Quick-start guide to carbon lock-in assessments

This **Quick-start guide** to carbon lock-in assessment has been prepared by Economic Consulting Associates on behalf of the Department for International Development (DFID) to accompany the full **Carbon Lock-in Toolkit** developed in February 2015.

What is carbon lock-in?

Carbon lock-in occurs when:

- ❑ a carbon intensive pathway is chosen, and
- ❑ once the pathway is taken, it is costly to change direction, and
- ❑ the chosen pathway has net negative consequences for national economic development/economic competitiveness in the future.

All of the above must be present for carbon lock-in to exist. But at the time a decision is made it cannot be known with certainty that carbon lock-in will occur.

Carbon lock-in is described more fully in **Section** 2 of the Toolkit.

Who should you use this guidance note, and when?

This guide is aimed at decision makers in national or local governments who are considering policy options[1] that may result, directly or indirectly, in carbon-intensive pathways. It is also useful for advisors, donors involved in developing interventions, and stakeholders affected by government decisions.

The focus is on making policy choices that are in the developing country's national self-interest but taking account of (see **Section 3.3** of the Toolkit):

- ❑ the financial opportunities available to developing countries from, and threats posed by, the future international framework relating to climate change (**see Annex A1** of the Toolkit),
- ❑ future trends in international energy prices (**Annex A3.1)** for forecasts of international prices for oil, natural gas and coal), and
- ❑ future trends in the costs of low carbon technologies (**Annex A3.3**).

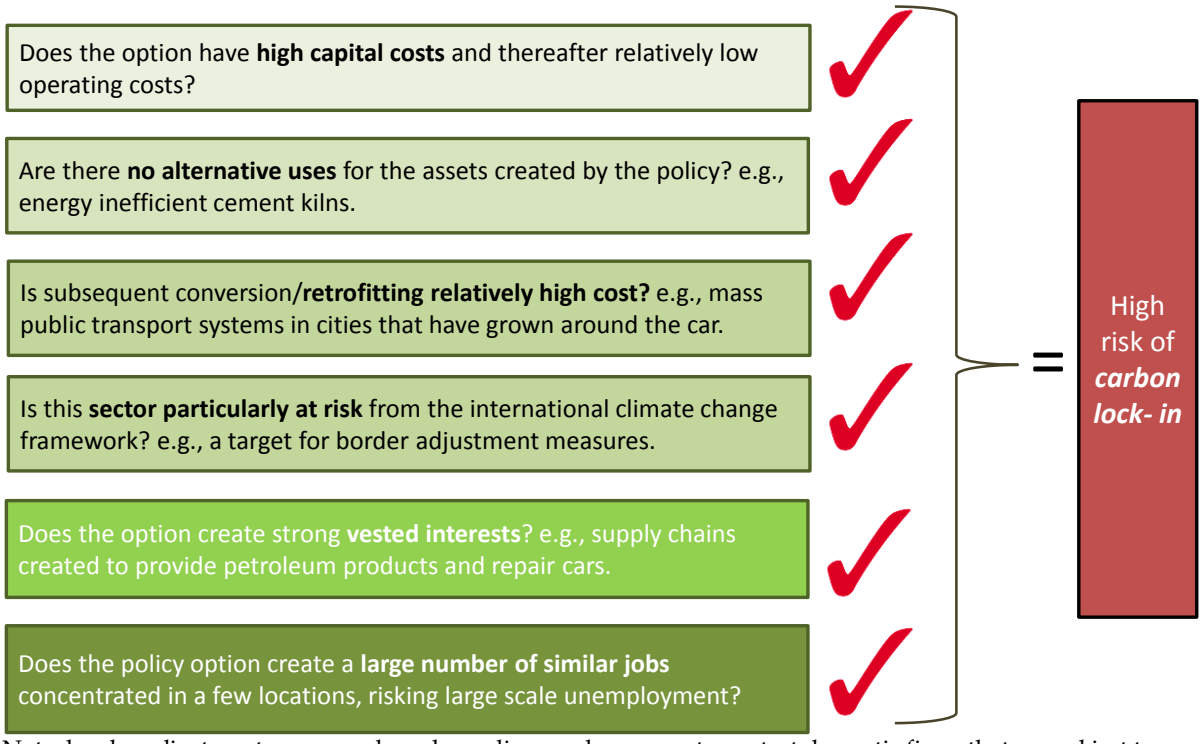
[1] Including do-nothing or wait-and-see options. For example, an option might be to introduce concentrated solar power now, or to wait for a few years to see if the costs come down and in the meantime to develop gas-fired power plants using gas-turbine technology with relatively low capital costs.

What to look out for?

High carbon-intensity does not necessarily imply carbon lock-in. Bearing in mind that **lock-in occurs when it is costly to change course at some future date**, the costliness of changing course depends on a range of factors. Factors that may lower the cost of switching might include (see **Sections 3.3 and 3.4** of the Toolkit): Is there a relatively low-cost conversion option (such as a switch to biomass)? Will it be cheap in the future to switch to alternative low carbon technology (e.g., will solar PV prices continue to fall)? Can old carbon-intensive assets be re-used for something economically productive (diesel generators used for back-up power)?

Lock-in also arises when a pathway creates strong interest groups that, once established, will be harmed in some way by a move away from the carbon intensive path. This is institutional lock-in (see **Section 3.5** of the Toolkit). The 'harm' will not always be economic harm, but may simply be the disruption of an established and comfortable pattern of life or the creation of uncertainties.

Some of the factors that tend to increase the likelihood of lock-in are shown in the diagram below. These are the **factors to watch out for when screening to see whether there is a risk of lock-in**, but a 'yes' answer to all of these questions does not necessarily mean that there will be lock-in, nor does the answer 'no' to all questions guarantee that there will be no lock-in.



Note: border adjustment measures have been discussed as a way to protect domestic firms that are subject to climate change regulation from competition from foreign firms that are not.

If several of these factors exist in one of the pathways under serious consideration, then a more careful assessment of carbon lock-in should be undertaken, as described below.

Deeper questions to ask

Policy decisions must be made in situations of considerable uncertainty. Good forecasts of international energy prices and technology costs help to lower uncertainty but, however good the forecasts, the future will always be uncertain and the best option cannot be identified with certainty.

The first question to ask is whether a low, or high, carbon pathway is the obviously economically correct choice under all likely future scenarios. In this case, the decision is clear. However, if the choice depends on how the future plays out (international energy prices, the climate change framework and technology costs), then further questions need to be posed.

The next set of **questions to ask when assessing policy options from a carbon lock-in perspective** are:

1) **Once a carbon intensive pathway is chosen, will it be costly to switch to a low carbon one (and will it be worthwhile)?**

2) **What are the economic consequences if we are locked-in to a high carbon pathway** and future *world energy prices/the international climate change framework/ low-carbon technology costs* are unsympathetic[2] to our policy choice? (Equally, what are the economic consequences if we choose a low carbon pathway and the future is unsympathetic to that choice?)

3) **How likely is it** that *world energy prices/the international climate change framework/low-carbon technology costs* will be unfavourable/favourable to our chosen pathway?

When asking the first question, we should bear in mind that there may, to varying degrees, be flexibility to adapt to changed circumstances[3].

A rigorous analysis would then combine the economic consequences derived from question (2) and the likelihood derived from question (3). In practice, few policy decisions will be based on a fully quantified assessment of the risks and consequences of multiple future scenarios. But, as a minimum decision makers should consider some 'what if' analyses involving various policy decisions and the subsequent consequences of various scenarios for *world energy prices/international climate change frameworks/future low-carbon technology costs*. For example:

> What if we choose policy option A and world energy prices are high, what will be the economic consequences? What if we choose policy option A and, instead, world energy prices are low, what then will be the economic consequences? What if we

[2] e.g., high fossil fuel prices and a strict international climate change framework that penalises countries with high carbon intensity through border adjustment measures or similar measures.
[3] If, for example, we build coal-fired power stations, we may be able to retrofit the plants with carbon-capture and storage, or convert the plants to burn natural gas or biomass. If these are not feasible, then our only feasible option would be to close down the coal-fired power plants and build new low-carbon power plants. If the cost of doing this is high, then we risk carbon lock-in if we choose to build coal-fired power plants.

choose policy option B and world energy prices are high, what are the economic consequences? etc., etc.

Further guidance and some suggested sources of data to help make such assessments are provided in **Section** 3 **and in Annexes** to the Toolkit.

A **4th question** that should also be asked is **whether there are additional policies that should be adopted to increase flexibility** (e.g., by designing coal-fired power plants to be capable of accepting carbon-capture and storage if the future international climate change framework makes high carbon emissions unattractive).

A simple illustration

Case studies are provided that illustrate carbon lock-in assessments (**Section** 4 **of the Toolkit**). Simplifying one of these, a typical assessment goes as follows[4]:

- **Consider the policy option**: Either: a) build coal-fired power plants, or b) build gas-fired power plants. Let us assume that it is not obvious that one decision is economically better than the other under all reasonable future scenarios.

- **Screening**: The checklist (in the diagram above) suggests that coal-fired power plants are likely to lead to carbon lock-in[5] both because of high capital cost and because of the creation of a large labour force concentrated in mining areas.

- **Question 1: Will it be costly to change pathway?** Converting a coal-fired power plant to biomass or gas is found to be infeasible[6]. Analysis shows that once the coal-fired option is implemented, it will be very costly to switch to a lower carbon pathway[7]. This satisfies two of the three conditions for carbon lock-in – it is carbon intensive and once the path is chosen, it will be costly to switch. But it does not prove that this pathway will have negative consequences for our economy.

- **Question 2: What will be the consequences?** Suppose we choose the coal-fired option and the future international climate change framework tightens such that the CO_2 'cost' rises over time to US$50/tonne[8], and this means that we are losing, say, US$ 1 billion per year[9]. Carbon lock-in would then be proven. On the other hand, suppose the future climate framework becomes very relaxed such that the CO_2 cost is close to zero, then we will be, say, US$1 billion per year better off. At the time the decision is made, we are therefore uncertain whether there will be carbon lock-in, but we know there is a risk.

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[4] For simplicity, this does not use the same assumptions as those in the case study.
[5] Because conventional coal-fired power generation produces large quantities of CO_2 per unit of electricity generated. In this illustration, we assume that gas-fired power generation has a more acceptable level of CO_2 emissions.
[6] This is assumed for illustrative purposes and cannot be assumed to be true generally.
[7] The capital cost is sunk and the variable fuel and O&M cost in this example is low.
[8] This is the high end of the scenarios considered in the case studies. The figures of US$50/tonne and US$0/tonne are used to illustrate policy paths over time that represent the costs or lost opportunities for developing countries that are associated with international climate change policies.
[9] Either by comparison with the alternative policy or compared with similar competing countries who followed a low carbon pathway. This is purely illustrative.

- **Question 3**: **How likely is it that policies will lead to CO_2 'costs' equivalent to US$50/tonne or more?** If we believe that there is a relatively high[10] probability that CO_2 costs will be US$50/tonne or more in the future then, in order to avoid carbon lock-in, our optimum choice would be gas-fired power plants to avoid the risk of carbon lock-in.

Finally, if we are still tempted to follow a high carbon strategy, we should ask whether there **is anything that can be done to increase the flexibility of a high carbon pathway** to allow us to switch to a low carbon one if *world energy prices/international climate change frameworks/ low-carbon technology costs* favour a switch. In this simple example, adapting the design of the coal-fired power plants to make them ready for retrofitting carbon-capture and storage, would increase flexibility and lower the risk of carbon lock-in.

[10] In this example, if the probability of CO_2 emissions costing US$50/tonne is 50% and there is a 50% probability that the value will be zero, then the expected outturn is 50% x US$1 billion + 50% x (-) US$1 billion = zero. If we believe that there is a greater than 50% probability that CO_2 costs will exceed US$50/tonne, then the expected (mathematical expectation) outturn from a low carbon pathway will be above zero dollars and the expected outturn from a high carbon pathway will be negative dollars.