long-term shift in technological regime. But technology policy, such as a system of subsidies, is needed to avoid early dominance of currently cost-effective technical options, escape lock-in, and keep open technology paths characterized by a great potential for learning and cost reduction. Note that a policy package consisting of carbon pricing and technology-specific policies can also be seen to stimulate a synthesis of market-pull and technology-push effects.

Regarding subsidies it is important to distinguish between support of research (R&D) and market applications. Studies show that research often brings the cost of renewable energy more quickly down than upscaling in markets. This applies to solar panels and possibly even to wind turbines (Klaassen et al, 2007; Funk, 2011). In other words, subsidizing R&D may often be a more effective environmental strategy from a long term perspective, to bring down total CO_2 emissions over a period of say 50 years or longer. Large scale subsidies to support market applications lack a good theoretical framing, as no external benefits are involved, unlike in the case of knowledge externalities associated with R&D. It is tempting to try to make renewable energy markets quickly large using public subsidies, but we really should be patient and first try to get their cost down by using scarce funds to subsidize R&D. This will also avoid being locked into outdated technology in ten or fifteen years from now. It is also true that there may be barriers to the diffusion of cleaner technologies and that it is necessary to support emerging technologies through the “valley of death”. So one has to evaluate very carefully what works best for each technology, where the opportunities and barrier are, and in which phase cost reductions are best realized.

9. Solving climate change without a global treaty?

Many participants in the environmental debate state that a global climate agreement will never materialize and that we can solve global warming without such a treaty. As a result, they focus on voluntary, unilateral, local or bottom-up solutions.[6] These ideas are driven by good intentions that unfortunately do not guarantee good outcomes, witness the arguments on green paradox and rebound in the previous sections. It is sometimes argued that optimism is justified because historical energy transitions occurred without any international treaty. But this forgets that we are now because of climate risks pursuing an “economically illogical” transition, namely from very concentrated energy sources and carriers (notably oil and gas) to considerably less concentrated and thus less attractive forms of energy (notably wind and solar). This difference is illustrated by the indicator “energy return on energy investment” which for oil is in the range of

[6] The famous Porter hypothesis is often mentioned to give support to unilateral policies. It states that environmental regulation can improve the competitiveness of a country by stimulating innovation. This means that the indirect benefits of environmental regulation through innovation more than offset any extra direct costs for firms created by the regulation. However, no definite proof for this is available, and the idea has been subject to much debate. Although the Porter hypothesis might be true in particular instances, it cannot be seen as a general rule (Ambec et al., 2011). Moreover, carbon leakage through trade and relocation effects is likely to make unilateral policies environmentally ineffective at the global scale.

30 to 40 nowadays, while for solar PV it is far below 10 and for many types of biofuels even below 2 (Murphy and Hall, 2010). Technological progress may improve these figures, but to what extent is highly uncertain. Moreover, time is limited, that is, a rapid transition is necessary to prevent dangerous climate change. In this context we must not overlook that historical energy transitions such as from wood to coal, from coal to oil, and electrification lasted roughly 200, 85 and 65 years, respectively (Huberty and Zysman, 2010).

I am the last to deny that an effective climate treaty will be extremely difficult to achieve, but in view of the foregoing arguments I simply see no substitute for it. Effective bottom-up solutions for global warming cannot emerge without such a treaty, as a consequence of the existence of the various escape routes discussed in Table 1 (Section 2). It is not a choice between bottom-up and top-down solutions. The top-down agreement has to stimulate the bottom-up solutions. A climate treaty will equalize the costs and prices of dirty energy at an international scale, and thus prevent that the competitive position of countries with a responsible, safe climate policy will be harmed. Despite risks of corruption and rent-seeking, some form of policy-induced carbon pricing, notably if realized through taxation, instead will offer a better chance to distribute both the costs of climate policy and its revenues in a maximally fair manner among all citizens of the world. This kind of policy actually will then reflect that humans should jointly share the ownership of, or the responsibility for, a stable and safe climate.

Without a climate agreement stringent national policies are not just unlikely, but if implemented will lead to carbon leakage. This denotes the problem that if climate policy is not equally strict in different countries this will affect the (relative) competitiveness of these countries, which in turn will induce a relocation of “dirty industries” and a shift in “dirty trade”. As a result, reduction of carbon dioxide emissions will be limited (Kuik and Gerlagh, 2003). An international climate agreement or border taxes on dirty imports can support the emergence of equally strict policies in countries, which would mean avoiding carbon leakage.

One might say now: “Waiting for a global climate treaty may be clearly highly desirable, but what is to be done then in the meantime in relation to growing emissions?” My response is that by following various other strategies than a climate agreement and associated stringent national carbon pricing, such as local, voluntary actions, ecolabelling, energy subsidies, we have the feeling that we are doing already a lot. But because of the escape routes discussed here the effectiveness of these strategies is disappointing. Instead, it is worthwhile to be patient and persistent, and put very much effort, time, intelligence, creativity, and – not to forget – money (through advertising and lobbying) into the negotiations for a stringent climate agreement.

Why has success in the negotiations for a post-Kyoto climate agreement proven so difficult? Besides political interest factors[7], an important reason is the widespread idea that climate policy will be extremely costly or even disastrous to our economies. However, there are several reasons to believe that the costs will turn out to be moderate. For example, the research costs to make solar PV technologies profitable have been estimated to be equal to 0.017 percent of the combined GDP of all OECD countries, or 1 percent of the cost of the Iraq war, or – if one assumes a period of 10 years to make solar PV electricity cost-effective – 4 percent of global spending on weapons research during the same period (van den Bergh, 2010). It is just a matter of changing priorities.

The Kyoto Protocol was quite quickly effectuated, namely a decade after climate change became a subject of study and debate in the social sciences, politics and society at large. One should of course not judge Kyoto too seriously in terms of its efficiency and effectiveness – it is best regarded as a litmus test for international environmental politics and as a stepping stone for something better. The time has come to use all possible leverage and creativity to accelerate the process of international climate negotiations. Without it renewable voluntary energy conservation, energy subsidies and energy standards will merely be strategies to escape an effective climate policy. With the current escape strategies we are only fooling ourselves.

10. Conclusions

The various escape routes associated with the different climate-energy strategies were summarized in Table 1 (Section 2) along with the ideal circumstances under which escape or leakage is minimal and the required policy responses to assure the effectiveness of each strategy. Not all of these strategies have been discussed here in equal detail. Nevertheless, the illustration of selected strategies offers a clear general message; namely, that we should not be fooled by good intentions and should remain critical of the indirect effects of particular energy-climate strategies. One should anyway be wary of such strategies because the fact that many of them meet less political and (polluter) lobbying resistance than the best solutions (some type of carbon pricing) is not a good sign and indicative of their ineffectiveness. If these strategies would be effective, resistance of polluters would be considerable. All in all, we need stringent climate regulation, preferably through some form of carbon pricing in all countries. This means we cannot give up on a stringent international climate agreement. There simply is no substitute for such an agreement. All considered alternatives will be far from effective without such an agreement.

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[7] For example, limited political will because of elections every four years, and unpopularity of (environmental) taxes in general.

It was further argued here not only that implementing purely technology-specific policies involve escape routes, but also that environmental regulation on its own may lead to a myopia-bias. In particular, it runs the risk of stimulating early dominance of cost-effective technologies and a focus on incremental innovations associated with such technologies rather than on stimulating investment in, and learning about, still expensive technologies that have the potential to lead to radical innovations and definite solutions in the long run. The solution is simple: both policy approaches are needed to form an overall climate policy package.

One should realize that carbon pricing, possibly along with an overall ceiling or limit to (ideally global) CO_2 emissions (i.e. tradable emission rights), really is the only instrument that can inform polluters – producers as well as consumers – consistently about their CO_2 emissions and alter or guide their behaviour away from these. In other words, carbon pricing is the only instrument that can guarantee that all goods and services in the economy will have a cost that is proportional to their total (direct and indirect) CO_2 emissions. As a result, carbon pricing simultaneously can stimulate fossil energy producers to reduce their CO_2 emissions, consumers to conserve energy and shift to less CO_2 intensive consumption, and renewable energy producers to increase production and reduce costs through learning. Moreover, only if carbon prices are right innovators will search in the right direction for solutions, meaning that these will be the best in terms of minimal CO_2 effects over the entire life-cycle of the associated new product or service. If prices are not right, innovation trajectories are likely to go in directions that involve too many, i.e. avoidable, CO_2 emissions. All together, it should be clear that carbon pricing will be able to close the escape routes and minimize carbon leakage over time, and that no other instrument can match this performance.

A methodological lesson of this paper is that although life is much easier if one adopts a partial viewpoint, we urgently need a more inclusive systems perspective on climate solutions that takes all unwanted indirect effects into account. Only this will allow the derivation and formulation of an effective climate policy package that closes carbon escape routes.

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