

POLICY BRIEF

Marginal Abatement Cost (MAC) Curve

This policy brief is part of the Technical Assistance to the Ghanaian National Climate Change Policy Framework (NCCPF). The analysis is supported by DFID and the Dutch Government

September 2010

Abstract

A marginal abatement cost curve (MACC) is a convenient way to present low carbon options as alternatives to business as usual economic activity. A MACC can be used to give a brief overview of potential and costs for low carbon technologies across the economy or for a specific sector. Although reading a MACC is relatively easy, making a useful interpretation is an art in itself, and it should be noted that a MACC is not sufficient to base policy decisions on. A MACC *can* be useful as a basis for discussion on other aspects (beyond a MACC): development benefits, health and environmental impacts, ease of implementation, and social acceptance. For Ghana, constructing and iteratively detailing a MACC can be useful in support of furthering climate compatible (low carbon) economic growth.

WHAT IS A MARGINAL ABATEMENT COST (MAC) CURVE?

A Marginal Abatement Cost (MAC) curve is a straightforward way to show options that may be part of a low carbon development pathway, and what the costs and impacts of these alternatives could be. A MACC presents the extra (or 'marginal') costs and carbon reduction (or 'abatement') potential of these options relative to a baseline. Typical options in a MACC include switching to clean energy, improving energy efficiency, avoiding deforestation, improving agricultural practices and avoiding gas flaring.

Low Carbon Growth for Ghana

Low carbon growth is economic growth with a reduced carbon footprint. Ghana is not responsible for current GHG concentrations, and is unlikely to have a significant global contribution in the near term. There are nevertheless interesting arguments why actively steering towards a low carbon economy is beneficial to Ghana.

1. It may reveal short term economic opportunities, like energy efficiency measures that are profitable.
2. Low carbon actions may be eligible for international support (e.g. NAMAs or carbon market).
3. A low carbon economy is more robust: in a carbon constrained world, demand for low carbon products will grow, while prices of imported (fossil) energy may be high and volatile.

HOW TO READ A MAC CURVE

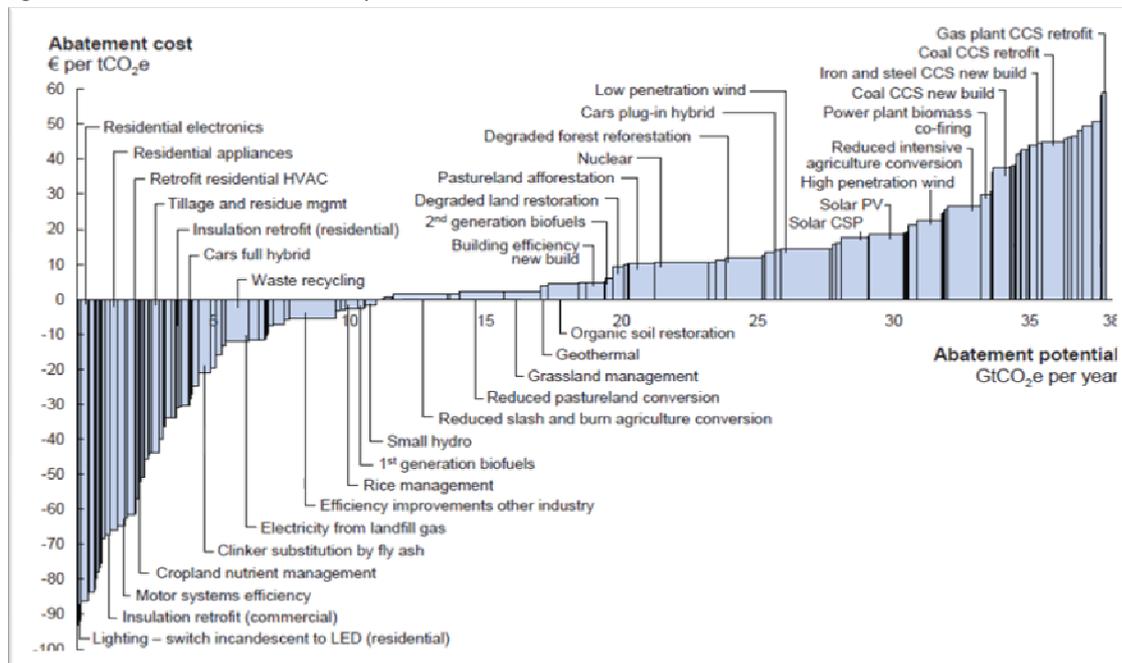
Figure 1 below shows an example of a MACC, taken from a study with a global scope and showing low carbon options up until a certain abatement cost level (e.g. less than 60 €/tonne CO₂-eq). The figure is read in the following way.

- Each bar represents a single low carbon option.
- The width of the bar represents the abatement potential relative to business as usual (BAU).
- The height of the bar represents the abatement cost per year, relative to business as usual. The costs are expressed in euros (or dollars, or cedis) per tonne emission avoided¹.

¹ Although CO₂ is the most common greenhouse gas, various others also exist. Methane for example, is a very potent greenhouse gas, around 25 times more serious than CO₂. For comparison, low carbon impacts in a MACC are normalized to CO₂-equivalent.

The sum of the width of all the bars shows the total low carbon potential and the total area of the bars indicates the marginal costs for choosing a low carbon pathway.

Figure 1: Global MAC curve beyond business as usual - 2030



Source: Pathways to a Low-Carbon economy version 2 (McKinsey&Company, 2009)

Note that the curve shows that over a quarter of the options under 60 €/tonne actually have *negative* costs, representing cases where the low carbon option is *cheaper* than the business as usual option. In some cases this points to real business opportunities, while in other cases non-market barriers may hinder the implementation of these options. In practice, caution is warranted in combining options with negative and positive costs to arrive at cost-neutral implementation. Furthermore, business opportunities only arise if the negative additional costs can be captured by the person taking the investment decision.

What is the baseline?

A MACC reflects the *marginal* costs relative to a baseline. This *baseline* reflects the technology choices and behaviour under ‘business as usual’ circumstances, not taking into account any low carbon policy interventions. A MACC is typically not about the present, but about a future year, for example 2020 or 2030. This has implications for what baseline technologies and low carbon alternatives could be.

USE OF MAC CURVES

MAC curve as a starting point for discussion

A MACC provides a quick overview of available low carbon options, and can be used as a starting point for prioritising such options. Planning low carbon development always involves much more than choosing the options with the least additional costs or largest abatement potential. A MACC therefore, is really only a starting point and policy makers or politicians *cannot* take decisions based

on a MACC alone - additional considerations and potential trade-offs that will need to be taken into account (see below).

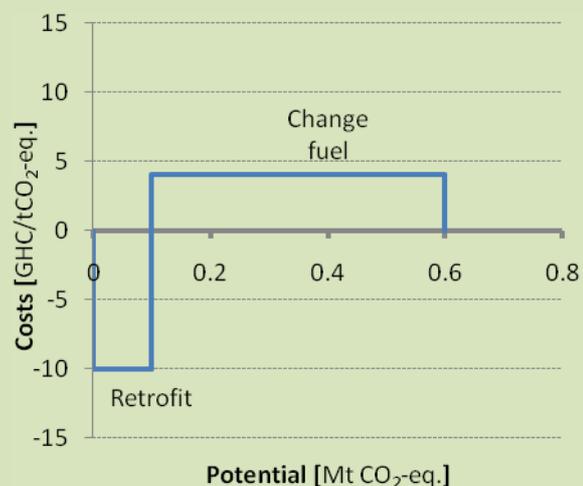
How do different actors use a MAC curve?

MAC curves are used by different actors for different purposes. Decision makers in government can use a MACC to help identify where policy interventions can be effective, and start dialogues with stakeholders on the best way to go about that. Entrepreneurs may use a MACC to analyse their sector(s) and identify low carbon options as business opportunities to enhance their competitive strength. Researchers construct and analyse MACCs in order to gain a better understanding of the link between emission reduction required to prevent climate change and concrete actions that could support this reduction. In short, a MACC can be used for a variety of purposes, but the scope and level of detail may vary.

Example: Low carbon options ABC power plant

In 2030, the ABC oil fired plant just outside Accra is expected to produce 500 GWh of electricity per year with a fixed amount of heavy fuel oil (this is the baseline). In a joint project with an international donor, the plant changes to a cleaner type of oil. This new fuel is more expensive (2 mln GHC costs annually), but it also reduces GHG emissions with 0.5 Mt annually. See option *Change fuel* in the graph.

In a second project, the plant is retrofitted to become more fuel efficient. This project saves another 0.1 Mt emissions annually, but is actually net profitable (1 mln GHC annual profit). See option *Retrofit* in the graph.



ISSUES AND LIMITATIONS

Although reading a MACC is straightforward, constructing it and interpreting its practical implications are not, as one needs to make various important assumptions. Likewise, when analysing a MACC, it is essential to be aware of the assumptions and have a general understanding of the limitations of the concept.

Assumptions and uncertainty

The starting point for a MACC is the construction of an emissions baseline in the target year, and an inventory of business-as-usual (or baseline) technologies. This is not only necessary for assessing the marginal costs of the low carbon alternatives, but also for assessing the potential. Next, an analysis of available low carbon technology alternatives in the target year will need to be conducted. Thirdly, it is necessary to make assumptions about the economics of specific abatement options (i.e. what is the economic lifetime, what are risk and return properties) and on the more general question of how to translate future costs and benefits to annual figures (i.e. the discount rate). There may be significant uncertainties on each assumption, especially in a developing country context with high economic growth rates, high discount rates and limited availability of high quality statistical data. A MACC therefore has to be interpreted with due care.

Further issues for consideration

When reading a MACC, it is tempting to think that switching to low carbon alternatives is all about costs, and that the negative cost options can be realized to generate income (or even pay for the more expensive options). However a number of issues need to be taken into consideration.

Behavioural aspects and transaction costs: A MACC consists mostly of technical options, and most MACCs do not cover transaction costs, such as costs associated with overcoming barriers. For example, barriers related to cultural constraints, broad awareness and acceptance of measures, or access to financial (credit) services necessary for pre-financing capital intensive investments. Some low carbon options require infrastructural adjustments, such as constructing a gas pipeline before switching from oil to gas in a power plant.

Discount rates & timing: The abatement costs in a MACC are annualised costs, including investment and operational costs, over the assumed life-time of the project or policy intervention underlying the mitigation option. Choosing the appropriate discount rate is essential and contested. Most MACCs use a societal discount rate of 4%, whereas discount rates from an investor's point of view are substantially higher (up to 15%) which increases the costs of low carbon options. Furthermore, many low carbon alternatives replace existing, business as usual technologies. Replacing existing working capital goods before the end of their economic lifetime is costly. It is therefore common to use windows of opportunity that are presented through maintenance moments or through replacement moments, which delays the realization of the low carbon options.

Dividing the baseline potential among low carbon alternatives: The comparison between the baseline and low carbon options is usually done either bottom-up through simple pair-wise comparisons, or top-down through more data-intensive (mostly energy system) models, which are better in taking interlinkages between different options into account. The bottom-up approach requires a number of choices. Different low carbon options may target replacing the same baseline technology: one megawatt of coal-fired power can be replaced by a megawatt of gas-fired power *or* a megawatt of solar power (but not both). Moreover, the technological potential for low carbon options may be larger than the baseline. As an illustration, one can never replace more oil-based power plants by solar energy than physically exist. And even though the technical potential for solar energy might be large, it may not make sense to have it exceed total energy demand.

MACC FOR GHANA

In preparation of a coordinated approach to climate change, for example under the national climate change policy framework (NCCPF) initiative, it makes sense to construct an initial MACC for Ghana. Some sectors may be included in more detail than others, depending on data availability and on technology opportunities in general. The MACC can be used to identify which sectors pose opportunities and within sectors, where the specific low carbon option are to be found.

Moreover, a MACC can include programs that are already being implemented. Even though in the strict sense, these are no longer new and additional, it does make sense to include some for two reasons. First, doing so can communicate the impact and costs of successful programs such as the introduction of the energy saving lamps (CFLs) over the past two years. Second, it can show what the impact could be of options that are included in current policy, but for which enforcement is weak.

The main challenge in constructing a MACC for Ghana will be the availability of data. Some data on greenhouse gas emissions and carbon footprints is not readily available. There is for example no commonly agreed data on the carbon stock and monetary value of Ghana's forests, yet, although research on the topic is underway. Where detailed data is unavailable, one needs to work with estimates. If no reasonable estimates can be made on some low carbon options, it is preferable to cover these options only at a later stage. In any case, uncertainty around the data in the initial MACC for Ghana will be high, underscoring the need for very careful interpretation.

The approach that might be suitable for Ghana is therefore to start with an initial, rough MACC and subsequently improve it, as data becomes available in more detail and as insights grow from discussions and stakeholder dialogues.

NEXT STEPS – BEYOND A MAC CURVE

In choosing and prioritising low carbon options, the following additional considerations may be considered in addition to potential and costs.

- Employment benefits
- Macro-economic impacts, e.g. increased energy security
- Health and environmental impacts
- Awareness and acceptance
- What are the barriers to implementation?
- Political feasibility, i.e. how easy it is to implement a low carbon intervention? Who are the relevant decision makers?
- Which policy instrument would be suitable?

As discussed above, a MACC is not a sufficient instrument to guide policy decisions, as it considers only two dimensions (potential and costs). In addition, there is inevitably uncertainty on the data and from the graph one cannot see if there are barriers to implementation of the low carbon option. A MACC can however be a valuable instrument as a basis for further discussion.

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