Assessing Development Impacts Associated with Low Emission Development Strategies: Lessons Learned from Pilot Efforts in Kenya and Montenegro

S. Cox and J. Katz
National Renewable Energy Laboratory (NREL)

Laura Würtenberger
Energy Research Centre of the Netherlands (ECN)

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

Technical Report
NREL/TP-6A20-58391
January 2014

Contract No. DE-AC36-08GO28308

Assessing Development Impacts Associated with Low Emission Development Strategies: Lessons Learned from Pilot Efforts in Kenya and Montenegro

S. Cox and J. Katz
National Renewable Energy Laboratory (NREL)

Laura Würtenberger
Energy Research Centre of the Netherlands (ECN)

Prepared under Task Nos. WFE2.2000, WFL1.1025,
and WW3Q.1004

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

Technical Report
NREL/TP-6A20- 58391
January 2014

Contract No. DE-AC36-08GO28308

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: mailto:reports@adonis.osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/help/ordermethods.aspx

Cover Photos: (left to right) photo by Pat Corkery, NREL 16416, photo from SunEdison, NREL 17423, photo by Pat Corkery, NREL 16560, photo by Dennis Schroeder, NREL 17613, photo by Dean Armstrong, NREL 17436, photo by Pat Corkery, NREL 17721.

Printed on paper containing at least 50% wastepaper, including 10% post consumer waste.

Acknowledgements

The authors would like to acknowledge the contributions of the following members of the LEDS Global Partnership Development Impact Assessment Working Group: Lachlan Cameron of the Energy research Centre of the Netherlands, Deborah Murphy of the International Institute for Sustainable Development, and Witze van der Gaast of the Joint Implementation Network. Their shared knowledge and insights of development priorities and assessment approaches and existing low emission development programs that incorporate multi-metric approaches contributed to a more meaningful evaluation of existing options and future opportunities for use of a development impact assessment tool as part of a LEDS. Additionally, the authors would like to thank Stephen King'uyu of the Ministry of Environment and Mineral Resources, Kenya, and Ron Benioff, Jaquelin Cochran, David Kline, Maggie Mann, and Kathleen Nawaz of NREL for their thorough and thoughtful reviews of this document.

Abstract

Low emission development strategies (LEDS) articulate economy-wide policies and implementation plans designed to enable a country to meet its long-term development objectives while reducing greenhouse gas emissions relative to a business-as-usual scenario. To inform an analytically robust and transparent prioritization of LEDS actions based on their economic, social, and environmental impacts, the LEDS Global Partnership designed a development impact assessment visual tool. The purpose of the tool is to assist policymakers and analysts in communicating the development impacts of LEDS options and in identifying a portfolio of actions that best meet both emissions reduction and development goals.

This paper summarizes the adaptation and piloting of the tool in Kenya and Montenegro. These two pilot experiences demonstrated several strengths of the tool: its flexibility and adaptability to complement and enhance other planning processes by summarizing and displaying impact information; its ability to leverage and communicate qualitative information about development impacts (including negative impacts); and its potential to support sector-specific as well as economy-wide decision making. The Kenyan and Montenegrin pilot projects also highlighted key needs for improving the tool and the framework it provides. Impactful improvements might include the specification of causal chains to provide evidence for impacts; the addition of baseline information to enable comparison of impacts across the whole economy rather than only within specific sectors; and the consideration of impact scale, timeframe, and relative priority. Potential areas for further study include assessing the complementarity of the tool with quantitative impact assessment methods and determining effective ways to integrate it into communication and decision-making processes.

Table of Contents

List of Figures

List of Tables

Introduction

Low emission development strategies (LEDS) and related plans present pathways for countries to achieve long-term national development goals in a manner that also minimizes greenhouse gas (GHG) emissions trajectories. LEDS are often economy-wide in scope and encompass all key emissions and development sectors, including energy, transport, agriculture, industry, waste, forestry, and other land use. The development scenarios included in a LEDS lay out concrete policies, programs, financing, and other actions to ensure the strategy is implementable both within key sectors as well as across the economy. As opposed to programs strictly focused on GHG emission mitigation, LEDS actions are aligned with the development goals of the country, such as poverty alleviation, economic growth, and energy security.

Designing a LEDS requires thorough and transparent economy-wide analysis and prioritization of mitigation and development actions. Considering the economic, social, and environmental impacts associated with these actions supports such analysis and contributes to well-informed decision making.

Country leaders and practitioners pursuing LEDS have noted that a critical limitation with LEDS analysis tools is their inability to adequately assess and visually present—in a simple manner—the variety of development impacts associated with LEDS options. Therefore, providing policymakers with a full picture of both the development and mitigation impacts of proposed actions is often difficult.

To address this issue, the LEDS Global Partnership[1] designed and has piloted the use of a development impact assessment (DIA) tool to visually display development impacts of LEDS actions to decision makers.[2] The purposes of the tool—referred to in this paper as the DIA visual tool—are to:

1. Communicate development impacts of LEDS actions
2. Support decision-making to determine sets of actions that contribute to national development goals (1).

This study builds on the findings in a paper published by Cowlin et al. (2012), titled *Broadening the Appeal of Marginal Abatement Cost Curves: Capturing both Carbon Mitigation and Development Benefits of Clean Energy Technologies*, which provides background on development of the DIA visual tool.

---

[1] The Low Emissions Development Strategies Global Partnership (LEDS GP) was founded to enhance coordination, information exchange, and cooperation among programs and countries working to advance low emissions growth. The LEDS Global Partnership, which brings together more than 100 governmental and international institutions, has facilitated discussions on the challenges associated with visualizing and communicating development impacts associated with LEDS, revealing broad consensus on these limitations. For more information, see ledsgp.org.

[2] Organizations that led the development and piloting of the DIA visual tool include the Energy Research Centre of the Netherlands (ECN), the German Agency for International Cooperation, the International Institute for Sustainable Development, the Joint Implementation Network, and the National Renewable Energy Laboratory.

The Development Impact Assessment (DIA) Tool

The DIA visual tool template (populated with illustrative 'dummy' data) is displayed in Figure 1. The visual is built around a marginal abatement cost curve (MAC curve), a common model for presenting and prioritizing abatement options based on cost and emissions reduction potential.[3] The DIA visual tool rotates the MAC curve such that technologies are ordered vertically from lowest to highest cost (1). The columns to the right of the MAC curve define broad impact categories (social, economic, and environmental), each containing several specific development impacts or indicators (e.g., health, gross domestic product, and water). For Figure 1, indicators were selected based on common development goals targeted by non-climate programs (such as targets set by the Millennium Development Goals[4]) (1). A fourth section was added to the three impact categories to capture considerations related to ease of implementation, such as awareness and acceptance of technology options.

To define the type or level of impact that each alternative low emission technology or action might have on an indicator of interest, the DIA visual tool also provides an impact scoring system. In the sample graphic shown in Figure 1, impacts are depicted as "highly positive," "positive," "neutral," or "negative."

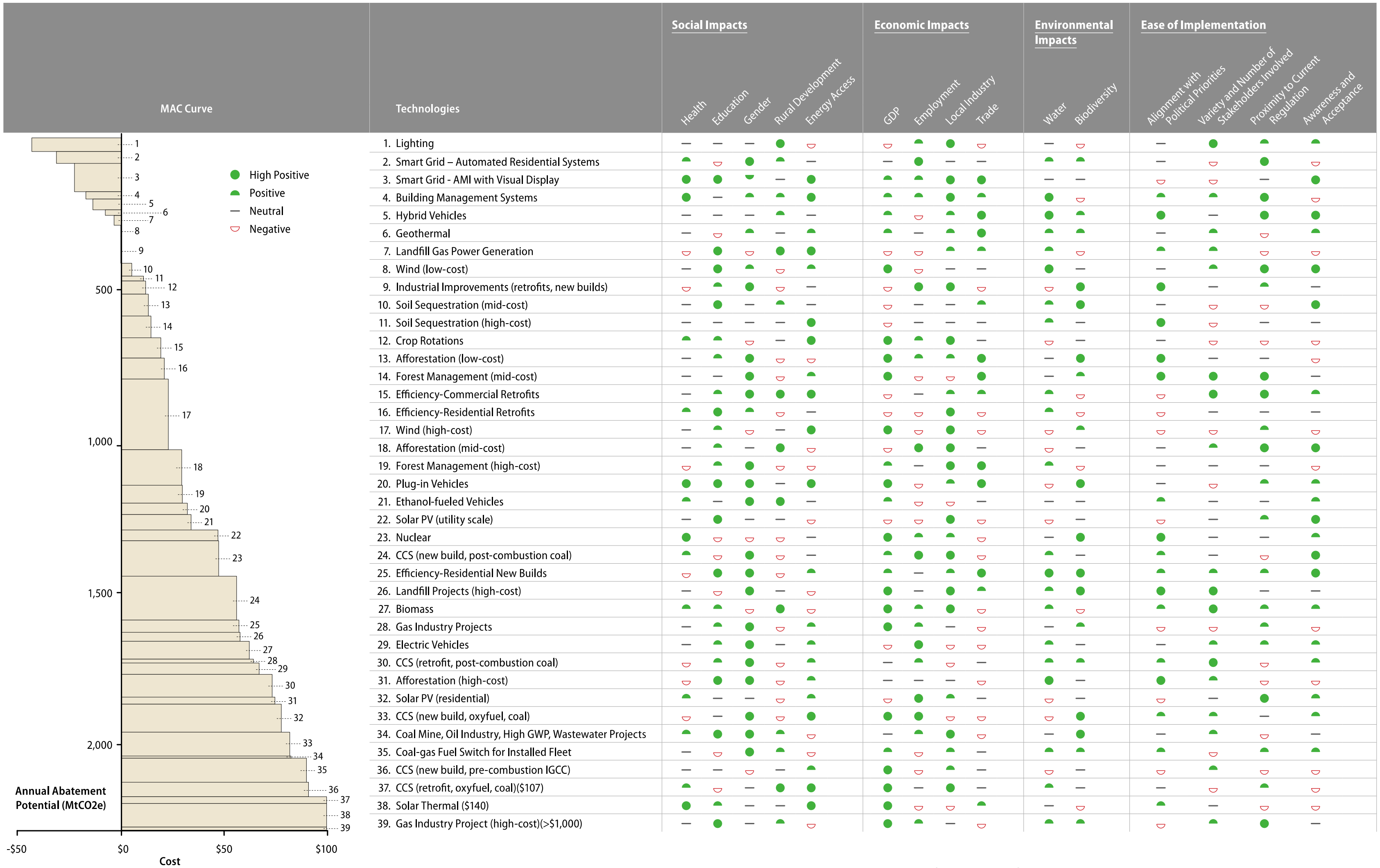
The DIA visual tool seeks to provide a flexible and simplified framework to compare technologies across sectors using multiple criteria of most interest to the country (1). Figure 1 provides an example of types of technologies and impacts that might be considered. In practice, country stakeholders can determine which technologies and benefits to include in the visual based on national priorities and data available. Further, the scoring system used for determining level of impact is also flexible to allow the visual to be applied to different types of assessment processes. Level of impact can be assigned through quantitative or qualitative analyses depending on data availability and method preferred by stakeholders.

To determine its practical strengths and limitations, the DIA visual tool has been adapted and piloted in Kenya and Montenegro. The remainder of this paper documents the pilot experiences in both countries and summarizes lessons learned in each case, as well as key findings and conclusions across the two case studies.

---

[3] The MAC curve shown here is a variable-width bar graph with GHG mitigation options arranged from least to highest cost per unit of reduced carbon. The y-axis represents the marginal cost of carbon abatement and the x-axis represents the total emissions reduction potential for that option.

[4] For more information, see www.un.org/millenniumgoals.



Technologies	Social Impacts					Economic Impacts				Environmental Impacts		Ease of Implementation			
	Health	Education	Gender	Rural Development	Energy Access	GDP	Employment	Local Industry	Trade	Water	Biodiversity	Alignment with Political Priorities	Variety and Number of Stakeholders Involved	Proximity to Current Regulation	Awareness and Acceptance
1. Lighting	—	—	—	●	◡	◡	◓	●	◡	—	◡	—	●	◓	◓
2. Smart Grid – Automated Residential Systems	◓	◡	●	◓	—	—	●	—	—	◓	◓	—	◡	●	◡
3. Smart Grid - AMI with Visual Display	●	●	◓	—	●	◓	◓	●	●	—	—	◡	◡	—	●
4. Building Management Systems	●	—	◓	◓	●	◓	◓	●	◓	●	◡	◓	◓	●	◡
5. Hybrid Vehicles	—	—	—	◓	—	◓	◡	◓	●	●	◓	●	—	●	●
6. Geothermal	—	◡	◓	—	◓	◓	—	◓	●	◓	◓	—	◓	◡	◓
7. Landfill Gas Power Generation	◡	●	◡	●	●	◡	◡	◓	◓	◓	◡	◓	◓	◡	◡
8. Wind (low-cost)	—	●	◓	◡	◓	●	◡	—	—	●	—	—	◓	●	●
9. Industrial Improvements (retrofits, new builds)	◡	◓	●	◡	—	◡	●	●	◡	◡	●	●	—	◓	—
10. Soil Sequestration (mid-cost)	—	●	—	◓	—	◡	—	—	◓	◓	●	—	◡	◡	●
11. Soil Sequestration (high-cost)	—	—	—	—	●	◡	—	—	—	◓	—	●	◡	—	—
12. Crop Rotations	◓	◓	◡	—	●	●	◓	●	—	◡	—	—	◡	◡	◡
13. Afforestation (low-cost)	—	◓	●	◡	◡	●	◓	◓	●	—	●	●	—	—	◡
14. Forest Management (mid-cost)	—	—	●	◡	◓	●	◡	◡	●	—	◓	●	●	●	—
15. Efficiency-Commercial Retrofits	—	◓	●	●	●	◡	—	◓	◓	◓	◡	◡	●	●	◓
16. Efficiency-Residential Retrofits	◓	●	◓	◡	—	◡	◡	●	◡	◓	◡	◡	—	—	—
17. Wind (high-cost)	—	◓	◡	—	●	●	◡	●	◡	◡	◓	◡	◡	◓	◡
18. Afforestation (mid-cost)	—	◓	—	●	◡	◡	●	●	—	◡	—	—	◓	●	●
19. Forest Management (high-cost)	◡	◓	●	◡	◡	◓	—	●	●	◓	◡	—	—	—	◡
20. Plug-in Vehicles	●	●	●	—	●	●	◡	◓	●	◡	●	—	◡	◓	◓
21. Ethanol-fueled Vehicles	◓	—	●	●	—	◓	◡	◡	—	—	—	◓	—	—	◓
22. Solar PV (utility scale)	—	●	—	—	◡	◡	◡	●	◡	◡	—	◡	—	◓	●
23. Nuclear	●	◡	◡	◡	—	●	◓	◓	◡	—	●	●	—	—	◓
24. CCS (new build, post-combustion coal)	◓	◡	●	◡	—	◓	●	●	◡	◓	—	◓	—	◡	●
25. Efficiency-Residential New Builds	◡	●	●	◡	◓	◓	—	◓	●	●	●	◓	◓	◓	●
26. Landfill Projects (high-cost)	—	◡	●	—	◡	●	—	●	◓	◓	●	●	●	—	—
27. Biomass	◓	◓	◡	●	◡	●	◓	●	◡	◓	◡	◓	●	◓	◓
28. Gas Industry Projects	—	◓	●	◡	◓	●	◓	—	◡	—	◓	◡	◡	◓	◡
29. Electric Vehicles	—	◓	●	—	◓	◡	●	◡	◡	◓	—	—	◓	◓	◓
30. CCS (retrofit, post-combustion coal)	◡	◓	●	◡	◓	—	◓	◡	—	◓	◓	◓	●	◡	◓
31. Afforestation (high-cost)	◡	●	●	◡	◓	—	—	—	◡	●	—	●	◓	◡	◡
32. Solar PV (residential)	◓	—	—	◡	◓	◡	●	◓	—	◡	—	◡	—	●	◓
33. CCS (new build, oxyfuel, coal)	◡	—	●	◡	●	●	●	◡	◡	◡	●	◓	◓	—	◓
34. Coal Mine, Oil Industry, High GWP, Wastewater Projects	◓	●	●	◓	◡	—	◓	●	◡	—	●	—	◓	◡	—
35. Coal-gas Fuel Switch for Installed Fleet	—	◡	●	◓	◡	◓	◡	◓	—	◓	◓	◓	◡	◓	◓
36. CCS (new build, pre-combustion IGCC)	—	—	◡	—	◓	●	◡	◓	—	◡	—	◡	◓	◡	◡
37. CCS (retrofit, oxyfuel, coal)($107)	◓	◡	—	●	●	●	—	●	—	◓	—	—	◡	◓	◡
38. Solar Thermal ($140)	●	◓	—	—	●	●	◡	◡	◓	—	◡	◓	—	◡	◡
39. Gas Industry Project (high-cost)(>$1,000)	—	●	—	◓	◡	●	◓	—	◡	◓	◓	◡	◓	●	—

The randomized data inserted in this table is for purposes of demonstration only and does not represent actual research.

Figure 1. Proposed development impact assessment visual intended to communicate simultaneously GHG mitigation potential and development benefits of technology options (1)

This figure was originally presented in Cowlin et al. (2012). As noted in that study, the figure does not represent analytical research findings, but instead includes 'dummy' variables for purposes of illustration.

Piloting the DIA Visual Tool in Kenya

Background: Kenya’s National Climate Change Action Plan

The DIA visual tool was applied to support an analysis of mitigation options for Kenya’s National Climate Change Action Plan (NCCAP). The objective of the NCCAP is to operationalize Kenya´s National Climate Change Response Strategy, and the plan was developed in an ambitious, participatory, and multi-stakeholder process led by Kenya’s Ministry of Environment and Mineral Resources. This process involved representatives from all relevant ministries, civil society, and the private sector.[5] The NCCAP was officially launched in March 2013.

For the mitigation analysis in the NCCAP, a low-carbon scenario assessment was undertaken by a consortium consisting of the International Institute for Sustainable Development (IISD), the Energy Research Center of the Netherlands (ECN), the ASB Partnership for the Tropical Forest Margins at the World Agroforestry Centre, and other local partners. The assessment was intended to provide the evidence for prioritizing low-carbon actions and ultimately for developing investment proposals to attract international climate finance through Nationally Appropriate Mitigation Actions and REDD+.[6]

The NCCAP’s low-carbon scenario analysis aimed to demonstrate how mitigation actions could contribute to low-carbon pathways in six United Nations Framework Convention on Climate Change (UNFCCC) sectors: energy, transport, industry, agriculture, forestry, and waste. It included an initial inventory of historical GHG emissions; a projection of how emissions could change up to 2030; and an analysis of low-carbon development opportunities in each of the six sectors. The opportunities analysis included the results of the sustainable development impact assessment using the DIA visual tool, as well as separate assessments of GHG emission reduction potential, costs, adaptation co-benefits, and the feasibility of implementing each option (2). All components of the low-carbon scenario analysis, including the output of the DIA visual tool, were ultimately used to identify a short list of priority mitigation options.

The analysis of the sustainable development impacts of mitigation options played a key role in the overall mitigation assessment, as (sustainable) development remains Kenya’s main priority: *Kenya Vision 2030*—the long-term development blueprint for the country—seeks to transform Kenya into “a newly industrializing, middle-income country providing a high quality of life to all its citizens” (3).

Methodology

The mitigation analysis team used the DIA visual tool to structure, summarize, and communicate the development impacts of low-carbon options for the NCCAP. The inclusion of the DIA visual tool and underlying assessment reflected the high importance placed on the sustainable

---

[5] See www.kccap.info for additional information on the NCCAP and to download all respective documents.

[6] For more information on Nationally Appropriate Mitigation Actions, see http://unfccc.int/focus/mitigation/items/7172.php. For more information on REDD+, see http://unfccc.int/methods/redd/redd_web_platform/items/4531.php.

development benefits by the government and stakeholders. The various components of the DIA visual template were adapted to the Kenyan context as described in this section.

Technology options (rows of the DIA visual tool) were chosen in an iterative and participatory process. Based on a literature review and expert assessment by Kenyan and international experts, a shortlist of technology options to be analyzed was presented to Kenyan stakeholders at various stakeholder consultation events. The final list was created using feedback from these stakeholder consultations and approved by the Task Force, which had the mandate to guide the process of developing the NCCAP and which was led by the Ministry of Environment and Mineral Resources. In some cases, the list was modified as the analysis progressed. The mitigation analysis for Kenya's NCCAP provides a more detailed description of the stakeholder consultation process (2).

Impact categories and indicators (columns of DIA visual tool) were modified in three primary ways from the original version of the DIA visual tool developed under the LEDS Global Partnership:

- The MAC curve was replaced by columns indicating abatement potential and, where figures were available, by marginal abatement costs of the option. This approach was taken for three reasons: i) it was assumed that not all stakeholders in Kenya would be familiar with reading MAC curves; ii) it was not possible to calculate marginal abatement costs for all options; and iii) it was assumed that providing the numerical values, where possible, would facilitate comparison of the options.
- Development impacts were assessed separately per sector (e.g., forestry, agriculture, and transport) or per sub-sector (e.g., electricity generation and energy demand). There were two reasons for doing so: i) the key development impacts differ between sectors. Limiting the matrix to these key impacts per sector makes the visual easier to read and facilitates understanding; and ii) the subsequent prioritization of low-carbon development options was also undertaken on a sectoral level. For example, the Ministry of Forestry and Wildlife and expert stakeholders would determine potential priority actions in the forestry sector rather than having a central decision-making body choose between a forestry option and an energy efficiency option.
- The development impact categories were chosen by the project team and presented to stakeholders for feedback at consultative events. However, due to time limitations, there was no systematic discussion of the impact categories and indicators with stakeholders.

Impact scoring system used the nomenclature from the original DIA template ("highly positive," "positive," "neutral," or "negative"). One additional category, "uncertain," was added because either it was not always possible to determine whether an option would have a positive or negative impact, or the impact would depend on how the option was undertaken. For example, the use of biofuels might or might not have negative impacts on food security, depending on which crops are used and the scale of biofuel use.

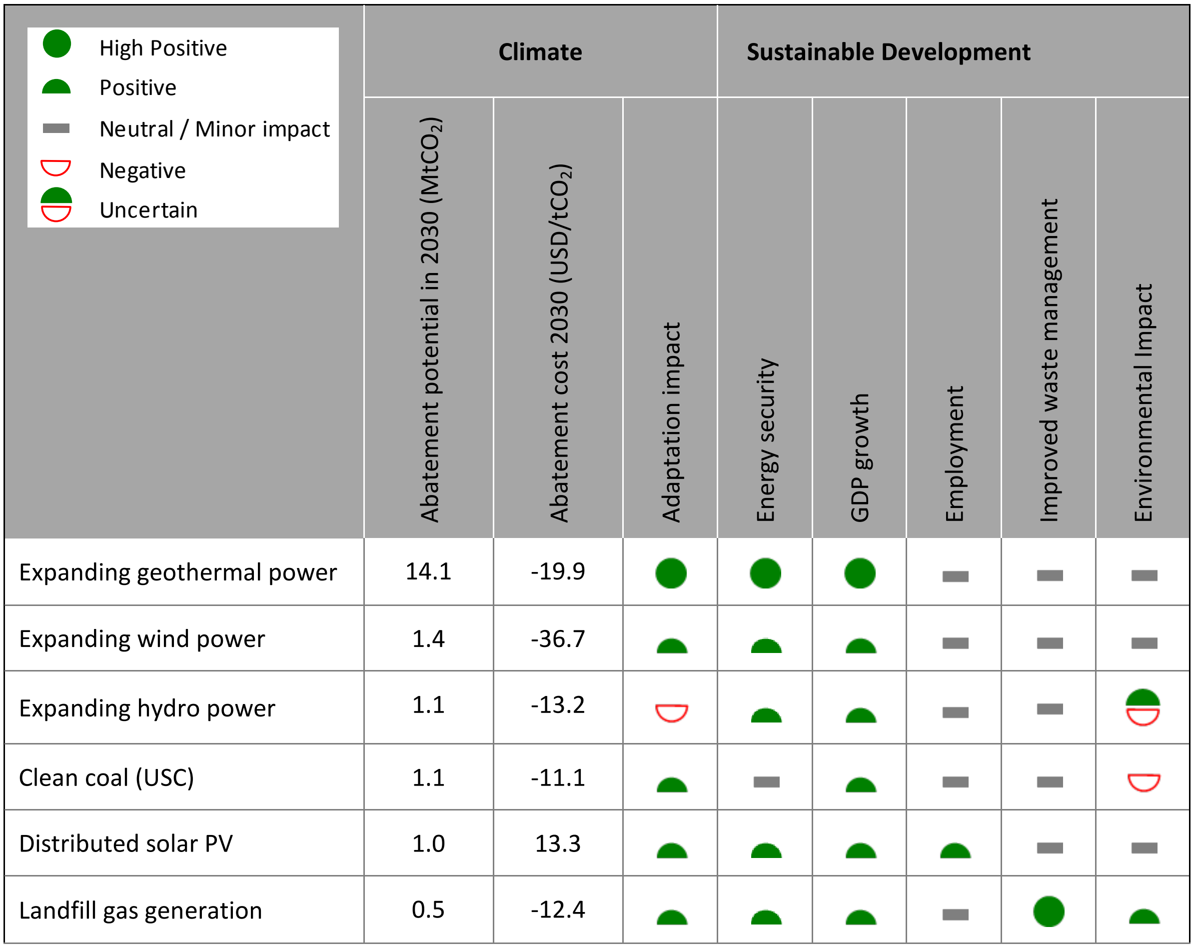
Impact assessment: A qualitative assessment of the development impacts of the low-carbon options was undertaken separately for each sector by a team of international and Kenyan experts. This assessment was based on assessments in literature where available as well as on considerations specific to the Kenyan context (given that for most technologies, there are no impact assessments in literature specifically for Kenya). The teams identified five sector-specific impact categories. The overall assessment of options was then validated at stakeholder workshops with small groups of sectoral experts and the Thematic Working Group that provided guidance to the mitigation analysis. The DIA visual tool was presented to participants at these consultative events as a basis for discussing development impacts.

In addition, key Kenyan stakeholders and experts had the opportunity to provide written feedback to the final technical reports, which include sections devoted to the assessment of development impacts and the DIA visuals.

The assessment of development impacts using the DIA visual was then taken into consideration alongside the NCCAP's other assessments (e.g., of mitigation potential and costs, and feasibility) to narrow the original list of all technology options to six potential priority low-carbon options across all sectors. Priority options were determined in an iterative process through discussions with Kenya's Ministry of Environment and Mineral Resources, line ministries, and with the Thematic Working Group and Task Force, which had the mandate to provide guidance to approve the results of the different subcomponents of the NCCAP. For most of these discussions, the DIA visual tool was part of the supporting material that formed the basis for the discussion; however, the visual was also found to require detailed explanation. Since stakeholder consultations and workshops were frequently time-constrained, in-depth discussion and verification of the DIA visual tool was not feasible.

Results

Figure 2 and Figure 3 show the results of the analysis of development impacts for low-carbon options for electricity generation and agriculture, respectively. Results for the other sectors (forestry, electricity demand, transport, industrial processes, and waste) are available in the respective technical reports for each sector.[7]



●	High Positive
◓	Positive
▬	Neutral / Minor impact
◡	Negative
◓◡	Uncertain

	Climate			Sustainable Development				
	Abatement potential in 2030 ($MtCO_2$)	Abatement cost 2030 (USD/tCO_2)	Adaptation impact	Energy security	GDP growth	Employment	Improved waste management	Environmental Impact
Expanding geothermal power	14.1	-19.9	●	●	●	▬	▬	▬
Expanding wind power	1.4	-36.7	◓	◓	◓	▬	▬	▬
Expanding hydro power	1.1	-13.2	◡	◓	◓	▬	▬	◓◡
Clean coal (USC)	1.1	-11.1	◓	▬	◓	▬	▬	◡
Distributed solar PV	1.0	13.3	◓	◓	◓	◓	▬	▬
Landfill gas generation	0.5	-12.4	◓	◓	◓	▬	●	◓

Figure 2. Overview of mitigation potential, costs, and adaptation and sustainable development impacts of low-carbon development options in the electricity sector in Kenya (4, reprinted with permission)

---

[7] This documentation can be downloaded at www.kccap.info.

● High Positive
◓ Positive
▬ Neutral / Minor impact
◡ Negative
◓◡ Uncertain

	Climate			Sustainable Development				
	Abatement potential in 2030 ($MtCO_2e$)	Abatement cost 2030 (US$/$tCO_2$)	Adaptation impact	Energy security	GDP growth	Employment / Rural livelihoods	Improved land management	Environmental benefits
Agroforestry	4.16	13.25	●	◓	◓	◓	●	●
Conservation Tillage	1.10	14.36	●	▬	◓	◓	●	●
Limiting Use of Fire in Range and Cropland Management	1.00	21.00	◓	▬	▬	▬	●	◓

Figure 3. Overview of mitigation potential, costs, and adaptation and sustainable development impacts of low-carbon development options in the agriculture sector in Kenya (5, reprinted with permission)

Each renewable energy option for electricity generation was assumed to have a positive impact on energy security in Kenya because the deployed resources do not require import of fossil fuels and do not compete with other uses for domestically available fossil fuels (4). Moreover, all low-carbon options in the electricity sector were assumed to contribute to growth in gross domestic product because electricity use is constrained by supply; thus, any additional electricity generation capacity in Kenya from renewable energy may contribute to economic activity. Given that geothermal electricity generation has by far the largest generation potential in Kenya, its potential contribution to energy security and growth in gross domestic product was assessed as highly positive.[8]

In terms of employment, no option except distributed solar photovoltaics (PV) was assumed to directly lead to significant, long-term job creation. The net employment impacts of renewable energy technologies versus conventional generation in general are not clear (6). Moreover, in the Kenyan context, the number of local manufacturing and installation jobs that would be created in the absence of an established renewables industry is also unclear. However, distributed solar PV was assumed to have the potential to contribute to job creation, as the installation and maintenance of wide scale deployment of distributed PV systems is relatively employment

---

[8] Development risk associated with geothermal and other renewable electricity generation options were considered in a separate feasibility of implementation section of the mitigation analysis. Development risk is not directly included in the DIA visual tool. Rather, the DIA assessment reflects impacts of renewable energy generation once plants are constructed.

intensive and requires specialist technicians that would typically be locally sourced. On the other hand, geothermal and wind power plants could contribute to short-term jobs in construction and a few jobs in operation and maintenance, but are assumed less likely than distributed solar to contribute to long-term sustained job creation.

In terms of climate resilience, hydropower generation was judged to be the low-carbon development option most vulnerable to climate change. Reductions in rainfall, and thus water reserves, directly reduce the availability of hydroelectricity. The other mitigation options discussed are largely resilient to climate change, or they would experience very small impacts in comparison to hydropower. All non-hydro options would increase climate resilience in the sense that they would lower Kenya's dependence on existing hydroelectric generation.

In the agriculture sector, agroforestry has significant sustainable development potential, as trees can act as a source of sustainable fuel wood, on-farm timber, and livestock fodder, which can alleviate the pressure on neighboring forests (5). Agroforestry can also have positive impacts on soil quality, leading to higher soil nutrient and water retention. In particular, nitrogen-fixing trees and shrubs can increase soil fertility and crop yields, which means that agroforestry systems can significantly enhance the livelihoods of smallholders.

Table 1 shows the potential priority low-carbon options that were identified in the mitigation analysis of Kenya's NCCAP based on the comprehensive assessment of low-carbon options across the six UNFCCC sectors.

Table 1. Potential Priority Low-carbon Options Identified in the Mitigation Analysis of Kenya's National Climate Change Action Plan (7)

Low carbon option	Abatement potential in 2030 ($MtCO_2e$)	Investment costs to 2030 (US$)	Sustainable development impacts
Restoration of forests on degraded land	32.6	2.2-3.4 billion	• Contributes to the constitution's goal of 10% tree cover • Biodiversity benefits • Sustainable forest products contribute to improved livelihoods • *Conservation may remove access to forests for communities*
Geothermal	14.1	10.3-13.1 billion	• Energy security, economic growth • *May require relocation of communities/villages*
Restoration of degraded forests	6.1	0.56-0.71 billion	• Sustained water availability (generation of hydropower) • Contributes to constitution's goal of 10% tree cover • Biodiversity benefits • Sustainable forest products contribute to improved livelihoods
Improved cook stoves and liquefied petroleum gas cook stoves	5.6+1.7	0.24 billion	• Health benefits from reduced indoor air pollution • Lower fuel wood demand and deforestation • Potential cost savings to households
Agroforestry	4.1	0.82-1.37 billion	• Increased soil fertility and crop yields, improving livelihoods of farmers and food security • Improved climate resilience • Contributes to goal of 10% tree cover on farms
Bus rapid transit (BRT) with light rail transit (LRT) corridors	2.8	2 billion	• Reduced traffic congestion • Improved local air quality • Improved road safety

Observations and Lesson Learned

The DIA visual tool provides a means of summarizing complex analysis. The main advantage of the DIA visual tool in Kenya was that it provided a way to summarize a large part of the assessment of low-carbon options in one table. However, it was also found that the DIA visual tool still required significant explanation and—because it contains so much information—was not always easy to interpret. The visualization proved to be a useful communication tool and provided a good basis for discussing the prioritization of options. It is recommended that the graphical attractiveness be tested with a group of stakeholders to improve its effectiveness.

The DIA visual tool provides a flexible framework for giving a more prominent role to sustainable development impacts in a low-carbon analysis. For the work undertaken under the NCCAP, the DIA visual tool provided input to the prioritization of low-carbon options. In line with the main purpose of the tool—to identify, structure, summarize, and communicate development impacts—it facilitated a more explicit enumeration of sustainable development (and climate resilience) impacts in the assessment of low-carbon options than is provided in traditional marginal abatement cost curves. In this way, the assessment of development impacts of different low-carbon options and the corresponding use of the DIA visual tool has the potential to lead to different choices of options than a MAC curve alone. Moreover, the assessment and communication of development impacts may increase awareness among decision makers of how priority low-carbon options contribute to meeting key development goals, thereby strengthening both LEDS and national development planning processes.

More time and an effective process to discuss DIA analysis with stakeholders are needed. The overall assessment of low emission development options was validated at stakeholder workshops, including with small groups of sectoral experts and the Thematic Working Group that provided guidance to the mitigation analysis. This is an important element of the analysis, as national experts are often aware of local impacts that are not evident from a "desk review." However, due to time constraints, conducting detailed discussions and workshops that focused explicitly on the assessment of sustainable development impacts was not possible. For similar processes in the future, it is recommended that more time be allocated to discuss and verify specifically the DIA analysis with the stakeholders who have the expertise and background to provide valuable input and feedback.

A more systematic alignment of development indicators with key development priorities is needed. The mitigation analysis team selected the development indicators used for the Kenyan piloting of the DIA visual tool after a detailed review of Government of Kenya planning documents. These indicators also reflect anecdotal discussions with stakeholders on which development indicators to take into account. However, due to limited time and resources, no systematic effort was undertaken with government representatives to ensure that the development indicators fully reflected the key priorities of the Government of Kenya. It would therefore be useful to select development indicators in a more systematic process in order to ensure alignment between the DIA visual tool and political priorities so that the visual resonates with stakeholders and enables effective prioritization of LEDS options.

A more quantitative analysis of key development indicators is needed. NCCAP stakeholders expressed a desire for quantitative assessment of development indicators at several occasions throughout the consultation process for the mitigation analysis. Especially for key indicators such as the impact of low emission development options on employment and on economic growth, a quantitative analysis could facilitate communication of DIA results to decision makers. Quantitative data may also contribute to an understanding of the scale of the impact (e.g., the percentage of the country's population or natural resources that a certain low emission intervention effects). For example, data on the number of beneficiaries of positive impacts (or victims of negative impacts) associated with a particular low emission development action would supplement quantitative estimates of GHG emissions reduction and implementation cost. The challenge of such quantitative analyses lies in the fact that they often require substantial data and/or models that are not readily available. However, for some measures and impact categories (e.g., time and fuel savings related to implementing modern and efficient public transport systems or impacts on health and quality of life of improved cook stoves), much quantitative work has already been undertaken for different countries and situations, which potentially could be approximated to future assessments elsewhere.

The DIA visualization needs to include supporting information in accompanying text. The DIA visual tool is useful for conveying information in a snapshot, but underlying information needs to be available. For example, Kenya experts requested information on how development impacts were determined, which was elaborated in the low-carbon analysis.

In Kenya, the analysis team integrated the DIA visual tool into the stakeholder-driven NCCAP development process to assess and present the sustainable development implications of low emission development options. The Montenegro pilot (described in the next section) tested the DIA visual tool's ability to summarize and visualize the outputs of LEDS processes that were conducted without explicitly incorporating the tool.

Piloting the DIA Visual Tool in Montenegro

Background: Montenegro's Technology Needs Assessment

Under the coordination of its Ministry of Sustainable Development and Tourism (and with support from the Joint Implementation Network and the Government of the Netherlands), the Government of Montenegro began a Technology Needs Assessment (TNA) in 2011 to identify and evaluate priority technology needs for climate change mitigation and adaptation that also reflect country-specific circumstances.[9] The TNA process provided the inputs needed to pilot the DIA visual tool with Montenegro.

As detailed in Markovic and van der Gaast (2012), implementing Montenegro's TNA consisted of several stakeholder-driven processes, including:

- An initial workshop in November 2011 in which stakeholders determined i) Montenegro's medium- to long-term development priorities in the context of climate change and ii) four key sectors with strong mitigation and sustainable development potential: aluminum production, road transport, electricity generation, and energy consumption in residential dwellings and commercial buildings[10]
- Identification by a Montenegrin TNA task force (consisting of governmental and sector experts as well as TNA consultants) of a range of feasible mitigation technologies within the four key sectors
- A second workshop in March 2012 in which stakeholders evaluated the extent to which each technology identified by the TNA task force would contribute to the social, economic, and environmental priorities determined during the November 2011 workshop. For sectors in which at least four mitigation technologies were identified (i.e., energy consumption, energy production, and transport), the multi-criteria decision analysis tool TNAssess[11] was used to score technologies within a sector relative to one another, and to weight scores according to priorities. (8)

Methodology

The DIA visual tool for Montenegro summarizes the more detailed analysis of development benefits created through the TNA process described above. The DIA visual tool was populated by an analysis team consisting of experts from the National Renewable Energy Laboratory with input from the Joint Implementation Network. The team utilized the TNA documentation to populate the DIA visual tool, but the tool itself was not integrated into the TNA process and has

---

[9] The "Decision on Development and Transfer of Technologies" at the seventh session of the UNFCCC Conference of Parties (COP7) included the TNA process as a component of the framework for implementing Article 4.5 of the convention. The UNFCCC encourages its parties (particularly developing country parties) to undertake TNAs. To date, 92 non-Annex I Parties have received funding from the Global Environmental Facility to implement TNAs. The methodology for conducting TNAs is available at http://unfccc.int/ttclear/pdf/TNAHandbook_9-15-2009.pdf.

[10] The TNA process also identified priority sectors for climate change adaptation. Given the emphasis of the DIA visual tool and LEDS in general on mitigation, adaptation options are not discussed in this paper, but more information is available in Markovic and van der Gaast (2012).

[11] TNAssess is a Microsoft Excel-based spreadsheet tool. More information is available from kevinbossley@catalyze.co.uk and jin@jiqweb.org.

not yet been shared formally with stakeholders, as the TNA process is now complete. The analysis team adapted the various components of the DIA visual template to the Montenegro context as described in this section.

Technology options (rows of the DIA visual tool) reflect the approximately 25 abatement technologies identified by the Montenegrin TNA task force. As in the TNA, these technologies were grouped in the DIA visual tool according to sector. A MAC curve was not included in the DIA visual tool because the Montenegrin TNA did not produce such an analysis.[12]

Impact categories and indicators (columns of DIA visual tool) were defined by the analysis team using information provided in technology-specific factsheets developed by the TNA task force. These fact sheets detail each technology's abatement potential; investment and operations and maintenance cost assuming full penetration over a 25-year life span; and other benefits related to Montenegro's development priorities. When possible, the analysis team drew names of impact categories and indicators directly from stakeholder responses to open-ended questions (translated to English). Since the TNA factsheets do not explicitly address ease-of-implementation, the team defined indicators in this section of the DIA visual tool using documented stakeholder input regarding policy implementation (1). In lieu of a MAC curve, indicators for "GHG Emissions Reduction," "Cost Saving," and "Low Investment Requirements" were added to the visual and scored using the same system as the other indicators. This approach allowed some of the information that may otherwise have been presented in a MAC curve to be incorporated into the visual.

Impact scoring system ("highly positive," "positive," "neutral," or "negative") was based on the original the DIA template shown in Figure 1.

Impact assessment: The analysis team assigned a score for each technology on each indicator based on the documentation produced during the March 2012 workshop, including the set of TNAssess scores and written rationales for these scores, as well as overall sector assessment documents for each of the four priority sectors.[13] The analysis team determined the magnitude of the positive scoring ("highly positive" versus "positive") by referencing the TNAssess tool's quantitative ranking of different technologies within a particular sector relative to one another. For instance, in the energy generation sector, stakeholders anticipated that several technology options would have an impact of lowering energy bills but indicated that two options in particular—exterior wall insulation in buildings (score 100) and solar thermal systems for the domestic and service sectors (score 90)—had the strongest savings potential relative to the other options. Therefore, these two technologies were scored "highly positive" in the DIA visual tool, while the others were scored "positive."

---

[12] No baseline costs were calculated to develop a business-as-usual case from which to estimate marginal cost of abatement for each technology. Instead, for each technology option, investment and operational costs were estimated assuming penetration at full technical potential over a certain period.

[13] The TNAssess tool is organized according to broad social, economic, and environmental assessments. Within each of these broad impact categories, stakeholders determine the least preferred technology (score 0) and most preferred (score 100) technology; other technologies were scored relative to these two (e.g., scores of 20, 50, and 90). Qualitative rationales are provided for the quantitative TNAssess score for each technology in each of the three impact categories.

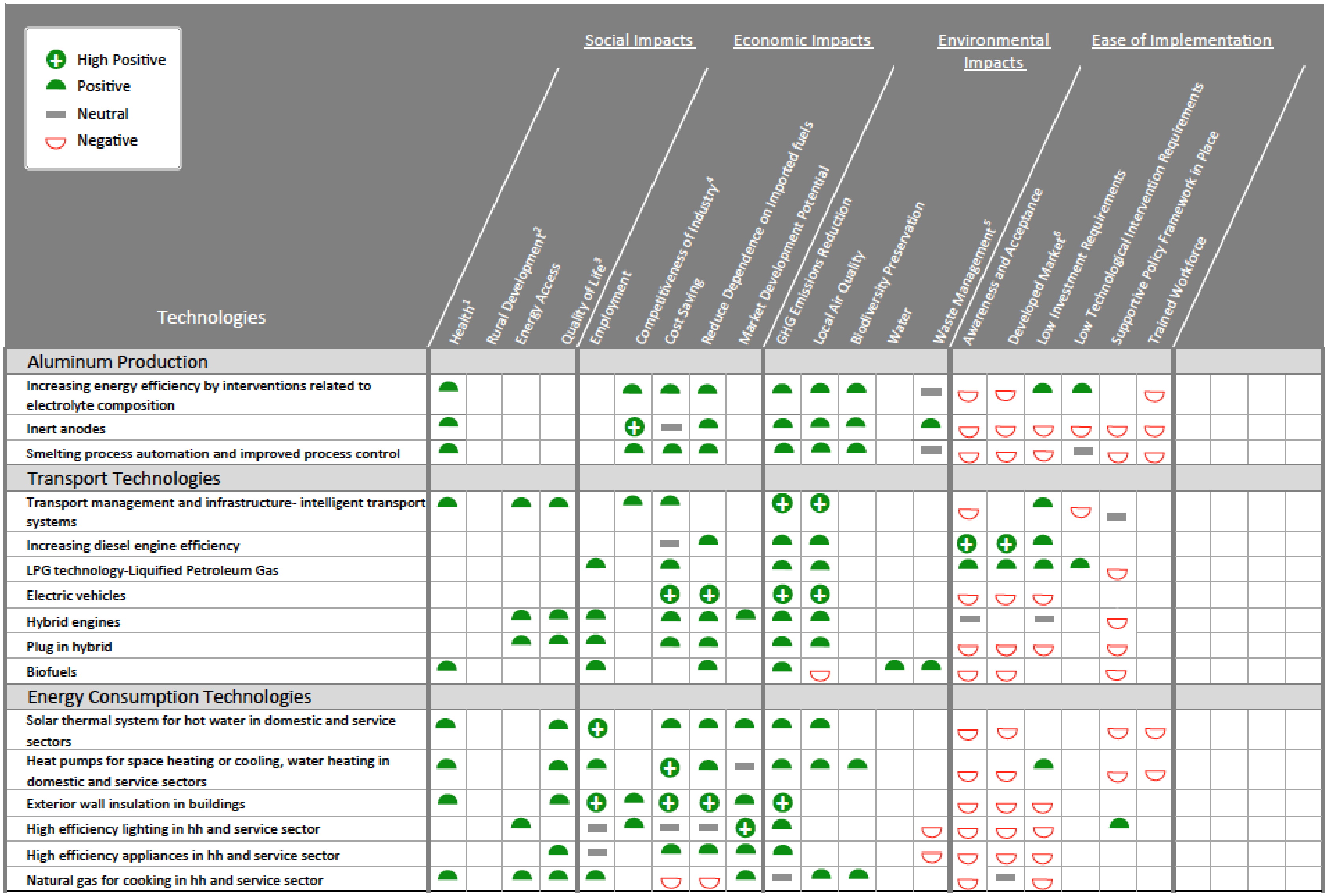
Since the analysis team populated the DIA visual tool independently from the TNA process and the results have not been formally shared, a next step is to gain feedback from Montenegrin stakeholders to determine the usefulness of the DIA visual tool in informing decision-making. The DIA visual tool used only data provided by the stakeholders through the TNA process. As noted in Cowlin et al. (2012), “Because the data reflect responses to open-ended questions, the benefits are not necessarily established through a consistent framework. Nevertheless, this study does not attempt to extrapolate responses in one technology to another.”

Results

The process described above produced a DIA visual tool (see Figure 4) that highlights the impacts of 26 technologies on 20 indicators, including four social indicators, five economic indicators, five environmental indicators, and six ease-of-implementation indicators. Impacts were identified using the four-point scoring system (“highly positive,” “positive,” “neutral,” or “negative”). The process of populating the DIA visual tool relied on the TNA documentation, which provided concise qualitative summaries of the stakeholder-driven technology evaluation within the broad categories of social, environmental, and economic impacts. References to each specific indicator within these categories varied within the qualitative documentation; e.g., three technologies referenced rural development and 22 referenced reducing dependence on imported fuels.[14] All broad impact categories include neutral and negative impacts for certain technologies.

---

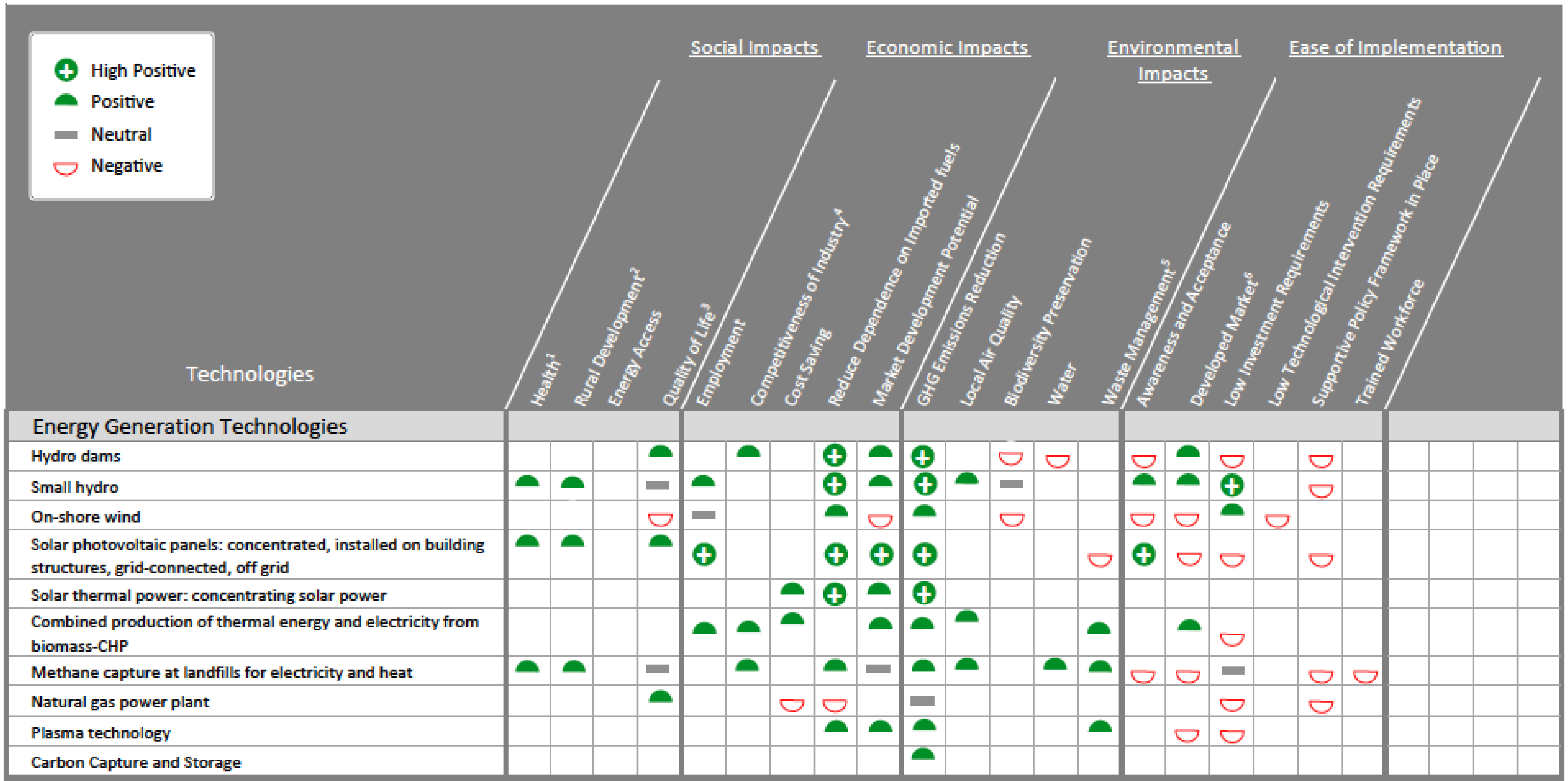
[14] Although the TNA summary documentation does not necessarily capture all indicators within the broad economic, environmental, and social categories for all technologies, the TNA process in Montenegro did facilitate the evaluation of specific indicators. Stakeholders initially identified several impacts related to national priorities, and these were grouped under economic, social, and environmental impacts. During the technology assessment, all possible impacts were revisited as an introduction to the workshop sessions, and each stakeholder had a printed list of impacts that he or she could use when assessing the technology options.



- ⊕ High Positive
- ◓ Positive
- ▬ Neutral
- ◡ Negative

Technologies	Social Impacts				Economic Impacts					Environmental Impacts					Ease of Implementation									
	Health[1]	Rural Development[2]	Energy Access	Quality of Life[3]	Employment	Competitiveness of Industry[4]	Cost Saving	Reduce Dependence on Imported fuels	Market Development Potential	GHG Emissions Reduction	Local Air Quality	Biodiversity Preservation	Water	Waste Management[5]	Awareness and Acceptance	Developed Market[6]	Low Investment Requirements	Low Technological Intervention Requirements	Supportive Policy Framework in Place	Trained Workforce				
Aluminum Production																								
Increasing energy efficiency by interventions related to electrolyte composition	◓					◓	◓	◓		◓	◓	◓		▬	◡	◡	◓	◓		◡				
Inert anodes	◓					⊕	▬	◓		◓	◓	◓		◓	◡	◡	◡	◡	◡	◡				
Smelting process automation and improved process control	◓					◓	◓	◓		◓	◓	◓		▬	◡	◡	◡	▬	◡	◡				
Transport Technologies																								
Transport management and infrastructure- intelligent transport systems	◓		◓	◓		◓	◓			⊕	⊕				◡		◓	◡	▬					
Increasing diesel engine efficiency							▬	◓		◓	◓				⊕	⊕	◓							
LPG technology-Liquified Petroleum Gas					◓		◓			◓	◓				◓	◓	◓	◓	◡					
Electric vehicles							⊕	⊕		⊕	⊕				◡	◡	◡							
Hybrid engines			◓	◓	◓		◓	◓	◓	◓	◓				▬		▬		◡					
Plug in hybrid			◓	◓	◓		◓	◓		◓	◓				◡	◡	◡		◡					
Biofuels	◓				◓			◓		◓	◡		◓	◓	◡	◡			◡					
Energy Consumption Technologies																								
Solar thermal system for hot water in domestic and service sectors	◓			◓	⊕		◓	◓	◓	◓	◓				◡	◡			◡	◡				
Heat pumps for space heating or cooling, water heating in domestic and service sectors	◓			◓	◓		⊕	◓	▬	◓	◓	◓			◡	◡	◓		◡	◡				
Exterior wall insulation in buildings	◓			◓	⊕	◓	⊕	⊕	◓	⊕					◡	◡	◡							
High efficiency lighting in hh and service sector			◓		▬	◓	▬	▬	⊕	◓				◡	◡	◡	◡		◓					
High efficiency appliances in hh and service sector				◓	▬		◓	◓	◓	◓				◡	◡	◡	◡							
Natural gas for cooking in hh and service sector	◓		◓	◓	◓		◡	◡	◓	▬	◓	◓			◡	▬	◡							

Figure 4. Pilot Visual for Montenegro based on Technology Sheets for Priority Sectors (continued on following page)



- ⊕ High Positive
- ◓ Positive
- ▬ Neutral
- ◡ Negative

Technologies	Social Impacts				Economic Impacts					Environmental Impacts					Ease of Implementation									
	Health[1]	Rural Development[2]	Energy Access	Quality of Life[3]	Employment	Competitiveness of Industry[4]	Cost Saving	Reduce Dependence on Imported fuels	Market Development Potential	GHG Emissions Reduction	Local Air Quality	Biodiversity Preservation	Water	Waste Management[5]	Awareness and Acceptance	Developed Market[6]	Low Investment Requirements	Low Technological Intervention Requirements	Supportive Policy Framework in Place	Trained Workforce				
Energy Generation Technologies																								
Hydro dams				◓		◓		⊕	◓	⊕		◡	◡		◡	◓	◡		◡					
Small hydro	◓	◓		▬	◓			⊕	◓	⊕	◓	▬			◓	◓	⊕		◡					
On-shore wind				◡	▬			◓	◡	◓		◡			◡	◡	◓	◡						
Solar photovoltaic panels: concentrated, installed on building structures, grid-connected, off grid	◓	◓		◓	⊕			⊕	⊕	⊕				◡	⊕	◡	◡		◡					
Solar thermal power: concentrating solar power							◓	⊕	◓	⊕														
Combined production of thermal energy and electricity from biomass-CHP					◓	◓	◓		◓	◓	◓			◓		◓	◡							
Methane capture at landfills for electricity and heat	◓	◓		▬		◓		◓	▬	◓	◓		◓	◓	◡	◡	▬		◡	◡				
Natural gas power plant				◓			◡	◡		▬							◡		◡					
Plasma technology								◓	◓	◓				◓		◡	◡							
Carbon Capture and Storage										◓														

[1] Health impacts include improved health of local smelter workers in aluminum industry as well as general health improvements from improved air quality.

[2] Rural development impacts include increased distributed generation as well as increased rural employment opportunities

[3] Quality of life impacts include improved travel/transportation experience, reduced noice, increased access to water recreation, and reduced burden resulting from firewood collection.

[4] Competitveness of industry impacts are anticipated in the following sectors: service, manufacturing, transportation, retail, civil engineering, agriculture, forestry/wood processing and tourism.

[5] Waste management impacts include sustainable use of biproducts and traditional benefits associated with waste management.

[6] Developed market characteristics include the existence of a mature private sector, technical institutes and adequate demonstration and acceptance of technology.

Limitations

A key limitation of the Montenegrin pilot project is that the DIA visual tool was not directly tested in a participatory setting with stakeholders. Rather, this pilot project represents a meta-analysis by experts from the National Renewable Energy Laboratory and the Joint Implementation Network using a portion of the information generated by the highly participatory TNA process. Therefore, the information in "people's heads" that was mobilized during the TNA workshops could only be leveraged in the DIA pilot project to the extent that stakeholder insights were recorded in the TNA documentation. The analysis was further limited by possible translation or interpretation errors of this documentation.

Though the TNA and DIA processes are similar, they are not designed to produce identical outputs. Therefore, several limitations arise from using TNA outputs alone to populate the DIA visual tool. The Montenegrin TNA followed the UNFCCC-approved methodology, which defines a process for calculating costs, weighting and scoring technologies against relative scales, and assessing technologies within their own decision context (i.e., a sector or sector category). Due to these methodological considerations, some ideal inputs for populating the DIA visual tool were not available. For instance, the DIA pilot project for Montenegro does not include baseline cost information needed to develop a MAC curve and to order technologies based on cost; nor does it fully consider all economic sectors. These limitations are not a reflection on the quality of the TNA process, but rather highlight the intrinsic differences and subtle incompatibilities between the two impact evaluation methods.

In accordance with the TNA Handbook,[15] TNA stakeholders evaluated a multitude of impacts associated with technology options during the March 2012 workshop but grouped their impact criteria under three broad headings: economic, environmental, and social impacts. Specific impacts within these broad categories (e.g., job creation, market development potential, or air quality) are inconsistently referenced among the technologies evaluated in the TNA summary documents. Thus, these impacts could not be systematically compared across all technologies using only the TNA documentation as an input to the DIA visual tool. This limits the ability of the DIA visual tool to convey holistically the tradeoffs of potential development technologies (1).

A final limitation of the Montenegrin pilot project is that because both the TNA and DIA visual tool reflect stakeholder judgment on the impacts associated with full penetration of selected technology options, the impact statements are highly qualitative.

Observations and Lessons Learned

The Montenegrin piloting of the DIA visual tool demonstrated several advantages of the tool and highlighted opportunities for improving the framework.

The DIA visual tool complements other planning processes, such as TNAs. Despite its limitations, the DIA visual tool could accommodate many of the highly qualitative outputs of Montenegro's TNA process, allowing stakeholder knowledge to be captured and visualized in a

---

[15] The handbook is available at http://www.undp.org/content/undp/en/home/librarypage/environment-energy/low_emission_climateresilientdevelopment/technology_needsassessmenthandbook/.

single graphic. In general, the TNA documentation (both qualitative and quantitative) provided useful inputs to create a DIA visual tool, and the two methods for assessing impacts associated with technology options provide complementary outputs. For instance, while the TNA scores and ranks technology options relative to one another, the DIA visual tool provides a framework for absolute scoring; i.e., the DIA visual tool has the capability to evaluate the impact of one technology independently of the other technologies under consideration and to describe impacts relative to a baseline. This functionality allows the DIA visual tool to clearly identify neutral and negative benefits. In a TNA, clearly differentiating negative and neutral impacts is less straightforward, because the main output of the TNA process is a ranking of technologies to support prioritization. Negative or less positive qualifications are implicit in the analysis and are not explicitly detailed.[16]

The DIA visual tool provides a flexible framework for defining priority development impacts and comparing technologies within (and potentially across) sectors. For Montenegro, the DIA visual tool produced a visual capable of communicating numerous impacts associated with technologies spanning multiple economic sectors, laying the foundation for prioritization of technologies in a LEDS. A potential strength of the DIA visual tool is its ability to compare impacts across sectors of the economy. In the Montenegrin case, because the sector-oriented TNA was used as the sole input into the DIA visual tool, such absolute economy-wide scoring was not fully realized. For instance, electric vehicles (a transport technology) and exterior wall insulation in buildings (an energy conservation technology) were identified in the DIA visual tool as having the same impact ("highly positive") on reducing dependence of imported fuels because each technology received the highest TNA scores within its respective sector in this area. However, the TNA documentation does not provide enough information to determine whether full penetration of each of these two technologies would result in comparable quantitative reductions in imported fuels, because technologies from different sectors are not directly compared in the TNA. Thus, the DIA visual tool's effectiveness in comparing and communicating impacts across sectors is a topic for future exploration and testing.

Stakeholder input is needed to prioritize low emission development options using the DIA visual tool. The TNA process in Montenegro systematically enabled the prioritization of technologies within target mitigation sectors using weighting and ranking to score various technology options. Ultimately, one objective of the DIA visual tool is to facilitate prioritization of options in a LEDS based on their contributions to national development goals. The Montenegrin pilot project produced a populated DIA visual tool showing a variety impacts and tradeoffs between low emission technologies. This multidimensional illustration could complement the TNA's single weighted, quantitative score for each technology. Stakeholders could conceivably use the DIA visual tool to "unpack" impacts and sort technologies according to which impacts are most important to them, or, alternatively, to prioritize those technologies that have the most positive impacts across all indicators. Additional stakeholder input and vetting is needed to determine how the DIA visual tool would be used in such a case to prioritize

---

[16] In the TNA method, the difference between least preferred options with negative impacts and those with positive scores becomes clear during the weighting process; e.g., if one technology has a negative impact on the environment, this criterion can be given a higher weight. For additional information on the TNA method and example outputs from the TNAssess tool, see the TNA Handbook, http://tech-action.org/Guidebooks/TNA_Handbook_Nov2010.pdf.

technology options. This input would allow stakeholders to compare technology prioritization resulting from use of the TNA and DIA visual tools and provide additional insights on the complementarity of the two methods.

Stronger development and documentation of causal foundations need to underlie impact statements. The Montenegrin pilot project also highlighted the need for stronger causal chains—and, where feasible, quantitative analysis—to support a higher degree of confidence in making claims about development impacts, particularly with respect to communicating nuance in the level of the impact (e.g., “highly positive” versus “positive”) (1).

Similarly, impact statements would also benefit from a clear and consistent definition of *who* experiences the impact; for example, during the March 2012 workshop, stakeholders identified “lower car maintenance costs due to lower use” as a potential benefit of encouraging bike path infrastructure. This benefit clearly refers to cost savings at the individual level but does not necessarily indicate the financial impact across the economy as a whole, which might be positive, neutral, or negative depending on the costs of implementing bike-friendly infrastructure. The clarity of the DIA visual tool might be improved if its “perspective” (e.g., individual citizen, economy, government) were consistently and transparently defined across all impact categories, or if the visual were modified to illustrate impacts on multiple stakeholder groups.

More nuanced impact descriptors are needed. Though the four-point scoring system (i.e., “highly positive,” “positive,” “neutral,” and “negative”) used in the Montenegrin pilot project provides a relatively simple scoring framework, it allows little nuance in expressing, for instance, the timeframe or scale over which a technology would be deployed. In the TNA, technology options are classified as short/medium/long term and small/medium/large scale and are grouped according to these classifications. Adding these types of temporal or spatial dimensions to the DIA visual tool could facilitate communication of technology aspects that are not well described by the positive/neutral/negative framework. Similarly, an “unknown” indicator might also be useful to communicate uncertainty associated with particular options and impacts; for instance, Montenegrin stakeholders identified “unstable price development” as an issue associated with using natural gas for cooking in households and service sector, as future natural gas prices could have either a positive or negative impact on the outlook for this technology. Uncertainty itself might be viewed as a negative attribute. Stakeholder input should determine how uncertainty is treated within the DIA visual tool.

Sensitivity analysis is needed to supplement the impact evaluation. The DIA visual tool does not currently support sensitivity analyses or weighting of priority impacts, which may help to address and communicate uncertainties (9). Since the DIA visual tool is intended to provide a holistic multidimensional visualization of multiple impacts and technologies, sensitivity analysis and criteria weighting may best be performed externally to the DIA visual tool (e.g., through a process such as the TNA). These analyses could complement the DIA visual tool and assist stakeholders in understanding and prioritizing low emission development options based on development impacts.

Key Findings

The Kenyan and Montenegrin pilot projects highlight several common insights and lessons on adapting the DIA visual tool to a country-specific context:

- ***The DIA visual tool provides a flexible framework for supporting and enhancing other LEDS or development planning processes and tools.*** The DIA visual tool can be adapted to present impacts of LEDS options identified through different processes to support low emission development planning. In the Kenyan pilot project, the DIA visual tool was integrated into the NCCAP development process and served as the primary communication tool to summarize development impacts of various options under consideration. In the Montenegrin pilot project, the tool was used to support a meta-analysis of existing TNA products and provided an alternative lens through which to view and interpret the results. The technologies, impacts, and scoring systems were defined differently in each of the pilot projects to reflect each country's approach to evaluating technology options for its LEDS. A highly flexible tool that can be adapted to various country circumstances and specific stakeholder input is required for these types of assessments.
- ***A particular value of the DIA visual tool is its ability to leverage qualitative impact assessments and data.*** Qualitative rather than quantitative assessments of technology options were used to pilot the DIA visual tool in both countries. Data constraints are often an issue in developing countries, and it is useful to have a tool that can be applied under these conditions. To ensure robust qualitative assessments, it is important to present specific causal chains for development impacts of technology options.
- ***Stakeholder engagement is essential to making the DIA visual tool useful for decision support.*** A key difference between the two pilot projects described in this report is that the Kenyan pilot project was conducted with stakeholders whereas the Montenegrin pilot project was based on an expert analysis of select products of the TNA process and has not yet been vetted with stakeholders. Though the DIA visual tool provided a complementary means of visualizing information generated through the TNA and leverages the outputs of the participatory process, the lack of direct stakeholder engagement in the Montenegrin pilot project limited the analysis. Further stakeholder input could inform the consistent definition and evaluation of specific impacts across all technology options, verify priority development indicators, provide additional insights on the strengths and weaknesses of the tool, and identify which impacts are critical decision drivers and that may require additional study.
- ***Further study is needed to determine how best to exploit the complementarity of the DIA visual tool with quantitative impact assessment methods***. Because neither the Montenegrin nor the Kenyan pilot projects of the DIA visual tool relied on quantitative impact assessments, further study is needed to determine the tool's strengths and weaknesses in leveraging quantitative assessment methods and tools. Presumably, the DIA visual tool could provide a useful framework for compiling and communicating available quantitative data and assessments (possibly alongside qualitative assessments) to inform decision-making. Moreover, the DIA visual tool could be used to identify development options and/or impacts for which additional in-depth analysis (quantitative or qualitative) would be valuable. This particular application was not explicitly included in the Kenya or Montenegro projects and needs further exploration.

- ***A MAC curve is not a prerequisite to populating the DIA visual tool.*** The MAC curve from the original visual framework was removed in both pilot projects. Yet, the DIA assessment in Kenya and the TNA in Montenegro incorporated technology cost in ways that resonated with stakeholders in each country. A portable tool is needed that can be applied in countries with or without MAC curves. Further, as noted for the Kenya pilot, in some cases, the MAC curve may even be a hurdle to adoption if stakeholders are not familiar with this type of analysis. Using the DIA visual tool's tabular format to compare technologies may be simpler.
- ***The adaptability of the DIA visual tool to support sector-specific decision-making may make it useful to line ministries (as well as cross-sectoral bodies) for LEDS planning.*** While designed to compare and communicate absolute impacts of various technologies across multiple sectors of an economy, the DIA visual tool can also be adapted to compare LEDS actions within certain sectors of interest. In both pilot projects, the visual was populated based on technology comparisons within key sectors rather than an economy-wide assessment of impacts. The consistent application of the tool to compare impacts at the sector or sub-sector level reflects each country's sector-specific approach to identifying low emission development options and to prioritizing these options within a sector-specific context. Indeed, in the Kenyan pilot project, the analysis team found that the DIA visual tool improved its specificity and appeal when it was designed to compare impacts within rather than across sectors, because several development priorities were sector-specific. In practice, LEDS-related decision-making often takes place at a sector level, with line ministries and other sector-level governance bodies determining the set of policies, programs, and technologies within their sector that will best contribute to developing a LEDS or realizing a GHG emission reduction target. The DIA visual tool's ability to facilitate prioritization of technology options within key sectors may support this type of planning and complement existing decision-making processes.
- ***Additional inputs are needed to use the DIA visual tool to compare technology options across economic sectors.*** Although decisions between specific low-carbon development options are often undertaken on a sectoral level, some development priorities (e.g., economic growth, employment, improved quality of life) cut across sectors. An economy-wide analysis of development impacts and low emission technologies could potentially improve both the cost-effectiveness and the "development-effectiveness" of a LEDS relative to a sector-specific approach. Such economy-wide analysis could also be used as a means to bring together diverse stakeholders and to break down traditionally siloed line ministries to build support for mutually beneficial LEDS options. The ability of the DIA visual tool to serve as a framework for comparing impacts across different sectors could potentially be improved by defining a baseline or business-as-usual scenario for each impact. Without such a baseline, neither the Montenegrin nor Kenyan adaptation of the DIA visual tool could produce a robust, absolute comparison of options across economic sectors.
- ***Further study is needed on effective ways to present and communicate the results of the DIA analysis to decision makers.*** To fully understand the strengths and limitations of the DIA visual tool in communicating development impacts of technologies and informing the development of a country-owned LEDS, it should be shared with stakeholders to determine how well the framework helps inform their decision-making processes. Further, the visual appeal and usability of the DIA visual tool should be further tested

with stakeholders. Different versions of the DIA visual tool may be appropriate for different audiences.

- ***Guidance on the application of the DIA visual tool may help to inform future efforts.*** Lessons learned from the pilot projects in Kenya and Montenegro could lay the foundation for developing general step-by-step guidance to users on designing and applying the DIA visual tool to support LEDS-related decision making. Such guidance would provide a structured approach to inform future applications of the tool.

Table 2 summarizes the results of the application of the DIA visual tool in Kenya and Montenegro.

Table 2. Comparison of Kenyan and Montenegrin Pilot Projects of the Development Impact Assessment Tool

	Kenya	**Montenegro**
Completion of DIA visual tool	International and Kenyan experts	International experts (National Renewable Energy Laboratory and Joint Implementation Network)
Inputs		
MAC curve used?	No[a]	No
Selection of technologies or actions	Low-carbon scenario assessment for NCCAP	TNA stakeholder workshops
Definition of impact categories	Expert team, validated with stakeholders	TNA fact sheets
Determination of technology-specific impacts	Expert team judgment, validated with stakeholders	TNAssess tool and stakeholder workshop documentation
Impact scoring system	Five-point system: • "Highly positive" • "Positive" • "Neutral/minor impact" • "Negative" • "Uncertain"	Four-point system: • "Highly positive" • "Positive" • "Neutral" • "Negative"
Impact categories	• Climate • Sustainable development	• Social • Economic • Environmental • Ease of implementation
Number of impacts assessed	Varies per sector, e.g., 8 for energy generation and agriculture (3 for climate; 5 for sustainable development)	Total of 20 • Four social impacts • Five economic impacts • Five environmental impacts • Six ease-of-implementation impacts
Sector-specific or economy-wide comparisons?	Sector-specific	Sector-specific
Sectors evaluated	• Agriculture • Electricity generation • Energy demand • Forestry • Industrial processes • Transport	• Aluminum production • Energy consumption • Energy generation • Transport
Vetted with stakeholders?	Yes	No

[a] Marginal abatement cost data points were summarized where available.

Conclusion and Next Steps

National development goals are the backbone of LEDS and related planning processes. The DIA visual tool seeks to raise the visibility of contributions of low emission development measures to development goals and facilitate a systematic incorporation of those impacts into planning. In Kenya and Montenegro, pilot experiences demonstrated the ability of the tool to complement and leverage other LEDS planning processes (such as the TNA process) or tools (such as a MAC curve). The DIA visual tool provides a flexible and portable framework to summarize and display both positive and negative impacts associated with low emission development options and is particularly effective in capturing the results of qualitative impact assessment methods. Notable limitations include a lack of robust causal chains to provide evidence for impacts, a need for greater quantitative specificity when assigning the level and scale of impact of measures, the need for further integration of the tool into planning processes and enhanced communication of results to key decision makers, and, if necessary, a need for improvements to ensure impacts can be assessed across the whole economy. To leverage the strengths of the tool and address the limitations, the LEDS Global Partnership will pursue these activities:

- **Tool improvements**: Based on findings from this report, members of the LEDS Global Partnership will improve the DIA visual tool. A compendium of development impact causal chains will be developed to improve robustness of the tool for both qualitative and quantitative applications. Additionally, the LEDS GP members will consider developing standard, suggested definitions for often-used impact categories (e.g., GDP impact and GHG emissions reduction) to support consistency in future DIA visual tool use. LEDS GP members will continue to present the tool at forums where further feedback can be received. Based on this feedback and lessons learned from these and future pilot efforts, the LEDS GP members will also consider developing general guidance on adapting and applying the DIA visual tool.
- **Broadening the application of the DIA visual tool through additional pilot projects and support efforts**: LEDS GP partners plan to pilot the tool in two additional countries in 2013. Lessons learned from these upcoming pilot projects will be tracked. LEDS GP partners will actively seek to encourage and provide technical support to existing international programs (e.g., the U.S. Enhancing Capacity for LEDS initiative, the United Nations Development Programme, the TNA program, and the German Agency for International Cooperation) to use the tool in their country support programs. The tool will also be made publicly available via the LEDS GP website.[17]
- **Inventorying development impact assessment tools, data sources, and methods**: To catalogue potential inputs to the DIA visual tool and develop a more comprehensive toolkit on benefit assessment, the LEDS GP Development Impacts Assessment Working Group[18] is compiling an inventory of resources for evaluating the economic, social, and environmental impacts of low emission development options on a country's development goals. This includes quantitative and quantitative tools, and both cross-sectoral and sector-specific tools, data, and methods. The inventory will reflect data requirements and

---

[17] ledsgp.org

[18] For more information on the working group, see ledsgp.org/analysis/impacts.

ease of use to help identify tools and approaches most appropriate in a specific country's context.

- **Regional peer learning**: The LEDS GP supports regional platforms in Africa, Asia, and Latin America. Development impact assessment for low emission planning is of great interest in each of these regions, and the LEDS-GP will support regional peer-to-peer consultation on analyzing development impacts and on developing a community of practice to strengthen participants' analysis and facilitate decision-making to achieve LEDS objectives.

References

(1) Cowlin, S.; Cochran, J.; Cox, S.; Davidson, C.; van der Gaast, W. (2012). "WREF 2012: Broadening the Appeal of Marginal Abatement Cost Curves: Capturing Both Carbon Mitigation and Development Benefits of Clean Energy Technologies." NREL/CP-6A20-54487.Golden, CO: National Renewable Energy Laboratory.

(2) IISD & ECN. (2012). *Kenya's Climate Change Action Plan: Mitigation - Chapter 1: Introduction*. Kenya Climate Change Action Plan, http://www.kccap.info/index.php?option=com_phocadownload&view=category&id=29&Itemid=41.

(3) Kenya Vision 2030. (2011). http://www.vision2030.go.ke/.

(4) Cameron, L.; Würtenberger, L.; Stiebert, S. (2012). "Mitigation Chapter 5: Electricity Generation." Supporting research developed by the International Institute for Sustainable Development (IISD) and Energy research Centre of the Netherlands (ECN) for Government of Kenya. *National Climate Change Action Plan*. Nairobi: Ministry of Environment and Mineral Resources.

(5) Stiebert, S.; Murphy, D.; Dion, J.; McFatridge, S. (2012). "Mitigation Chapter 3: Agriculture." Supporting research developed by the International Institute for Sustainable Development (IISD) and Energy Research Centre of the Netherlands (ECN) for Government of Kenya. *National Climate Change Action Plan*. Nairobi: Ministry of Environment and Mineral Resources.

(6) International Renewable Energy Agency (IRENA). (2011). IRENA *Working Paper: Renewable Energy Jobs: Status, Prospects & Policies.*

(7) IISD, ECN, and ASB Partnership for the Tropical Forest Margins. (2012). "Mitigation: Executive Summary" *National Climate Change Action Plan*. Nairobi: Government of Republic of Kenya. Pages 11-12. http://www.kccap.info/index.php?option=com_phocadownload&view=category&id=36.

(8) Markovic, M.; van der Gaast, W. (2012). "Montenegro Prioritises Technologies for Climate and Development." *Joint Implementation Quarterly*18(1); pp. 3-7.

(9) van der Gaast, W. (2012). "Pilot of visual tool and links with TNA in Montenegro." Presented at Webinar on Development Impact Assessment for Low Emissions Development, http://en.openei.org/w/index.php?title=File:DIAPilot_Montenegro.pdf&page=1.