The Economic, Social and Environmental Impacts of Greening the Industrial Sector in Cambodia

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The views expressed in this report are those of the authors alone.

FOREWORD

NCSD's Strategic Plan 2018-2023 identifies as one of the country's 'green economy' priorities to promote sustainability in consumption and production of goods and services, thereby protecting the environment and social well-being while increasing business competitiveness and promoting innovation.

Guided by its strategic plan 2018-2023, the General Secretariat of the NCSD worked with the Global Green Growth Institute (GGGI) to undertake extensive analysis to understand how we can make the Cambodian industries more competitive, and more sustainable at the same time.

In industrial manufacturing, we often observe an inefficient use of resources such as energy, water, and material - due to old equipment and sub-optimal production processes. This leads to unnecessary production costs for businesses, but also contributes to depletion of valuable natural resources. Increasing industrial pollution and waste pose an environmental and public health risk.

However, this can be managed. A country such as Cambodia needs to promote its industrial growth to create jobs and increase the people's income. The economic modelling presented in this report demonstrates that Cambodia can grow, and grow more, by opting for a green industrial growth that is sustainable in the long term. The analysis shows that Cambodian manufacturers can increase productivity up to 80% by introducing more energy efficient and resource efficient technologies and processes. We estimate that the introduction of resource efficient technology in garment, electronics, bricks and food processing can create more than 500 000 additional jobs. This means income creation for Cambodian households. On top of that, the economic growth generated can bring in more tax revenue for the government – which can be invested in important social sectors such as health, education and environmental protection We estimate that the adoption of more sustainable production processes in these industrial sectors in Cambodia can reduce 3.37 million tons, of greenhouse gas emissions - with 17% reduction in the garment sector and a 30% reduction in electronics. This would be a significant step forward for achieving Cambodia's international commitment to mitigate climate change under the 2015 "Paris Agreement". A decrease in pollution has a positive impact on public health and well-being, but also on other economic sectors such as tourism potential.

The finding of this analysis can serve as a basis for the Government to make the shifting happen by realizing the promotion of skill development, introduction of energy management protocols or energy efficiency standards, just to name a few examples of the measures which can incentive the switch to green manufacturing.

Phnom Penh, 23. June 2021

Chair of the National Council for Sustainable Development

Minister of Environment

SAY SAMAL

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List of acronyms

BAU	Business as Usual
Bn	Billion
BOD	Biological Oxygen Demand
BTU	British Thermal Unit
CBA	Cost Benefit Analysis
CCAP	Climate Change Action Plan
CCCA	Cambodia Climate Change Alliance program
CCCSP	Cambodia Climate Change Strategic Plan
CO^2 eq	CO^2 equivalent
CTLF	Clothing, Textile, Leather, and Footwear
E&E	Electronics and Electrics
EE	Energy Efficiency
EE-FS	Energy Efficiency and Fuel Switching
EX	Export
GDP	Gross Domestic Product
Gg	Giga gram
GHG	Greenhouse Gas Emissions
GI	Green Industry
GJ	Giga Joule
GOC	Government of Cambodia
INDC	Intended Nationally Determined Contributions
kW	kilowatt
KTOE	Kilo Ton of Oil Equivalent
kWh	kilowatt hour
LI	Labor Intensity
ME	Material Efficiency
MWh	Megawatt hour
MJ	Mega Joule
Mn	Million
NAMA	Nationally Appropriate Mitigation Actions
NCSD	National Council for Sustainable Development
NEEP	National Energy Efficiency Policy 2018-2035
NSDP	National Strategic Development Plan
O&M	Operation and Maintenance
PM10	Particulate matter of size less than 10 microns
RE	Renewable Energy
SCC	Social Cost of Carbon
SD	System Dynamics
SDGs	Sustainable Development Goals
SEC	Specific Energy Consumption
SMEs	Small and Medium Enterprises
TJ	Tera Joule
TOE	Ton of Oil Equivalent
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
TWh	Terawatt hour
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollars
WE	Water Efficiency
WWT	Wastewater Treatment

1. Executive summary

1.1 Introduction and methodological approach

The Cambodian economy has undergone profound structural change over the recent decades. The services sector has been the largest contributor to economic growth since the late 1990s, surpassing traditional sectors such as agriculture, fisheries, and forestry. The industry sector, with its growing contribution to Gross Domestic Product (GDP) (from 17% in 1998 to 29% in 2016), has also played a key role in supporting economic growth, employment creation, and poverty reduction.

As indicated in the Cambodia Industrial Development Policy 2015-2025, the industrial sector is at a crossroads. The largest manufacturing subsectors have reached maturity; to maintain sector expansion, new ways must be found to access new and more premium markets. The policy aim is to develop new "creative and highly competitive [sectors] that focus[es] not only on consumer products but also production equipment."

Achieving economic diversification and sector expansion will require significant investments. Channeling investments with effective public policy to technologies that achieve both productive improvements and reduced social and environment impacts will ensure that full and sustainable economic benefits can be realized. Pollution is a significant inhibitor to economic growth for a multitude of reasons including the reduction of labor productivity due to negative health impacts and other societal costs.

This study provides evidence on the economics and social benefits of greening the industrial sector of Cambodia. It looks at benefits at both the firm-level and economy-wide gains. It aims to inform the development of green growth priorities in the next phase (2019-2023) of Cambodia' national policy and investment plan, National Strategic Development Plan (NSDP).

Specifically, this report provides a green growth transition assessment based on a robust economic analysis. This is achieved through a quantitative study, making use of integrated modeling and scenario analysis. This includes an assessment of the required investment for resource efficiency improvements and adopting sustainable energy sources, and the resulting avoided costs and added benefits.

The report focuses on four industrial subsectors. Their selection was based on the following criteria: (a) national economic significance such as share of GDP and employment, (b) reliance on natural resources and climate vulnerability, and (c) a qualitative assessment of future competitiveness (informed by stakeholder input). The four subsectors selected are:

- **Food processing** (as part of the Food, Beverages, and Tobacco sector included in GDP statistics, specifically Section C-Manufacturing, Division 10-Manufacturing of Food Products, of the Cambodia Standard Industrial Classification, excluding tobacco products).

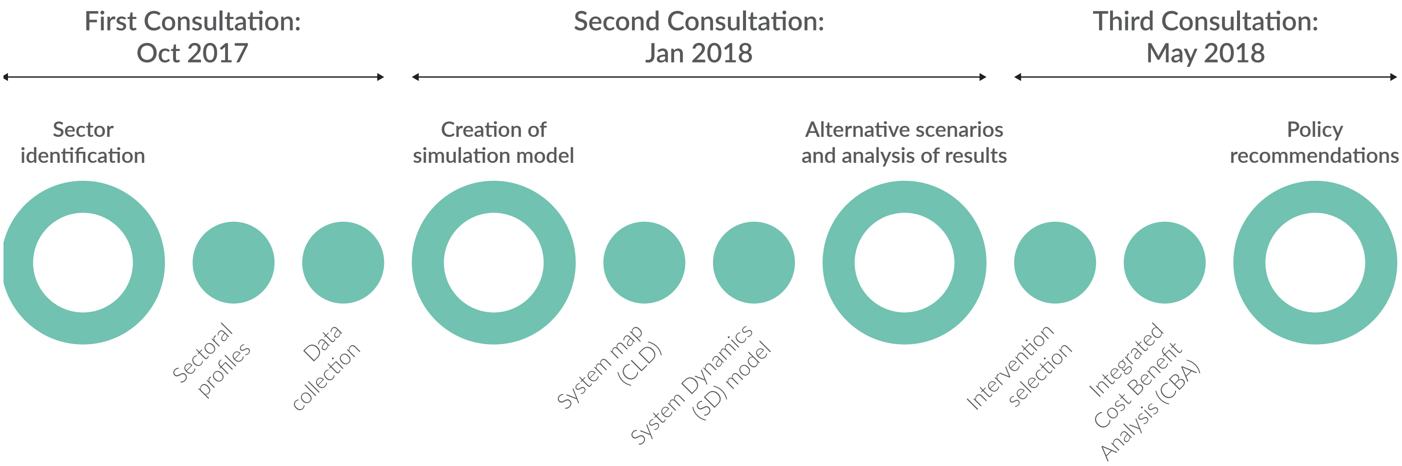
- **Construction** (with a focus on bricks production, specifically Section C, Division 23, Manufacturing of Non-Metallic Mineral Products of the Cambodia Standard Industrial Classification).

- **Garments manufacturing** (as part of the Textile, Wearing Apparel, and Footwear sector included in GDP statistics. Specifically, we include Section C, Division 13, Group 131 to 143 of the Cambodia Standard Industrial Classification for resource consumption, and Group 142-Footwear for the estimation of GDP and employment).

- **Electronics manufacturing** (specifically Section C, Division 25, Group 259 to 265, e.g. Manufacture of Consumer Electronics, Manufacture of Electronics Components, Computers, and Peripheral Equipment, and 271-Manufacture of Electrical Equipment of the Cambodia Standard Industrial Classification).

Research consisted of four phases: (i) subsector identification, (ii) development of a simulation model, (iii) simulation of baseline and alternative scenarios and the results analysis, and (iv) the formulation of policy recommendations. These main phases are presented in Figure 1.

Figure 1: Approach for the formulation of policy recommendations.



Three national consultative workshops were held to facilitate the study, including the collection and verification of data, the selection of subsectors and indicators, the formulation of scenarios, and the validation of the baseline and Green Industry (GI) scenarios. These consultations took place in January, May, and October 2018. Additional bilateral exchanges with relevant line ministries as well as national and international experts were conducted to focus on the analysis and complement data gaps throughout the study.

1.2 What is the Green Industry (GI) Scenario?

A GI scenario is a simulation created to quantify the likely outcomes of green growth investments on various performance indicators (e.g., material, labor, energy, and water cost of production, as well as profitability and generation of waste and emissions) for the four subsectors analyzed, when compared to the Business as Usual (BAU) case. Several scenarios were simulated to assess the potential contribution (to economic growth, employment creation, and emissions and water pollution reduction) of a green industrial transition for the four subsectors analyzed. These scenarios include intervention areas and targets (see Table 1). They were identified and defined with the support of local stakeholders, involving the private sector, government representatives, academia, and civil society.

A review of a subset of performance indicators of the subsectors, such as revenues and costs of firms, was used as a starting point to identify intervention areas and targets:

- On revenues, emphasis is put on increasing the **export potential (EX**), possibly connected to access to new markets that offer a premium price.
- On costs, scenarios are tested for the possibility to reduce the cost of labor, energy (also through fuel switching, **EE-FS), water**, and **materials**. Emphasis was put on additional indicators of performance, beyond revenues and costs, to measure the social and environmental impacts of production, with scenarios assessing the outcomes of reducing **water pollution** and increasing the use of **renewable energy (RE)**.

The abovementioned intervention areas were tested in isolation (i.e., creating a simulation, and hence a scenario, for each intervention and associated target) and simultaneously. **The GI scenario assumes that targets are achieved simultaneously**. We first estimate total costs and benefits of reaching a given target, then we elaborate on what policy interventions could be used to equitably share the costs and benefits across economic actors.

Table 1: Overview of intervention areas and assumed targets/values in the GI scenario

Intervention Area	Assumed Target	Scenario Abbreviation
Production for export	Garments: 5% increase per year, until 2025 Bricks: no change Food processing: 2.5% increase per year, until 2025 Electronics: 5% increase per year, until 2025	EX
Labor efficiency	3% improvement per year between 2020 and 2025	LI
Energy efficiency	20% above BAU by 2025	EE
Water efficiency	30% above BAU by 2025	WE
Material efficiency[1]	20% above BAU by 2025	ME
Wastewater treatment	Reaching 100% by 2025 (20% more than BAU by 2025)	WWT
Renewable energy	15% of total electricity consumption by 2025	RE
All of the above	All of the above	GI

1.3 There is an economic/business case for GI scenario vs BAU

The study concludes that achieving GI targets leads to positive social, economic, and environmental outcomes. Results of the scenario simulations show that:

- The GI scenario is **worth investing in** because it generates positive financial returns for firms and for society, resulting in economy-wide benefits.

- The GI scenario **reduces costs** by lowering consumption of production inputs (e.g., materials, energy, and water) and mitigating the negative environmental impacts of production. In this regard, the GI scenario shows reduced societal costs, i.e. public expenditure and costs for households relating to water and air pollution and resulting health impacts.

- The GI scenario **generates new opportunities**. Emerging sectors are poised to grow, and will do so with higher profit margins and a smaller environmental footprint.

- **Effective policy interventions are needed to promote or incentivize the achievement of a GI scenario**, but effective options are available (**i incentives and mandates**) to maximize the performance of all economic actors.

1.3.1 Economic returns are attractive, and growth is decoupled from environmental impacts

Economy-wide perspective

The GI scenarios are projected to generate an increase in real GDP (base year 2015) of Riel 10,860Bn (United States Dollars 2.715 Bn) over the baseline in 2030. This is an improvement of 46% for garments, 14.7% for bricks, 33% for food processing, and 35.5% for electronics.

Employment also increases over time in the GI scenario, with net job creation projected to reach 512,000 additional jobs in 2030 compared to 2020.[2]

[1] *No material efficiency improvements are assumed for the bricks sector in this analysis.*
[2] *Employment in the model is estimated by multiplying production by labor intensity for each subsector.*

Figure 2: GI scenario outcomes for GDP and GHG emissions, year 2030, % relative to the BAU scenario

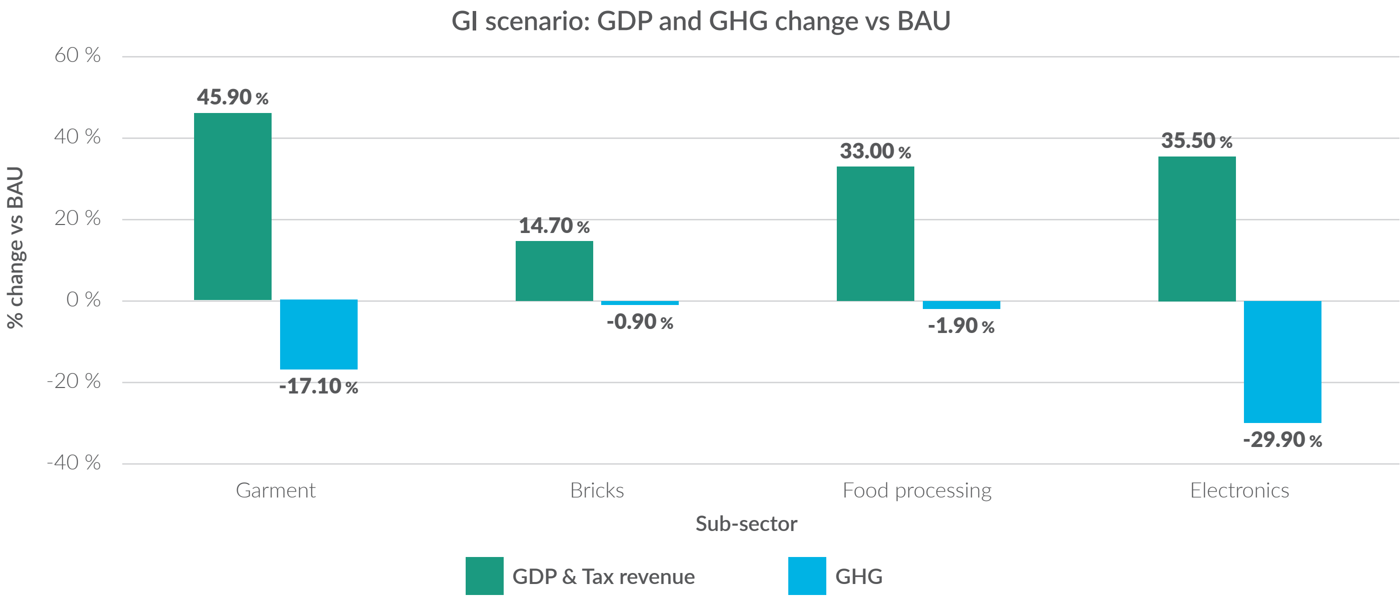
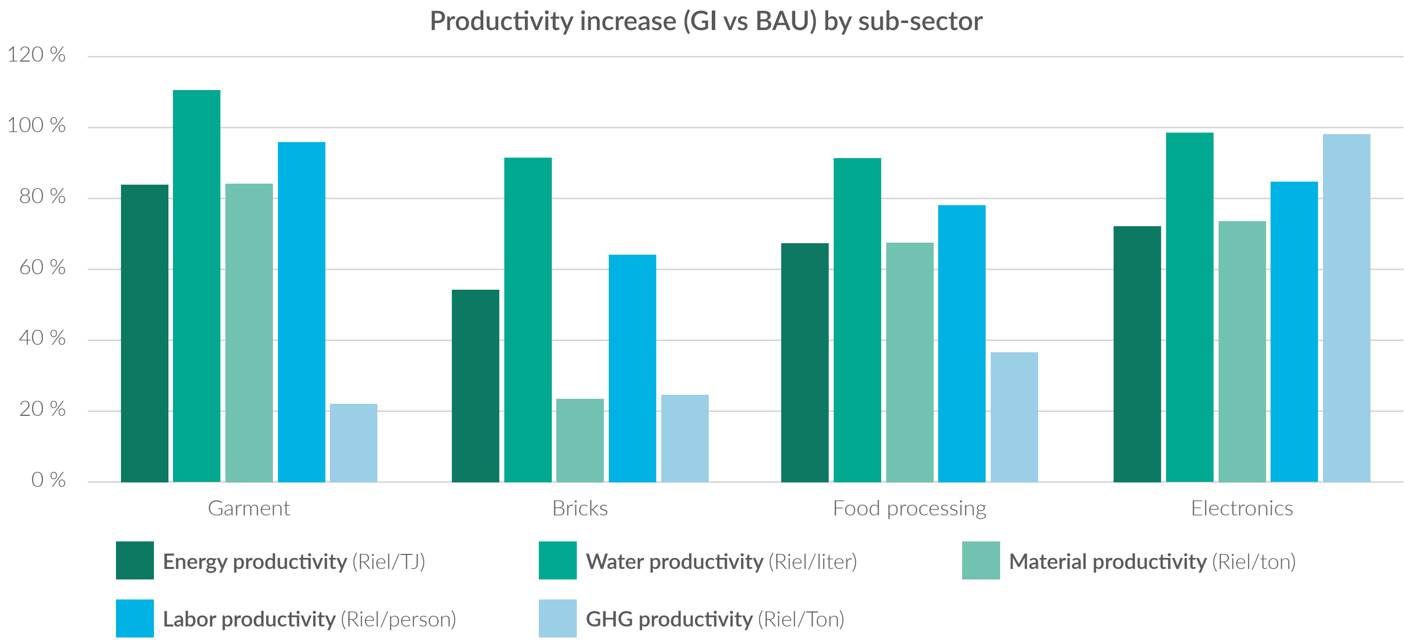


Figure 3: GI scenario outcomes on productivity, year 2030, % relative to the BAU scenario.



Finally, total Greenhouse Gas (GHG emissions) are projected to be 3.37 million tons and 6.59 million tons lower than the baseline values in the year 2030 and 2040, respectively. This is a reduction of 17.1% for garments, 0.9% for bricks, 1.9% for food processing, and 29.9% for electronics in the year 2030.

With lower resource consumption, leading to reduced costs and higher GDP, productivity[3] increases for all subsectors in the GI scenario. Specifically, productivity increases by up to 80% by 2030 (for garments and electronics; for water and labor productivity), with values depending on the resource intensity and cost structure of the subsector (Figure 3). This means that, for instance, for each unit of energy used, the firm generates 80% more value added (or GDP), holding prices constant.

Firm-level perspective

Resource efficiency improvements in the GI scenario reduce production costs, thereby increasing profitability. Results show largest cost reductions for food processing (-21%) and electronics (-18%), followed by bricks (-17%) and garments manufacturing (-12%). These cost reductions translate to higher profit margins, which range from a 23.5% increase over baseline results for bricks to a 47.4% increase for garments, as shown in Table 2.

1.3.2 Avoided costs outweigh investment requirements

Economy-wide perspective

Achieving GI targets requires capital investments. New equipment will need to be purchased to improve labor and resource efficiency and to reduce the environmental and health impacts of production. The study concludes that the economic benefits far outweigh total investment. While the investment required totals Riel 16,975 Bn in the GI scenario by 2030 (or 2% of GDP over the next 10 years), the benefits reach Riel 113,960 Bnbillion. The benefits are therefore 6.7 times larger than the investment required, and generate positive returns.

Firm-level perspective

Results show that GI investments are financially viable. The payback time ranges on average between 2.5 and 4.5 years. The attractiveness of these investments increases when considering economy-wide impacts of environmental externalities (e.g., improvements in air and water quality), reaching beyond project boundaries.

The investment required, if implemented entirely by the private sector, represents the following percentage of taxable income (defined as revenues minus costs of

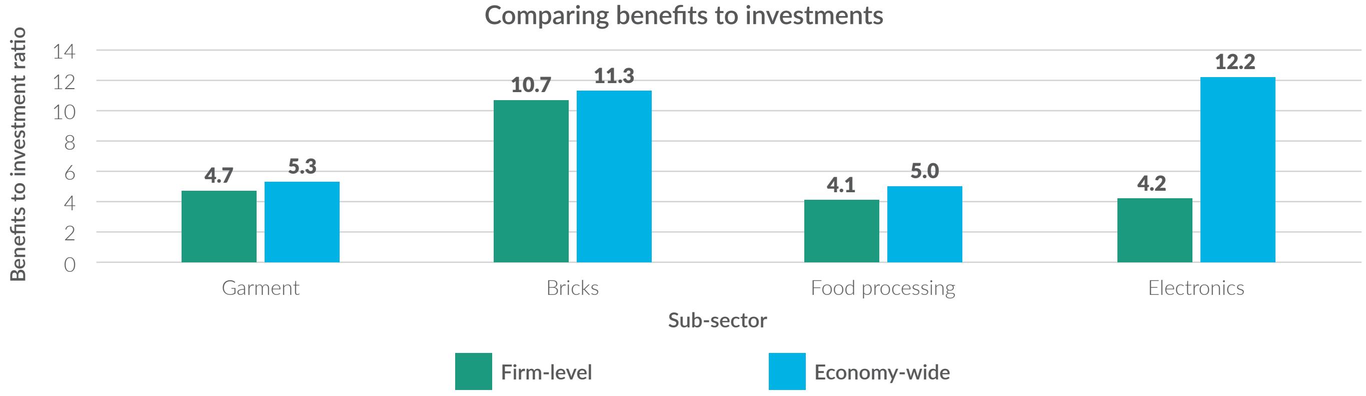
Table 2: Percentage increase in average firm profit margins in the GI scenario

PROFIT MARGIN	EX*	LI	EE	WE	ME	WWT	RE	GI
Garments	0.0%	6.9%	5.1%	0.6%	34.4%	0.0%	0.6%	47.4%
Bricks	0.0%	20.0%	3.5%	0.0%	0.0%	0.0%	0.0%	23.5%
Food processing	0.0%	2.2%	8.9%	1.1%	21.6%	-0.1%	0.3%	34.0%
Electronics	0.0%	7.8%	7.4%	4.6%	18.8%	-1.1%	1.3%	38.9%

** An increase of production for export, if achieved with the same technology and production processes (i.e., when implemented in isolation, not in conjunction with other GI interventions), increases total revenues and profits but does not impact the profit margin. This is because costs and revenues increase proportionally with production.*

[3] *Productivity in the model is estimated by dividing GDP by production inputs (materials, labor, energy, and water) and productivity is also calculated in relation to GHG emissions.*

Figure 4: GI scenario, benefits to investment ratio, year 2030, firm-level and economy-wide.



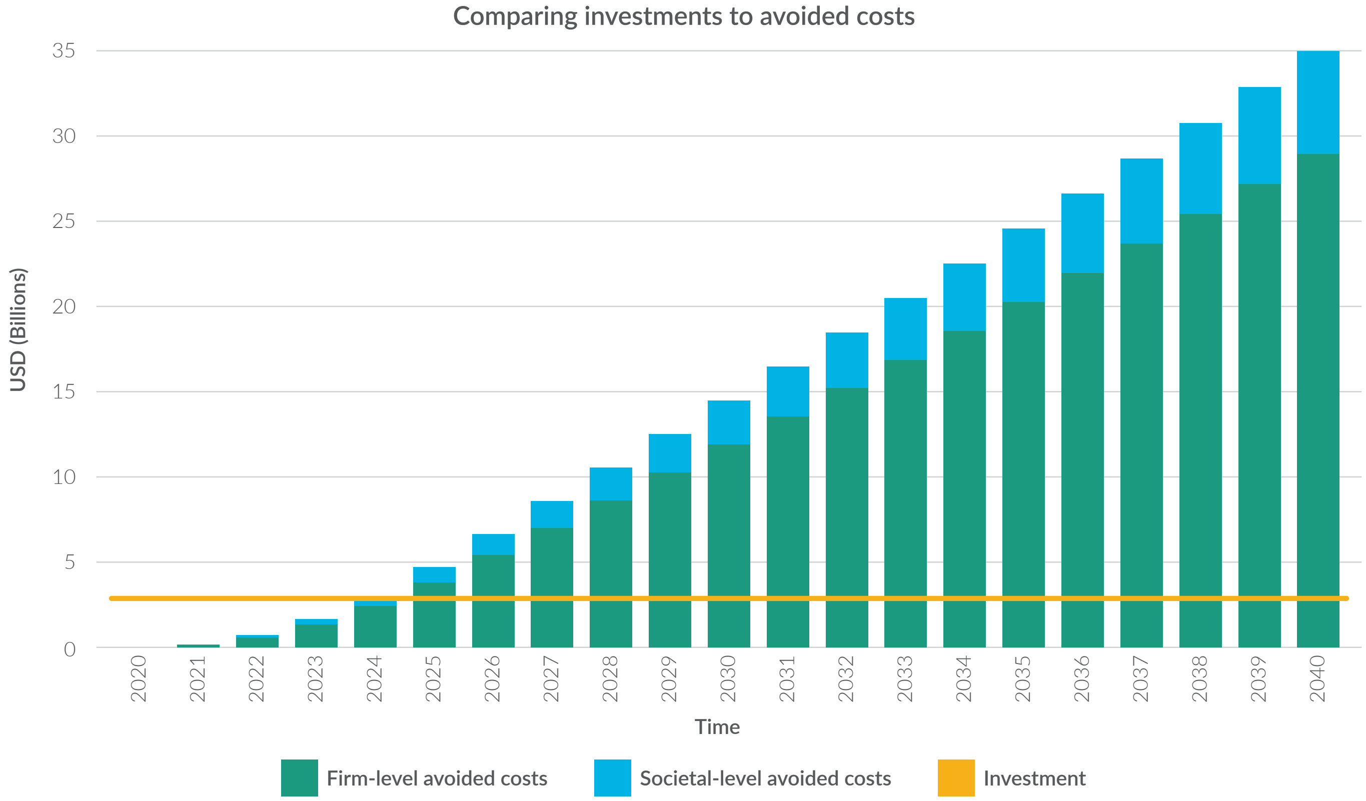


Table 3: GI outcomes, payback time by subsector, firm-level and economy-wide

Subsector	Payback time
Garments	4.63 years(firm-level) 4.36 years(economy-wide)
Bricks	3.18 years(firm-level) 3.10 years(economy-wide)
Food processing	4.56 years(firm-level) 4.11 years(economy-wide)
Electronics	4.48 years(firm-level) 2.51 years(economy-wide)

production): 4.8% for bricks (for which material efficiency is not assumed) and grows to 25.4% for garments, 27.3% for electronics, and 30.7% for food processing.

1.3.3 Economic diversification creates economic and environmental synergies

The GI scenario highlights that economic diversification can benefit a variety of key performance indicators. For instance, electronics has the second highest profit margin, while scoring the second lowest in air emission intensity, the lowest in water pollution intensity, and the highest potential for recycling. However, it has the highest toxic metal intensity.

Based on these data and on the forecasted growth of the sectors, the following observations can be made:

- Focusing on emerging sectors (e.g., electronics) supports economic diversification that leads to more value added (due to the high profit margin of emerging sectors, such as electronics). It also reduces environmental impact (due to the lower reliance on material inputs, and the use of more advanced equipment and modern forms of energy, like electricity), and often safer labor conditions.
- Improving the performance of established sectors (e.g., garments) improves economic performance and reduces environmental pressure by the firms. These are large sectors and absolute reductions in water and air pollution bring considerable societal cost reductions.

1.4 Recommendations

The analysis highlights the economic viability of reaching GI targets. To realize the benefits forecasted in the GI scenario, investments are needed. Several strategies and policies can be designed and implemented to stimulate investments. These include primarily, among other options, (a) the provision of incentives, the (b) introduction of new regulations/mandates, and (c) capacity building and awareness raising. While the latter is not modeled in this analysis, capacity building primarily increases the willingness of the private sector to invest, and awareness raising can be used to stimulate co-financing (cost sharing) for societal benefits.

The GI scenario calls for the following intervention areas identified to be collectively addressed to reduce costs and increase access to markets:

i. *Expanding exports*: Trade and logistics-related development policies should be promoted to increase GDP, employment, logistics infrastructure, and to create income. An increase of production is likely to lead to increased social and environmental, and hence economic, economy-wide costs. Synergies can be created if export promotion targets markets that value a greener industry, requiring certification or a certain degree of technology advancement, and possibly offer a premium price.

ii. *Labor intensity*: Reducing labor intensity (LI) can effectively reduce production costs. If this is coupled with an increase in labor productivity, then it can lead to higher per capita salaries. Higher labor productivity means that more production and therefore more value is created per employee. Awareness raising and vocational training are crucial to achieve such an impact, as are incentives to trigger investments in modernizing the production chain (requiring a more skilled workforce).

iii. *Energy efficiency*: Achieving 20% improvement in energy efficiency (EE) is economically viable and has a short payback time. As a result, the implementation of new mandates or regulations, coupled with awareness raising, demonstration projects, and capacity building, are suitable intervention options. Mandates and regulations could be introduced for specific energy services (e.g., lighting and cooling) and, in addition, incentives could be provided to reward performance at the production level for sectors where the payback time is longer (e.g., bricks) and where the share of energy cost – and hence capital investment – is highest (e.g., food processing and electronics). It is also important to highlight the role of fuel switching in reducing environmental pressure. This is the case for biomass which, if sustainably grown and certified, could reduce GHG emissions, increase energy security, and create new value chains.

iv. *Water efficiency*: Investing in water efficiency (WE) becomes economically attractive when considering economy-wide impacts. However, the payback time is long for certain subsectors (e.g., bricks and food processing). Incentives could be provided to lower capital costs, or for performance-based rewards (based on metered water use reductions). Awareness raising and demonstration projects are also viable interventions to highlight the role that WE can play in reducing costs. This applies not only at the firm-level but also economy-wide or for communities living near industrial activities.

v. *Material efficiency*: Improving material efficiency (ME) is economically viable. Investments can be paid back within four to five years, but require high upfront capital costs. As a result, incentives could be provided to reduce the payback time for industries, either by lowering capital costs or by reducing the cost of financing.

vi. *Wastewater treatment*: This is a costly intervention that increases the cost of production and does not generate revenues for firms. A mandate is likely to be ineffective in the absence of monitoring and enforcement, due to the lack of economic incentives and limited bankability for the investment. As a result, the introduction of a tax (with water metering and monitoring of pollution), or an incentive to reduce running costs (also with enforcement) would be more effective. The introduction of a public incentive would be justified by savings on health costs.

vii. *Renewable energy*: The use of solar panels for power generation has a long payback time, and a comparatively high capital cost. But considerable savings can be made both from a firm-level and from an economy-wide perspective. When considering economy-wide impacts, the payback time becomes shorter than 10 years, or about half the lifetime of solar panels. To stimulate investments in solar panels, and realize emission reductions and reduced health costs, incentives could be provided to lower the burden of capital cost and increase access to financing. Awareness raising is also necessary, since the cost saving is attractive but renewable electricity generation is distant from the core business of the four subsectors analyzed. There are also specific technical and regulatory challenges that may need to be overcome to promote distributed generation including regulation to manage and valorize reverse flows to the power grid and/or implement more flexible licensing processes for installations.

The quantitative model used in the study can inform policy development specifically in two areas: incentives and regulations/mandates. This is because the GI scenario estimates investments, avoided costs, and economy-wide benefits. As a result, the modeling provides evidence to justify targeted public subsidy where economic benefits are identified, through subsidies to mobilize private sector investment. The study does not fully analyze policy and regulatory barriers for each subsector and each GI intervention area.

1.4.1 Determining Incentives

Incentives are identified as a good intervention option to reduce capital costs and the cost of financing in the GI scenario. Given the short payback time of most interventions, incentives should be temporary (implemented only in the short term) but should target investments with a long lifetime.

Incentives can be provided as tax reductions (i.e., foregone revenue, rewarding performance) or as a direct contribution (i.e., budgetary expenditure, rewarding investment). To conceptualize a basis for determining incentives, the study proposes that the amount of incentives that the government could provide, in the form of a reallocation of avoided costs in the GI scenario, is estimated as follows:

i. **Tax reduction: total (cumulative) avoided cost for the government/taxable income**

ii. **Direct budget contribution: total (cumulative) avoided cost for the government/total investment**

Note: cumulative avoided costs are calculated for the period 2020-2030; the cost to the government is assumed to be 10% of the estimated health cost of air and water pollution.

These two options can be used in isolation or combination, depending on the local context. For instance, tax reductions are preferred when fiscal sustainability (e.g., deficit) is a concern. Direct budget contributions are preferred when short-term results are required to lower upfront capital costs.

Combinations are found when an incentive is set based on the investment required (e.g., 20%), but it is delivered in the form of a tax reduction over five or 10 years. The results of the analysis, providing a range for the potential amount of incentives that could be provided by the government, are presented below:

Energy efficiency:

i. 2% of tax reductions in case of foregone revenue OR (ii) 10% to 15% of the investment in the case of direct incentives

Water efficiency:

i. 0.5% (for food processing, garments, and bricks) to 15% (for electronics) of tax reductions OR (ii) 10% to 20% (for bricks and food processing) or a higher value for garments and electronics of the investment

Wastewater treatment:

i. 5% of tax reductions (in case of foregone revenues) OR (ii) a higher percentage of the investment in the case of direct incentives (with monitoring)

Renewable energy:

i. 0.4% and 1.5% of tax reductions OR (ii) up to 60% of the investment in the case of direct incentives

Finally, it is estimated that value for money would be maximized if incentives were to be provided for reducing water pollution and for RE. These are areas that directly impact budgetary costs of the government.

1.4.2 Introducing Mandates

Mandates and regulations introduced by the government are identified as a good intervention option when large societal costs result from industrial production. There are two reasons for promoting the use of regulation to realize the GI scenario:

- Competitiveness: The incremental costs of adopting technology that contributes to GI targets may generate more benefits than costs for companies, and do so often with a short payback time.

- Value for money: Mandates and regulations transfer costs from government (and households) to industry. If there is a direct link between production and societal costs, a more cost-effective intervention is to act at the source (industrial level).

Based on the GI analysis and literature review relevant to the intervention areas in the GI scenario, the following regulations and mandates could be used to realize the GI scenario:

Energy efficiency:

- Identify common industrial equipment (e.g., motors) and/or processes with a scope to implement minimum energy performance standards

- Focus on energy services rather than sectors (e.g., mandate the use of LED lights, labelled and energy efficient heating/cooling units, and ban the use of unsustainable fuelwood)

- Stimulate the use of more efficient and lower carbon intensive energy sources, through targeted mandates for the adoption of technologies and equipment that support fuel switching

Water efficiency:

- Increase water metering coverage, and monitor water losses and infrastructure efficiency

- Regulate the use of water efficient faucets and label products

Material efficiency:

- Regulate the import of equipment, allowing only medium- to highly-efficient technology

Wastewater treatment:

- Enforce on-site wastewater treatment (WWT) and monitor performance

1.5 Conclusions

The analysis presented in this study extends the knowledge available in the country. Results indicate that GI targets are economically viable. The study also highlights that synergies can be found across targets. Overall, the modeling assessment shows that implementing GI investment would reduce costs for firms and society, while increasing the industry's competitiveness. It also shows that GI investments have the potential to stimulate greener and more sustained lucrative industrial growth.

On top of providing quantitative estimates to advance the current policy debate on industrial development, this study proposes and applies a framework and method of analysis for industrial subsectors. The insights emerging from this work could be used to inform related policy discussions. This includes both the numerical results and the method used. In fact, this method could be applied to new sectors, and to estimate the likely outcomes of new policy options.

2. Introduction

Cambodia's structural economy is rapidly evolving. The Green Growth Potential Assessment Report (GGGI, 2017) highlighted that the industrial sector in Cambodia grew strongly in the past decade. Most recent data show GDP growth for the sector at almost 11 % in 2016, compared to about 7% growth of the entire economy for that year (World Bank, 2018). As a result of the industry sector's rapid growth, its share in total GDP has been increasing steadily in recent years from about 23% in 2009 to nearly 32% in 2016 (World Bank, 2018). The sector's expansion is also reflected in its growing energy demand, with total final consumption of the industry sector increasing by about 11% from 2010 to 2015 (ERIA and MME, 2016).[4] The garments sector has been the driving force for industrial growth and the sector's increasing energy consumption, followed by the fabrication of clay bricks for building construction, rice mills for processing paddy into polished rice, rubber production, and the food sector including the fabrication of ice for refrigeration. It is expected that energy consumption in the industry sector will continue to grow at a similar pace of 4-5% per year.

The Royal Government of Cambodia has set the targets to transform the country into an upper middle-income economy by 2030 and high-income country by 2050.[5] For that purpose, the government adopted the Cambodia Industrial Development Policy (2015-2025) in 2015 as a guide for systemic solutions to develop a competitive industry sector. The Industrial Development Policy highlights a wide range of issues, including diversification of the industrial base, development of the country's physical infrastructure (water, telecommunications, transport, and sewage), development of a skilled labor force, and improving access to finance (Cambodia Industrial Development Policy, 2015).

At present, the Cambodian industry is struggling to match the production costs of its regional competitors, such as Vietnam and Thailand. One of the main reasons for this is the lack of resource efficient practices in Cambodia's industry. In addition, although the industrial sector is providing economic growth and much needed jobs, it also creates pollution and increasing pressure on society (e.g., health) and the environment (e.g., water and air quality), leading to the emergence of unexpected impacts on productivity and unplanned expenses.

Therefore, improving resource productivity and decoupling industrial growth from environmental impacts will pave the way for more sustainable industrialization. The study is motivated by the need to provide evidence on the economic and financial benefits for promoting green growth in the industrial sector of Cambodia, recognized as a priority in the Rectangular Strategy and the National Strategic Development Plan (NSDP). This is achieved through a quantitative study, making use of integrated modeling and scenario analysis. This includes an assessment of the required investment for a GI scenario, the resulting avoided costs, and added benefits.

The study provides indications for key policy areas that will need to be strengthened for a green growth transition. This includes a review of direct capital investments, incentives and disincentives, targets mandated by law, and public awareness interventions and an assessment of the suitability of each of these intervention options (as well as more detailed provisions) for each of the subsectors and intervention areas tested.

The report focuses on four industrial subsectors, which were selected based on various criteria and informed by stakeholder input. Further, the Cambodia Industrial

[4] IEA (2017) indicates a much higher increase of total final consumption of the industry sector by about 42% from 2009 to 2015, compared to a 36% increase in consumption for the entire economy. Regardless of which of the two sources reflects the actual situation more accurately, both confirm that energy demand in the industry sector is growing, making energy efficiency measures more relevant.

[5] The NSDP uses different terms in different sections of the document, stating the goal of Cambodia becoming a "developed country by 2050" (p. 4, p. 175) as well as becoming a "high income country by 2050" (p.105).

Development Policy 2015-2025 states the following in the context of priority sectors for policy development and implementation:

"First [priority are] new industries or manufacturing ventures with the capability of breaking into new markets, with high value-added products, creative and highly competitive that focus[es] not only on consumer products but also production equipment such as machinery assembly, mechanic/ electronic/electric equipment assembly, means of transport assembly, and natural resource processing."

As a result, two main approaches were used: (i) a conventional one, based on data availability, and on the relevance of the subsectors to national development targets; and (ii) an exploratory one, based on future growth potential, matching the national ambition to develop high value and low impact sectors.

This ensures that a relevant mix of sectors is considered to highlight how a green growth approach can help reduce the impacts of current production as well as identify future opportunities to decouple growth and environmental impact. The criteria used to identify relevant sectors therefore included national economic significance (e.g., share of GDP and employment), reliance on natural resources and impacts (e.g., water and energy consumption), and competitiveness (a qualitative assessment, stakeholder-led, on the potential future growth of manufacturing sectors). Appendix A provides more details on the selection criteria and sector prioritization.

Table 4 provides a summary of the prioritization performed at the highest level of aggregation (using national data for available industrial sectors). More detailed information on the economic, social, and environmental performance of the sectors analyzed is provided in Section 3.2 .

The table highlights that textile, wearing apparel, and footwear is the most relevant sector for GDP (38% of industrial GDP and 66% of manufacturing GDP in 2015). Food, beverages, and tobacco follows, which scores second both on GDP and on employment (15.8% of manufacturing employment, after garments at 70.6% in 2011). Metallic and non-metallic manufacturing are the most energy intensive sectors (per ton produced and per value of production with the lower energy productivity). High reliance on natural resources was observed for wood, paper and publishing, rubber manufacturing, and food processing. In addition to the use of raw materials,

Table 4: High-level prioritization of industrial subsectors (see Appendix A for further information)

	GDP	Employment	Energy	Natural resources	Waste	Climate change
Food, Beverages, and Tobacco	Medium	Medium	Low	High	Medium	High
Textile, Wearing Apparel, and Footwear	High	High	Medium	Low	High	Low
Wood, Paper and Publishing	Low	Low	High	High	Low	Low
Rubber Manufacturing	Low	Low	Medium	High	Low	Low
Other Manufacturing						
Non-Metallic Manufacturing	Low	Low	High	Medium	Medium	Low
Basic Metal and Metal Products	Low	Low	High	Medium	Medium	Low
Other manufacturing	Low	Low	Low	Low	Low	Low

Legend:

High significance

Medium significance

Low significance

water consumption is high for these industries, especially food processing. Concerning waste generation, a more in-depth review of the subsectors is necessary. Here we note that the most energy intensive sectors, including cement and brick manufacturing, are also the ones at the top of the list for air emissions. Electronics is the highest for toxic metals and toxic discharge, followed by food processing, which is the largest contributor to water pollution. Finally, the most vulnerable sector to climate change is food processing, due to the comparatively larger impact of climate change on food production.

After having reviewed several industrial sectors, collected and analyzed available data, and gathered inputs from stakeholders, the following industrial subsectors were selected for this study:

- **Food processing** (as part of the Food, Beverages, and Tobacco sector included in GDP statistics, specifically Section C-Manufacturing, Division 10-Manufacturing of Food Products, Group 101 to 110 of the Cambodia Standard Industrial Classification, excluding tobacco products).
- **Construction** (with a focus on brick production, specifically Section C, Division 23, Manufacturing of Non-Metallic Mineral Products, Group 239 and Class 2932 and 2394 of the Cambodia Standard Industrial Classification).
- **Garments manufacturing** (as part of the Textile, Wearing Apparel, and Footwear sector included in GDP statistics. Specifically, we include Section C, Division 13, Group 131 to 143 of the Cambodia Standard Industrial Classification for resource consumption, and Group 142–Footwear, for the estimation of GDP and employment).
- **Electronics manufacturing** (specifically Section C, Division 25, Group 259 to 265; e.g. Manufacture of Consumer Electronics, Manufacture of Electronics Components, Computers, and Peripheral Equipment, and 271-Manufacture of Electrical Equipment of the Cambodia Standard Industrial Classification).

3. Methodology

3.1 Overview

The methodology used has four main phases. It starts with sector identification, and is followed by the creation of a simulation model, the simulation of baseline and alternative scenarios and the analysis of results, and finally the formulation of policy recommendations. These main phases are presented in Figure 5.

Once the sectors are confirmed and the data availability has been assessed, the creation of subsectoral simulation models starts. This task consists of two main activities: the creation of a system map (or Causal Loop Diagram, CLD) and the development of a quantitative simulation model (the System Dynamics model). The latter is informed by the data collected, the information received from stakeholders, and the CLDs. The model is described in Section 3.3.

Once the models are developed, the scenarios can be simulated and analyzed. This includes the BAU and several alternative cases related to different aspects of green growth. All the alternative scenarios together form the GI scenario. These simulations are based on the identification of specific intervention areas and related targets. The list of available targets, by sector, was first drafted based on the review of existing policy documents and best practices in the Association of Southeast Asian Nations (ASEAN) region. This list was then submitted

Figure 5: Approach for the formulation of policy recommendations.

The identification of key sectors includes the creation of sectoral profiles, the identification of criteria to determine the relevance of several industrial subsectors, and data collection at the national and international levels. This process resulted in the creation of subsectoral profiles, summarized in Section 2.1 and also presented as appendices, and the compilation of a database used to customize and calibrate the simulation models.

to local stakeholders for review, then validated and discussed in two workshops for a final selection and quantification of targets. Next is the interpretation of results using an integrated Cost Benefit Analysis (CBA). The CBA includes quantitative results (the BAU and GI simulations) and is estimated at the "firm-level"[6] as well as considering "economy-wide"[7] outcomes of interventions. The results of this assessment are presented in Section 3.

Finally, once the results of various scenarios are validated, analyzed, and interpreted, policy recommendations are formulated. These are presented in Section 4.

3.2 Sectoral Profiles

3.2.1 Contribution to GDP

Garments

The textile and garments industry is Cambodia's most important manufacturing sector concerning contribution to GDP (UNDP, 2015). The industry classification includes all enterprises and businesses across the majority of the supply chain, from textile producers to footwear, and garment and apparel manufacturers. This profile provides information on businesses through the supply chain; however, an emphasis is put on garments. The garments industry contributes approximately 19% to Cambodia's GDP and produces 72% of the country's exports (UNDP, 2015).

Bricks

The bricks industry is tied closely with the construction sector which is one of the key sectors driving Cambodia's economic growth (GERES, 2017). In 2016, the construction sector generated roughly USD 2.3 Bn in value added and constituted 11.4% of GDP (NIS, 2017). At the end of March 2017, total investments of USD 1.28 Bn in construction projects were to be admitted by the Ministry of Land Management, Urban Planning, and Construction (MLMUPC) (GERES, 2017). The annual production of the Cambodian bricks manufacturing sector exceeds 500 million units.

Food processing

The food industry processes raw and intermediate inputs derived from the agriculture sector, such as crops, livestock, fish, and forestry products (FAO, 1997). This typically involves processes for preserving goods for end user consumption and may or may not involve value added processing activities (EuroCham, 2017). In 2016, Cambodia's food processing industry contributed 14.4% to manufacturing GDP and held on average a share of 2.2% in total GDP during the last decade (NIS, 2017).

Electronics

The Electronics and Electrics (E&E) industry encompasses a broad range of components, and intermediate and final products that are traded and sold in global markets (Gereffi & Frederick, 2013). According to the Malaysian Reserve (2017), the Greater Mekong Subregion will be one of the major new growth hubs for low-cost manufacturing in Asia. Between 2008 and 2013, Cambodia saw an increase in electronics production; however, total exports remained relatively low in absolute terms (BDG Asia, 2014). In 2012, Cambodia's E&E exports recorded USD 63 Mn, not a large amount in relation to the manufacturing sector, but a significant increase compared to previous years when exports were USD 5 Mn or less (GOC, 2014). In 2013, Cambodia's E&E exports totaled USD 225 Mn for electronics and electrical equipment (UNDESA, 2017), with more than half consisting of lower-end parts such as insulated cables and fuses (BDG Asia, 2014). By 2016, total E&E exports increased to around USD 434.2 Mn (UNDESA, 2017).

3.2.2 Cost structure

The subsectors analyzed differ in many ways. One key difference emerges when reviewing their cost structure, as summarized in Table 5. Specifically, we note the following:

- Capital and material costs are predominant for garments, reaching a total of 85.5% of total costs. Labor, representing 8.7% of production costs, is also affected by the minimum wage enforced in the sector. Energy and water represent 5.3% and 0.5% of total costs.

[6] *"Firm-level" indicates that the economic performance of the investment is estimated only by taking into account direct impact on the cost structure of the subsector (reduction of energy and water costs).*

[7] *"Economy-wide" indicates that, in addition to considering firm-level impacts to estimate the economic performance of the investment, outcomes beyond the subsector are taken into consideration (e.g., reduction of air and water pollution and subsequent reduction of health costs for households and the private sector).*

- Labor is the largest cost item for bricks. This indicates that the sector is still very labor intensive. Capital and energy costs follow, with 25% and 10.6% of total costs, respectively.

- Food processing has high shares of material and energy costs, with the latter being the highest among all subsectors. While estimates of capital costs are not available, which push other cost shares higher, total costs and GDP match available statistics, meaning that capital costs have been implicitly incorporated in other cost items.

- Electronics shows a more balanced cost structure, with high material costs and similar shares for capital, labor, and energy costs. Electronics is also the sector with the largest relative water cost, representing 4.8% of total costs.

Table 5: Cost structure of the four subsectors analyzed.

	Capital	Material	Labor	Energy	Water
Garments	43.5%	42.0%	8.7%	5.3%	0.5%
Bricks	25.0%	0.6%	63.8%	10.6%	0.02%
Food processing	N/A	65.4%	5.5%	27.2%	2.0%
Electronics	18.6%	40.9%	17.7%	18.0%	4.8%

3.2.3 Resource use

Garments

- Energy: Energy consumption by energy source is shown in Table 6, showing strong reliance of the garments sector on wood. According to a benchmarking survey of the ILO and the IFC (2009), the average energy cost per ton of garments is USD 560 (42 Giga Joule or GJ of energy consumption), with a wide range from USD 30 (two GJ) to USD 1,737 (273 GJ) per ton. Further, factories employing more than 3,000 employees tend to have a higher energy intensity with approximately 74 GJ per ton of product (ILO & IFC, 2009).

- Water: On average, approximately 100 to 150 liters of water are needed to process one kilogram of textile. With an annual amount of approximately 28 million tons being dyed, the apparel industry has an annual water footprint of more than five trillion liters of water. In addition, consumer laundering consumes around 1,650 liters per kilogram of textile (Maxwell, McAndrew, & Ryan, 2015).

- Materials: The amount of resources used per ton of garments is estimated to be 1.25 tons of textile, based on material losses ranging between 10% and 30% (Reverse Resources, 2016). In total, 738,500 tons of textile were produced in 2017 in Cambodia.

Table 6: Energy consumption by source for the four subsectors analyzed.

Sector	Electricity (%)	Wood (%)	Diesel Oil (%)	HFO (%)	LPG (%)
Garments	24.5	43.4	27.9	4.2	-
Bricks	-	97.3	2.7	-	-
Food processing	3.1	73.4	18.3	-	5.2
Electronics	59.2	-	40.8	-	-

Source: (ILO & IFC, 2009; Williams, 2009; UNIDO, 2016)

Table 6: Energy consumption by source for the four subsectors analyzed. Source: (ILO & IFC, 2009; Williams, 2009; UNIDO, 2016)

Bricks

- Energy: Energy consumption by energy source is shown in Table 6, showing strong reliance of bricks manufacturing on wood and wood products. According to a UNIDO (2013a) case study, the specific energy consumption (SEC) of Cambodia's bricks industry is higher than seven Mega Joules (MJ) per kilogram of bricks fired (UNIDO, 2013a). Neighboring countries have an SEC of one to two MJ per kilogram, which indicates that Cambodia's SEC is very high and implies a large potential for realizing EE savings (UNIDO, 2013b). However, bricks manufacturing is also the second largest industrial consumer of fuelwood (with 28 percent of total consumption) and rice husks (with 36 percent of total consumption), according to research by GERES (Joya, 2015; EMC & ARUP, 2016).

- Water: Envirowise (2001) indicates that the water used per ton of clay processed for bricks production for an average company is around 104 liters per ton. Dust control alone requires between three and23 liters of water per ton of clay (Sterner, 2010). The amount of water used during the forming process depends on the process type. In the Dry-Press Process up to 10%, the Stiff-Mud Process between 10% and 15%, and the Soft-Mud Process between 20% and 30% of water is added to form the clay into the desired shape (BIA, 2006). Table 7 presents potential gains from improving resource efficiency (water and clay) for bricks manufacturing in Cambodia.

- Materials: Material use for bricks manufacturing is assumed to be fully utilized, with a 1:1 ratio. Specifically, one ton of clay-bearing soil, sand, and lime is expected to result in one ton of bricks.

Table 7: Overview of resource use and potential savings in bricks production (Envirowise, 2001)

Resource use	'Average' company		'Good' company		Benefits of good practice	
	m^3 or tons	Value (£)	m^3 or tons	Value (£)	m^3 or tons	Value (£)
Water use	8,100	14,580	5,100	9,180	3,000	5,400
Clay use	78,000	156,000	72,000	144,000	6,000	12,000
Total benefit						**17,400**

Food processing

- Energy: Energy consumption by energy source is shown in Table 6, showing strong reliance of food processing on wood and wood products. UNIDO (2016) has conducted EE assessments in various companies of Cambodia's food processing sector, indicating that the potential for fuel switching is considerable, but wood could be used even more when considering the cost of energy, being the cheapest option available (UNIDO, 2016).

- Water: Water consumption in the food processing sector was estimated based on the UNIDO (2016) case studies on the food processing sector. For food and beverages, the average consumption is 21 cubic meters (m^3) per ton of production, whereby rice noodle companies are leading in water consumption with around 35 m^3 per ton on average, followed by beverage consumption with around 5.7 m^3 per ton of production.

- Materials: No data could be found on specific materials use, or inputs from production, for food processing. It is assumed in the modeling exercise that the material inputs are 10% higher than the final production, to account for losses in the production process.

Electronics

- Energy: Energy consumption by energy source is shown in Table 6, showing strong reliance of electronics manufacturing on electricity and diesel oil. Energy requirements for the production of electronics heavily depend on the final product, length of the supply chain, and the efficiency of sourcing the materials. As an example, the production of a two-gram computer chip requires 32 kilograms of water, 1.6 kilograms of fossil fuels, 700 grams of elemental gases, 72 grams of chemicals, and 41.2 MJ of energy (Cushman-Roisin & Cremonini, 2017).

- Water: Water requirements change considerably when building different products, or adopting different technologies. One example is the production of computer monitors, specifically a Cathode Ray Tube (CRT) versus a Liquid Crystal Display (LCD). The amount of water consumption is 4.7 times higher in the case of CRT relative to LCD (Socolof, Overly, Kincaid, & Geibig, 2001), indicating the need to consider resource availability when deciding whether to invest in the production of conventional or a more advanced product.

- Materials: No data could be found on specific materials use, or inputs from production, for electronics manufacturing. It is assumed in the modeling exercise that the material inputs are 10% higher than the final production, to account for losses in the production process.

3.2.4 Labor profile

Garments

By March 2015, Cambodia had 640 formally registered garments and footwear factories (CNV Internationaal, 2016). In the same year, the Government of Cambodia reported 686,150 employees in the garments and footwear sector (UNDP, 2015), while a study of CNV Internationaal indicates that this number might exceed 800,000 workers if the informal sector is considered (UNDP, 2015; CNV Internationaal, 2016). The garments and footwear sector accounts for 77% of all manufacturing jobs in Cambodia (CNV Internationaal, 2016). Exporting factories provide more than 620,000 jobs (ILO, 2016a) and the number increases to more than 800,000 jobs if the informal sector is considered (CNV Internationaal, 2016).

Employers in Cambodia are obliged to pay their employees a minimum wage, which was introduced specifically for the garments and footwear manufacturing sector (ILO, 2016b). The minimum wage for the garments and footwear industry increased from USD 40 per month in 1997 to USD 140 per month in 2016 (ILO, 2016a) and USD 170 per month effective January 2018 (The Straits Times, 2017). In addition to the minimum wage, Cambodian employees are entitled by law to additional payments and benefits such as seniority bonus, attendance bonus, overtime pay, and paid maternity leave if they fulfill the respective requirements (ILO, 2005).

Table 8: Emissions, water consumption, and solid waste generation from computer display production (Socolof, Overly, Kincaid, & Geibig, 2001)

Life cycle stage	CO^2 emission (kg/functional unit)		Water consumption (L/functional unit)		Solid wastes (kg/functional unit)	
	CRT	LCD	CRT	LCD	CRT	LCD
Upstream	29.2	107	**554**	**263**	9.55	13.1
Manufacturing	179	62.2	**11’400**	**2’150**	81.2	12.6
Use	445	166	1140	425	83.3	31.1
End-of-life	2.59	1.39	-27.3	-18	-1.66	-4.42
Total	655 (98.68% of total air emission)	336 (97.18% of total air emission)	13’100	2’820	172	52.3

Bricks

In 2011, there were 895 established bricks manufacturing enterprises in Cambodia (EMC & ARUP, 2016). Officially, only 42% of companies are operating under an official license (GERES, 2017). Calculations based on Industry Energy Efficiency case studies indicate that the employment intensity of the Cambodian bricks manufacturing process ranges between two and seven people per million bricks per year, excluding contractors and transporters (UNIDO, 2016). Based on a UNIDO case study, the labor costs per brick start from around USD 2,500 per 1,000 bricks, with a potential to increase labor productivity by around 40% (UNIDO, 2013b).

Food processing

According to the Council for the Development of Cambodia (2013), as of 2012 there were 70 factories registered in the sector, employing on average 179 employees each, but with a range between eight and 1,546 employees per factory (CDC, 2013). The Ministry of Economy and Finance's (MEF) Macro Economic Monitoring indicates that the number of establishments in food and beverage processing constantly grew between 2014 and 2016, reaching 105 from 80, while tobacco processors remained almost constant (EMC & ARUP, 2016). According to Cambodia's list of establishments in 2009, there were roughly 50,000 Small and Medium Enterprises (SMEs) in the agro-processing sector, employing almost 130,000 people (KDI, 2013). The grain milling subsector (including rice milling) provides around 71% of employment in agro-processing, followed by wine making and sugar manufacturing, with 8.5% and 5.4% of employment, respectively (KDI, 2013). In 2011, SMEs in the food processing sector provided around 94,382 jobs, whereas larger factories employed approximately 12,500 people[8] (CDC, 2013).

Electronics

The E&E sector is a significant contributor of jobs in the ASEAN region, employing more than 2.5 million workers (ILO, 2016). In Singapore, E&E manufacturing contributes up to 39% of manufacturing employment, followed by Malaysia with 27%, and the Philippines and Thailand with 13.3% and 12.2%, respectively (ILO, 2016). When considering total jobs, Thailand's E&E manufacturing employment was the highest in the ASEAN region with 780,000 people in 2015 (ILO, 2016), a number which slightly decreased to 754,000 in 2016 (Hotrakool, 2016).

3.2.5 Environmental impact

Table 9 illustrates the pollution intensity of the textiles, cement, food, and electronics sectors, based on work carried out by the Asian Development Bank (ADB,2016). It provides an overview of the pollution intensity in kilograms per employee per year and total pollutants emitted by subsector in tons per year.

Garments

Despite the fact that the textile industry seems to be at the lower end in terms of pollution intensity as shown in Table 9, the size of the sector in relation to the other industries makes it the major polluter in every category but toxic metal pollution (ADB, 2016; San, Spoann & Schmidt, 2018). In fact, the garment industry is the largest emitter of toxic discharges into water bodies, representing almost 70% of total toxic pollutant loads from all sectors (ADB, 2016). Approximately 396 enterprises account for 62.8% of toxic discharges. With respect to toxic discharges into water bodies, it is estimated that 16.9% are responsible for more than 90% of emitted toxic materials (ADB, 2016). A second study on industrial pollution in Cambodia confirms these figures. It indicates that the increasing number of factories have led to an increase in solid waste production, mainly in and around Phnom Penh City and Kandal Province. Industrial waste generated from industrial production consists of unused pieces of cloth, sludge, leather, rubber, raw material residues, and industrial wastewater (MoE, 2009). The study also estimates that the garments industry is emitting the highest amount of toxic chemicals into land and air, and toxic metals into land, air, and water in Phnom Penh (San, Spoann & Schmidt, 2018).

Bricks

The cement, lime, and plaster sector has by far the highest air emission intensity on a per employee basis, and contributes to toxic discharge on land, both for toxic heavy metals and overall toxic materials (ADB, 2016; San, Spoann & Schmidt, 2018). In addition, the sector significantly contributes to the pollution of water bodies, especially when it comes to emitting total suspended solids (TSS). This is confirmed by an ADB study, which indicates that despite its relative small share of businesses (0.2% of total) and contribution to employment (0.1% of industrial employment), it is the largest emitter of SO_2, NO_2, and Total Suspended Particulates (TSP) emissions, and responsible for 88% of total particulate matter of size less than 10 microns (PM10) (ADB, 2016).

[8] Calculated based on the average number of employees per factory (179) and the total number of factories indicated in 2012 (CDC, 2013).

Table 9: Pollution intensity by subsector. Source: (ADB, 2016)

Air emission intensity	Unit	SO2	NO2	CO	VOC	PM10	TSP	Total
Textiles	kg/per./yr	12.3	16.1	2.2	5.4	0.3	2.2	38.5
Cement	kg/per./yr	5535.2	673.7	31.5	9912.5	5765.6	0.1	21918.6
Food	kg/per./yr	249.7	208.2	29.2	28.6	14.8	69.7	600.3
Electronics	kg/per./yr	52.1	19.9	16.1	21.3	0.2	3.4	112.9
Toxic metal intensity	**Unit**	**To Air**	**To Land**	**To Water**	**Total**			
Textiles	kg/per./yr	0.014	0.299	0.001	0.314			
Cement	kg/per./yr	0.091	3.728	0	3.819			
Food	kg/per./yr	0.015	2.273	0.008	2.297			
Electronics	kg/per./yr	0.273	6.496	0.026	6.794			
Toxic discharge intensity	**Unit**	**To Air**	**To Land**	**To Water**	**Total**			
Textiles	kg/per./yr	4.1	2	0.9	6.9			
Cement	kg/per./yr	2.6	7.4	4	14			
Food	kg/per./yr	15.4	9.3	0.8	25.6			
Electronics	kg/per./yr	26.4	24.9	0.3	51.5			
Water pollution intensity	**Unit**	**BOD**	**TSS**	**Total**				
Textiles	kg/per./yr	0.9	4.4	5.3				
Cement	kg/per./yr	0.1	239.7	239.8				
Food	kg/per./yr	16.6	17.9	34.5				
Electronics	kg/per./yr	0.9	1.4	2.3				

Food processing

The food processing sector significantly contributes to toxic discharges to air and land (ADB, 2016). The sector also significantly contributes to the pollution of water bodies, especially when it comes to biological oxygen demand (BOD) and total suspended solids (TSS) emissions (ADB, 2016). According to the assessment of a smallholder development project in the People's Democratic Republic of Lao financed by the ADB (2013a), the establishment of an agro-processing industry is likely to increase the amount of food waste (by-products and leftovers from product refinement). A similar trend could be expected for Cambodia, with the risk of increased soil and water pollution (ADB, 2013a).

Electronics

Despite the fact that the E&E industry seems to be at the lower end in terms of air and water pollution intensity, total toxic discharge intensity, including toxic metal discharge intensity, is very high on a per employee basis. This indicates that E&E manufacturing could potentially become a major emitter of toxic pollution in Cambodia (ADB, 2016; San, Spoann & Schmidt, 2018) should the industry be poised for further growth. The extent to which this may happen also depends on the type of production taking place in Cambodia. For instance, producing a CRT display generates three times more solid waste per unit (172 kilograms) than an LCD display (52.3 kilograms). Further, recycling is higher for LCDs, with 4.42 kg/unit versus only 1.66 kg/unit in the case of CRTs (Socolof, Overly, Kincaid & Geibig, 2001).

3.3 Model description

The creation of customized simulation models, one for each subsector, is based on the identification of causality in the definition of profitability and impacts of economic activity. System Dynamics (SD) was used as the underlying methodology, using a participatory approach and taking into account the many inputs received from stakeholders.

SD is a methodology designed to investigate how different parts of a system interact with one another. As a result, it is well suited, and commonly used, to assess how social, economic, and environmental indicators interact in determining the performance of a system or a sector. In fact, the use of SD allows for the seamless integration of social, economic, and environmental indicators in a single framework of analysis through the use of stocks and flows (and hence allows for the direct integration of natural capital in socioeconomic models). An SD model can be fully customized to a local context, and in our case to different industrial subsectors.

For the reasons given above, SD has been extensively applied to green economy and green growth studies (and to other areas in which a systemic approach is required, such as climate adaptation and sustainable asset valuation), from global (e.g., UNEP Green Economy Report) to local applications (e.g., WWF LIVES project in the provinces of Kratie and Stung Treng in Cambodia).

SD allows for the creation of time-based simulations that forecast scenario outcomes on social, economic, and environmental indicators, including selected Sustainable Development Goals (SDGs), informing both policy formulation and evaluation (through the anticipation of synergies and trade-offs -- or side effects -- over time). When integrated models are built with SD, it is possible to assess whether policy interventions, through "what if" scenarios, lead to the desired outcomes or also generate the emergence of side effects (i.e., economic growth is accompanied by increasing stress to the environment).

The models created for each subsector include several indicators, grouped as follows: (1) production costs and revenues, (2) environmental impacts of production, and (3) societal impacts of production. These variables of the model are used to estimate additional indicators, such as productivity (for labor, energy, water, waste, and air emissions).

3.3.1 Overview

Four simulation models have been created for this study: garments, food processing, construction (bricks and cement), and electronics. The models simulate from the year 2000 until 2040. Data were collected for most indicators, from domestic and international sources, from peer-reviewed studies and reports, as well as from meetings with local stakeholders and experts.

Several indicators have been identified for inclusion in the simulation models. These primarily reflect production revenues and costs, as well as their environmental impacts and contribution to socioeconomic development.

At the firm-level, emphasis is put on required investments, policy-induced avoided costs, and added benefits. Concerning the economy-wide CBA, attention is put on social, economic, and environmental indicators for direct, indirect, and induced policy outcomes. The model calculates both annual and cumulative values, over the lifetime of the investment.

The presentation of the model starts with revenues and costs (capital and operation and maintenance, labor, energy, and water), and environmental impacts (water pollution, GHG emissions, and solid waste). It then continues with productivity indicators, which summarize economic performance in relation to inputs and outcomes of production. Key equations are presented, describing how productivity indicators are estimated (using both economic value addition and resource use). As a result, the presentation of energy, water, material, labor, and GHG productivity will cover both the estimation of GDP for the sector and the consumption of resources required to generate such value added. Next is the presentation of how the CBA is carried out, at the firm-level and economy-wide.

3.3.2 Revenues and profitability

The profitability of an industrial subsector is estimated in the model as GDP, representing the value added of the sector. GDP is estimated by considering two main elements: the taxable income of the sector and taxation. The equation used for the calculation of the garments sector GDP is formulated as:

GDP= Taxable income*(1-Tax Rate)

Figure 6 provides an overview of the variables used for the calculation of the variable "gdp textile, wearing, and apparel" in the form of a tree diagram, or causes tree. A causes tree shows the variables used for the calculation of the indicator selected. The indicator of interest is the first on the right, and its causes are presented on the left. This tree diagram illustrates the variables used for the calculation of GDP, being the taxable income (estimated using revenues and costs) and the tax rate.

Figure 6: Causes tree GDP garment sector. The diagram indicates that the revenues are estimated using production and a market price. Production costs are estimated as the sum of capital and other variable costs (including material costs), plus labor and water and energy costs.

3.3.3 Cost of operation

Capital and variable cost, labor cost, and water and energy cost are the cost items used to estimate total production cost. Figure 7 provides a more in-depth view of how these variables are calculated.

The "**capital and variable cost**" is calculated as the sum of capital and material costs. Both variables are estimated using production for the sector, and a measure of intensity (the amount of capital cost required for each ton of production, or the cost of materials per ton of production).

*Capital Cost = Capital Costs Per Ton Produced*Production*

*Material Cost = Material Consumption*Materials Price*

The "**labor cost**" is calculated based on the total employment of the sector and the annual salary per capita given in the sector. Total employment is estimated using total production and an employment multiplier (full time jobs per ton produced). The labor cost of the sector is calculated as the multiplication between employment and labor cost per employee.

*Labor Cost = Employment *Annual Salary Per Capita*

The "**water and energy cost**" is the sum of the water and energy cost of production. While water costs are calculated based on water consumption (estimated using production and water intensity) and water price, the energy cost calculation is more detailed and considers various forms of energy and their respective prices.

Energy Cost = Biomass Cost +Electricity Cost +Gas Cost +Liquid Fuel Cost + LPG Cost

As indicated above, the cost of each fuel used is calculated based on the quantity consumed and its price. The variable "biomass cost garment" is presented as an example:

*Biomass Cost Garment = Biomass Consumption*Biomass Price*

The electricity price for all sectors is based on initial prices indicated by Derbyshire (2015), on top of the proportion of RE used to estimate potential changes in future prices (based on modifications to the energy mix of power generation). The IF THEN ELSE function is used to

Figure 6: Causes tree GDP garment sector. The diagram indicates that the revenues are estimated using production and a market price. Production costs are estimated as the sum of capital and other variable costs (including material costs), plus labor and water and energy costs.

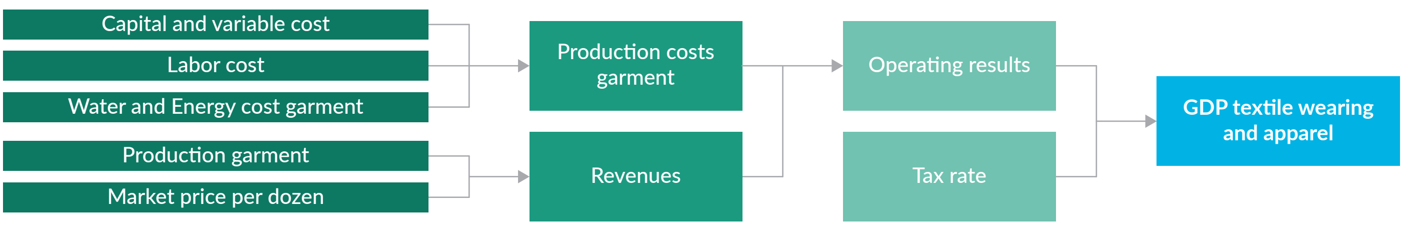


Figure 7: Causes tree production costs garments

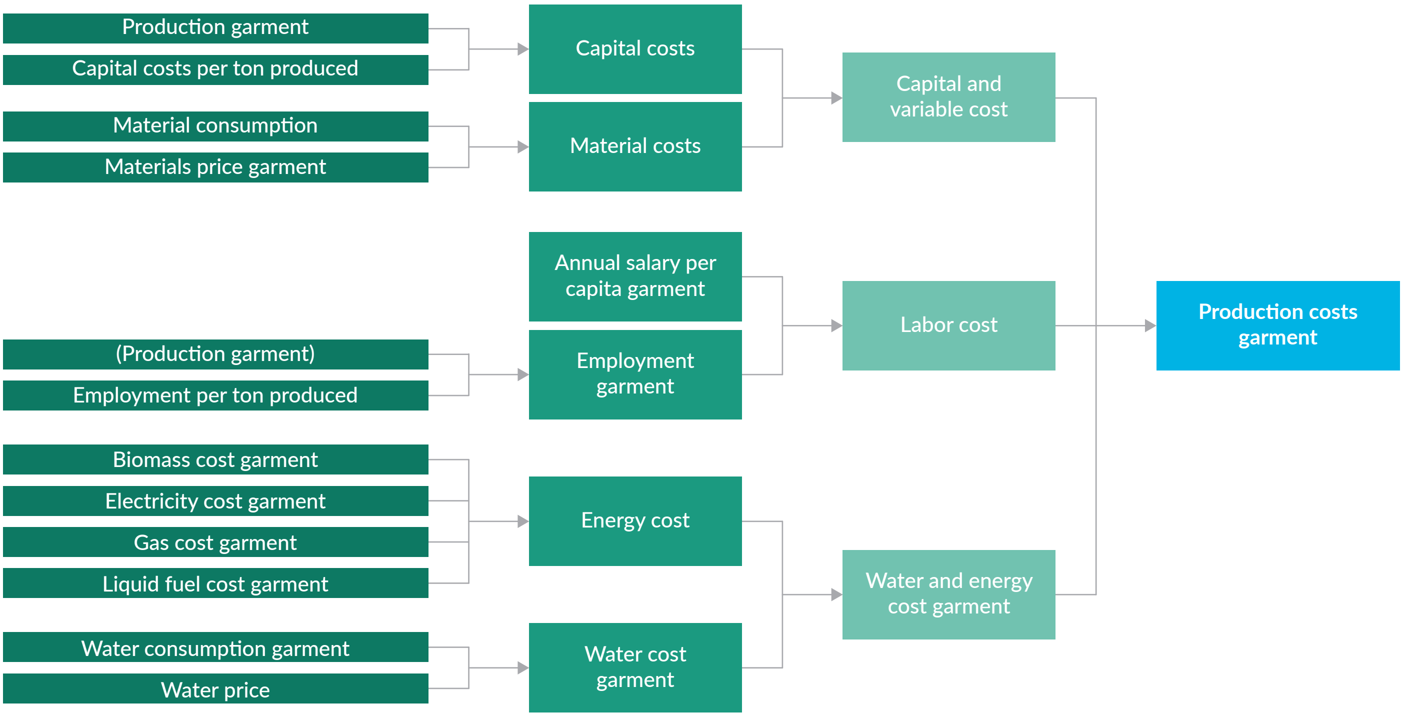
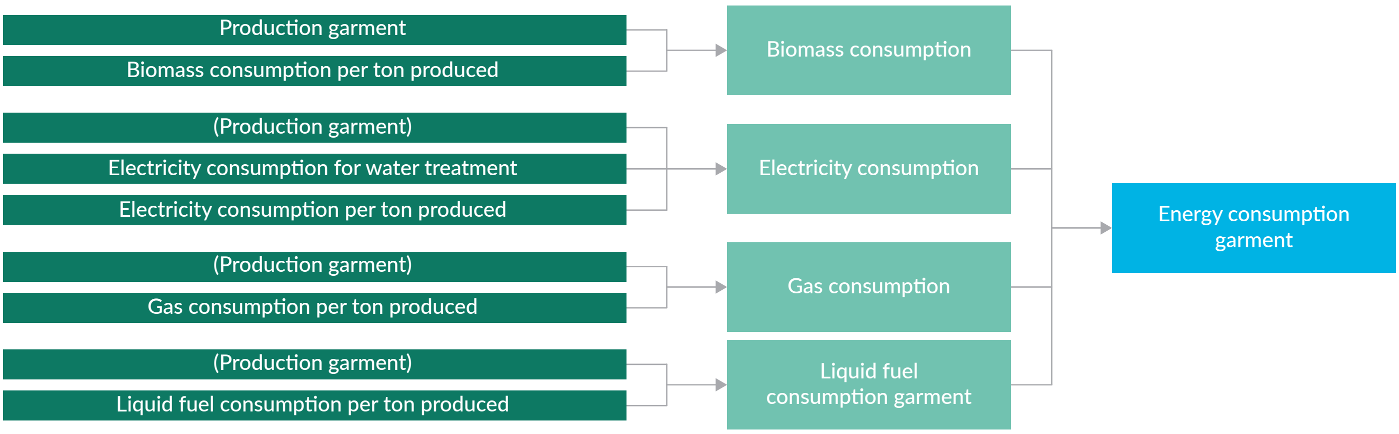


Figure 8: Causes tree energy consumption garments



simulate the impact of RE on electricity prices, based on the assumption that electricity from renewable sources is cheaper than conventional sources. If the RE policy is active (switch = 1), then the electricity price is a weighted average between the cost of conventional and RE, which is based on the share of RE in the market. If the RE policy is inactive (switch = 0), then the electricity price is assumed to remain constant based on 2017 values.

*Electricity Price = IF THEN ELSE (Policy Switch Renewable = 1, Electricity Price Per TJ * (1 - Share of Renewable Energy) + Renewable Electricity Price * Share of Renewable Energy, Electricity Price Per TJ)*

The estimation of energy consumption is also more elaborate than the one for water, labor, and materials. In this case, total sectoral energy consumption is based on production and energy intensity per ton of production, by energy source (UNIDO, 2016). The model also allows, under different scenario assumptions, to modify both energy intensity and the fuel mix of the subsector.

Figure 8 provides an overview of the variables used to determine the energy consumption of the garments sector, and shows that electricity consumption is estimated both for production and for on-site WWT. Total energy consumption is calculated using the following equation:

Total Energy Consumption = Biomass Consumption+Electricity Consumption+Gas Consumption+Liquid Fuel Consumption Garment + LPG Consumption

3.3.4 Environmental impacts

GHG Emissions

The model estimates total subsectoral GHG emissions from energy and land use. The variables used to determine total sectoral GHG emissions are presented in Figure 9.

Emissions from energy use are calculated based on total energy consumption by fuel and a respective emission factor. Figure 10 illustrates the variables used to calculate total emissions from energy use and emissions by fuel source. The use of RE contributes to the reduction of emissions from electricity generation. Similarly, fuel switching will also modify the energy consumption and emissions generated by each subsector.

Emissions from land use represent the carbon sequestration capacity that is lost because of production, specifically because of biomass consumption. In other words, these are the emissions generated by using biomass as energy source.

Figure 9: Causes tree total GHG emissions garments

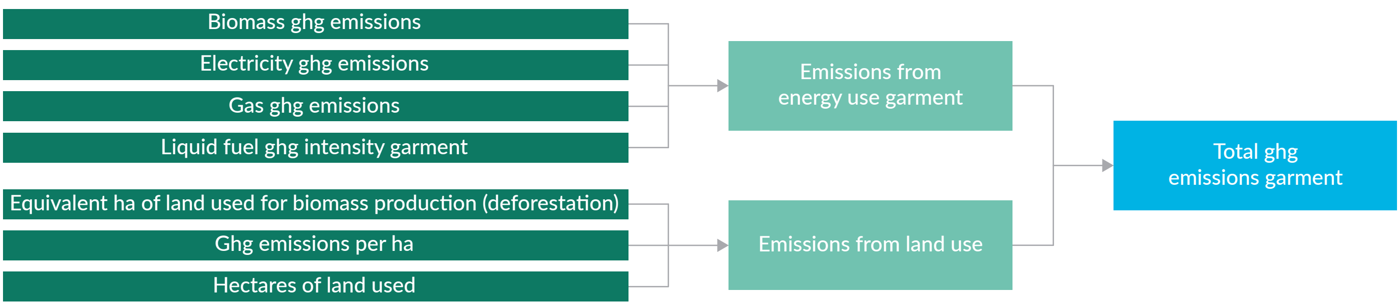


Figure 10: Causes tree emissions from energy use garments

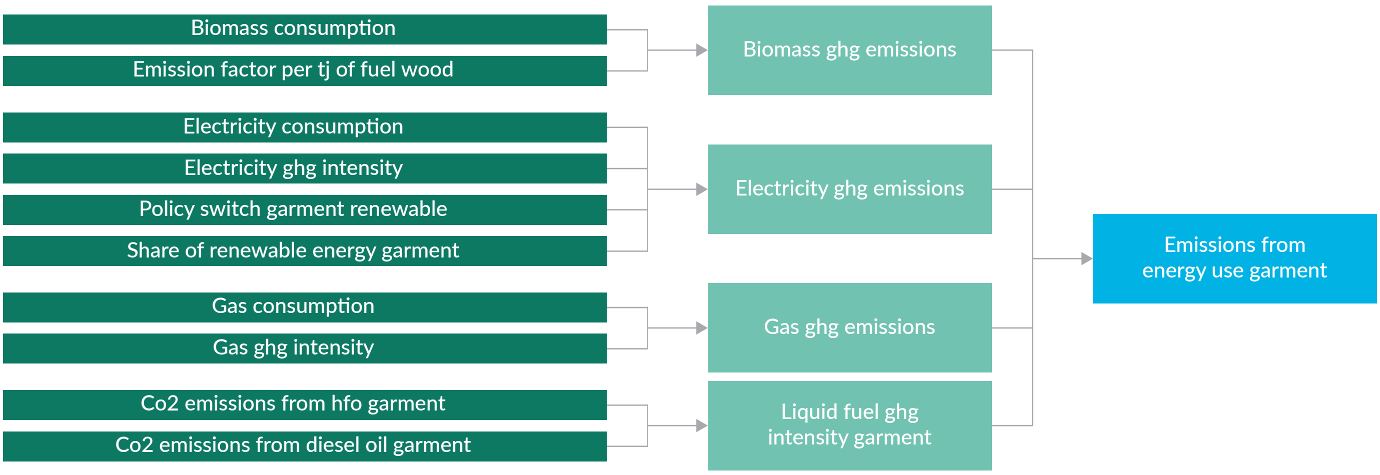


Figure 11: Emissions from land use

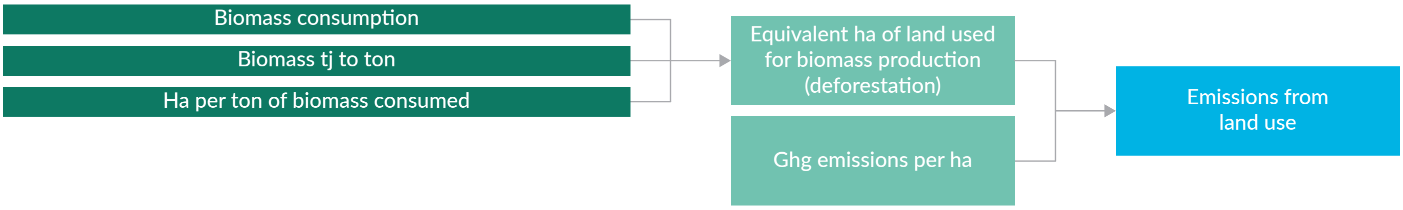
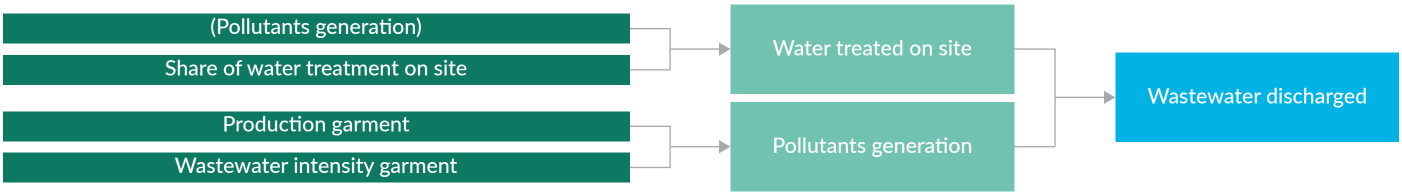


Figure 12: Wastewater treatment garments



Wastewater generation

The amount of wastewater generated by a subsector depends on production and required water use. The amount of untreated wastewater discharged into theenvironment depends on the amount of water used and the share that is treated on-site. The variables used to determine the water treated and the water discharged are displayed in Figure 12.

The total amount of pollutants generated, or wastewater generated, is calculated by multiplying total production by wastewater intensity.

*Pollutants Generation = Production *Wastewater Intensity*

Pollutants discharged into sewage and the environment depend on the share of wastewater that is treated on-site. This is an input to the model that can be modified in alternative scenarios. The amount of water treatment taking place on-site is used to determine costs for WWT (both capital and variable, including electricity consumption and cost).

Solid waste creation

The amount of solid waste generated is estimated based on total production and waste generation intensity. The equation used to calculate solid waste generation is formulated as:

*Solid Waste Generation = Production * Solid Waste Generation Intensity Under alternative scenarios, it is assumed that the total amount of solid waste will decrease proportionally with material intensity. In other words, if material intensity declines by 10% (less material is used per unit of output), solid waste generation will also decline by 10%.*

3.3.5 Environmental and society-wide costs

This section presents how society-wide costs, or those indicators included in the economy-wide CBA, are calculated. The starting point is the estimation of the impacts of production, through resource use and waste/pollution generation, which were presented in the section above. This section focuses on how such impacts are converted into costs, both for companies and society.

Economic valuation of emissions

The economic valuation of emissions, representing the cost of GHG emissions, can be calculated using two methods. The first one considers a potential market price for emissions, or the cost of abatement of one ton of GHG. This is an approach that assesses the potential impact of, for instance, the introduction of taxation (e.g., $10/ton of CO^2), allowing to estimate the economic value of air emissions. The second approach is based on the health impact of emissions, considering the increased incidence of respiratory diseases and the growing frequency, impact, and cost of weather-related natural disasters. This is also called Social Costs of Carbon (SCC) (Nordhaus, 2016).

In both cases, the starting point is the estimation of annual emissions, which are then multiplied by the value of emissions per ton. The model uses both approaches, and the following equations are used:

*Valuation of Emissions = Total GHG Emissions *Assumed Value of Emissions*

*Health Costs of Emissions= Total GHG Emissions *SCC per Ton of GHG*

WWT cost

Wastewater management costs consist of the cost of operation and maintenance (O&M) for WWT plants, and the electricity usage and related cost of WWT. All variables used to determine the costs of on-site WWT and its drivers are depicted in Figure 13.

The equation used to calculate the cost of WWT is formulated as the sum of O&M and electricity costs. Electricity consumption for WWT is estimated based on the wastewater treated on-site and the electricity consumption per liter treated.

*Waste Water Treatment Cost = Electricity Price *Electricity Consumption for Water Treatment+"O&M Cost of Water Treatment"*

*Electricity Consumption for Water Treatment = "Water Treated On-Site"*Electricity Consumption per Liter Treated*TJ per kWhThe O&M of WWT is based on the total wastewater treated on-site, and a cost factor for O&M per liter treated.*

Untreated wastewater health cost

The cost of untreated wastewater, i.e. the impact of water pollution on health, is primarily affected by the amount of untreated wastewater discharged. A constant factor is used to estimate the cost of each liter of untreated water. Hence, untreated wastewater health costs are calculated as:

*Untreated Wastewater Health Cost = Pollutants Discharge*Health Cost per Liter of Wastewater*

Waste management cost

The cost of waste management is driven by the amount of solid waste generated, which in turn is impacted by production. Hence, solid waste management costs are calculated as:

*Waste Management Cost = Solid Waste Generation*Waste Management Cost per Ton*

Inclusive costs

The variable "inclusive costs" accounts for all costs of production, both direct and indirect. Inclusive costs

Figure 13: Causes tree wastewater treatment cost garments

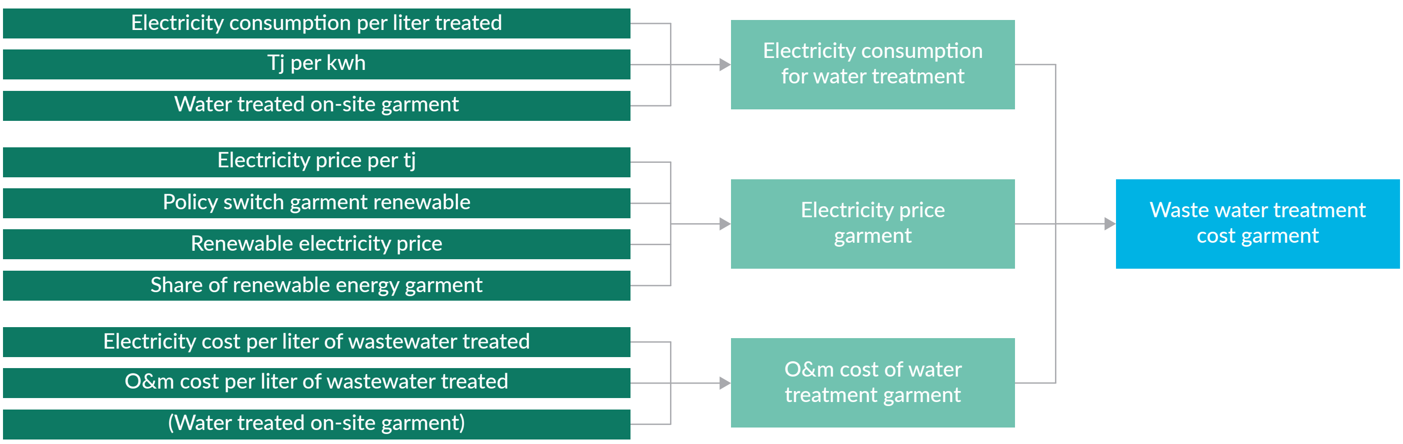
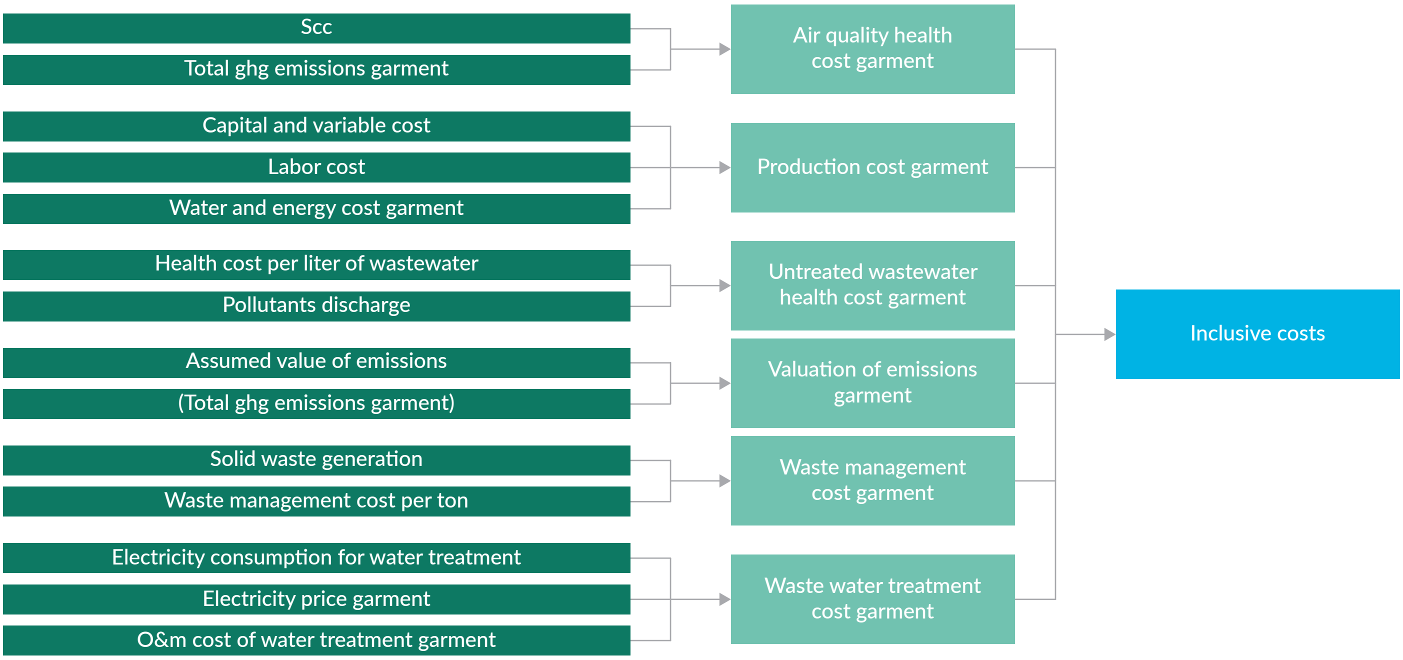


Figure 14: Causes tree inclusive costs garments



are estimated to assess the economy-wide impacts of production, and compared with more traditional cost accounting (including capital and O&M, materials, labor, energy, and water). The variables used to calculate the inclusive costs of the garments sector are displayed in Figure 14. The following equation is used to calculate total inclusive costs by sector:

Inclusive Costs = Production Costs +Valuation of Emissions +Wastewater Treatment Cost +Waste Management Cost +Air Quality Health Cost+ Untreated Wastewater Health Cost

3.3.6 Productivity

The model estimates four key indicators of productivity: energy, water, labor, and GHG. Productivity is defined as the amount of GDP generated with one unit of input or output of production. For instance, energy productivity is the amount of GDP, and hence riel, generated by using one kilowatt hour (kWh) of electricity, or one Tera Joule (TJ) of energy. As a result, if productivity increases we are either receiving a higher price for what we produce, or we are using fewer inputs (or generating less emissions and wastewater or solid waste) for each unit produced. Practically, it is more desirable to generate Riel 2 per kWh used, rather than Riel 1 per kWh. Similarly, it is more desirable to generate Riel 2 per kg of GHG emissions created, rather than Riel 1 per kg of GHG emissions created.

In light of the above, productivity is the inverse of intensity. In fact, energy or water intensity, for example, is estimated by dividing energy or water consumption by GDP. Intensity tells us how much energy or water we consume to produce one riel of GDP. Productivity, the inverse of this formulation, tells us how much riels we generate for each kWh of energy or liter of water consumed.

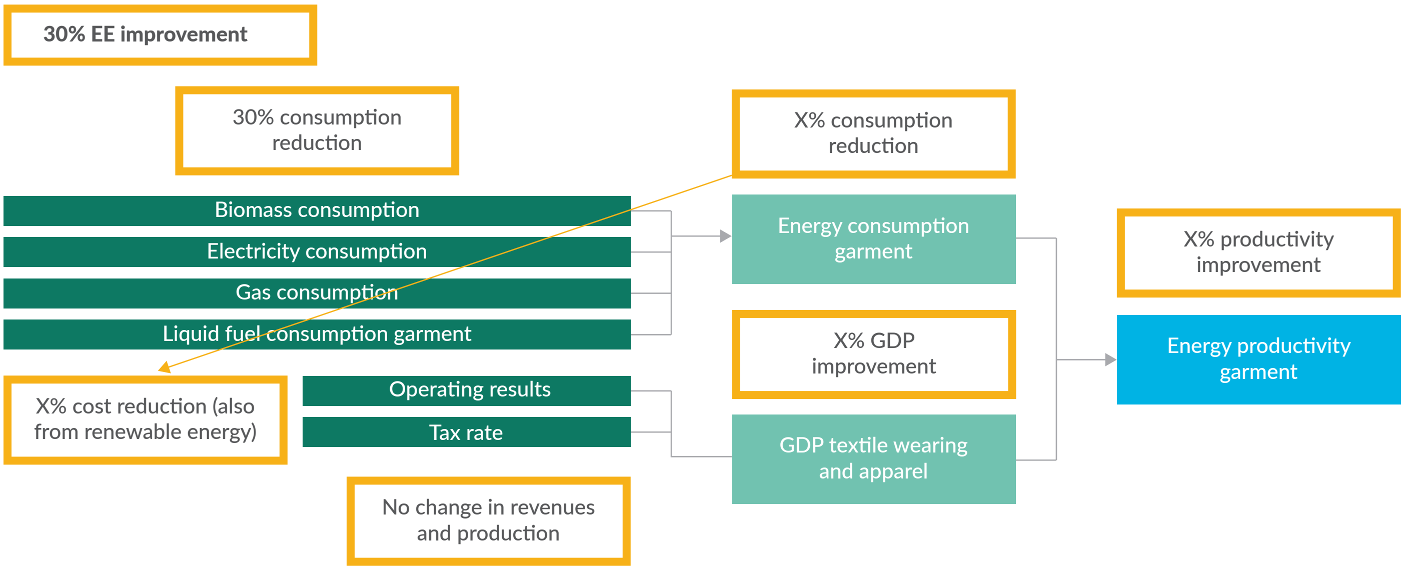
Energy productivity

Energy productivity represents the value added generated per TJ of energy consumed. The energy productivity of the garment sector is calculated based on GDP and total energy consumption. The following equation is used for the calculation:

Energy Productivity = GDP /Energy Consumption

The variables used to calculate energy productivity are displayed in Figure 15 and Figure 16 through a tree diagram. Worth mentioning are EE and RE.

Figure 15: Causes tree energy productivity garments



The first diagram shows that, from left to right, if a 30% improvement in EE is achieved (without fuel switching), there will be a 30% reduction in energy consumption. This will result in an increase in energy productivity because even if production and revenues do not change, a decline in costs results in higher GDP (GDP is primarily driven by revenues and costs).

The second diagram, meanwhile, shows the impact of increasing the use of RE. Since electricity generated by solar power is cheaper than electricity purchased from the grid, an increase in the use of RE is expected to reduce the cost of electricity consumption. Practically, the amount of electricity consumed remains the same, but the price declines. Similar to what was described above for EE, this reduces costs, increases value added and profits, and hence productivity.

Water productivity

Water productivity represents the economic value generated per liter of water consumed. It is calculated by dividing GDP by water consumption. The following equation is used to calculate water productivity and Figure 17 presents the tree diagram.

Water Productivity = GDP /Water Consumption

Labor productivity

Labor productivity indicates the value added generated per employee each year. The labor productivity of the garments sector depends on GDP and the number of workers employed in production. The following equation is used to calculate labor productivity and Figure 18 presents the tree diagram.

Labor Productivity = GDP /Employment

Figure 16: Causes tree energy productivity garments

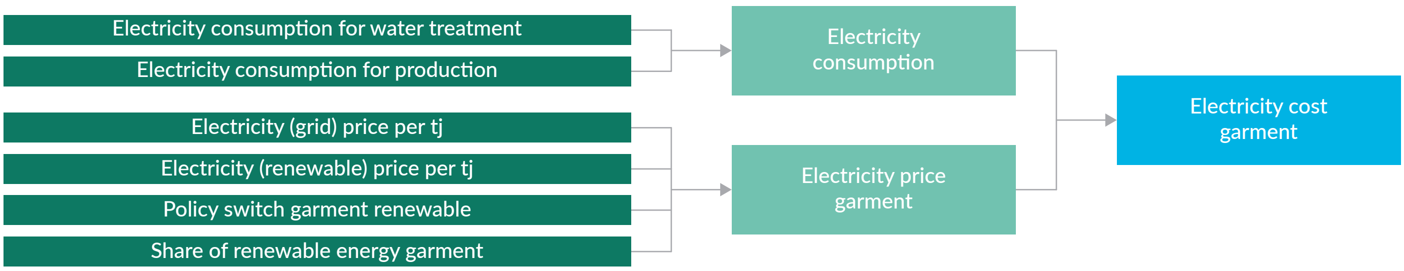


Figure 17: Causes tree water productivity garments

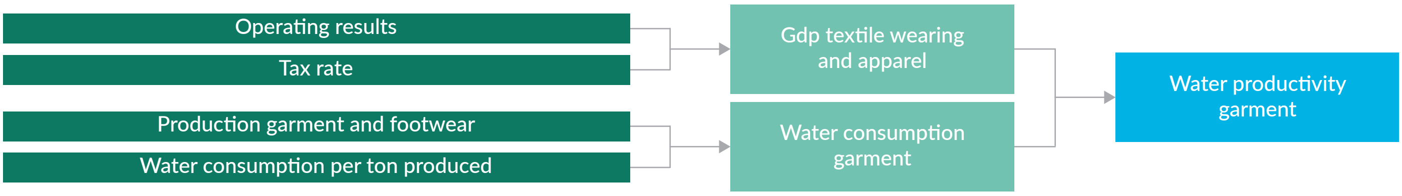


Figure 18: Causes tree labor productivity garments

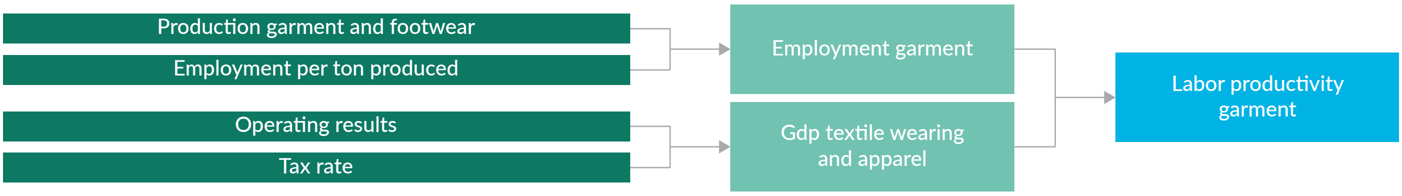
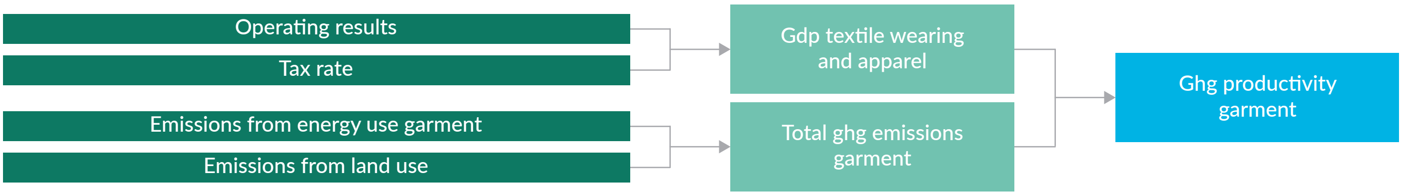


Figure 19: Causes tree GHG productivity garments



GHG productivity

GHG productivity indicates the amount of value added per ton of GHG emitted. The GHG productivity is calculated based on GDP and GHG emissions. The following equation is used to calculate GHG productivity and Figure 19 presents the tree diagram.

GHG Productivity = GDP /Total GHG Emissions

3.4 Data collection

Data collection started at the beginning of the project to support the identification of the sectors to be analyzed, and continued throughout the development of the models and formulation of scenarios. A comprehensive approach to data collection was employed, including (a) the review of several national databases, reports, and research papers; (b) the identification and review of international reports and peer-reviewed papers; and (c) consultations with various stakeholders, with bilateral meetings as well as project consultation meetings.

Table 10 summarizes the availability of data (dark green), the indicators that could be calculated with confidence (light green), and data gaps that required making assumptions (pink). It can be seen that, at opposite ends, garment is the subsector for which most data are available and electronics is the one with most data gaps (at least, at the national level). More specific data sources used are presented in Appendix B, by subsector and distinguishing between national and international data sources.

Concerning data gaps, three main patterns emerged during the project: (a) uneven data availability for industrial subsectors (limited data on GDP and lack of data on energy consumption) in national databases; (b) absence of data at the subsectoral level on revenues and costs, as well as on environmental impacts; and (c) lack of information on technology cost and effectiveness for the specific context of Cambodia. Countering the lack of data at the subsectoral level is the availability of specific data at firm level (from UNIDO projects, such as Hot Spot and TEST). This led to the compilation of a database for model customization and calibration that used both top-down (subsectoral) and bottom- up (company level) data.

Table 10: Data availability and data gaps, by subsector.

	Garment		Bricke		Food processing		Electronics	
	Cambodia	International	Cambodia	International	Cambodia	International	Cambodia	International
Economic indicators								
GDP and value of production	x	x	o		x			x
Production			x					x
Employment	x	x	x		x			x
Capital investment	x		o	x		o	o	x
Enery consumption	x	x	x	x	x	x		x
Water consumption	o		x		x	o		x
Solid waste generation		x				x		
Land use			x					
Pollution (air & water)								
Air pollution (SO2, CO, NO2, VOC, PM10, TSP)	x		x		x		x	
Toxic discharges (to air, water)	x		x		x		x	
Water pollutants (BOD, TSS)	x		x		x		x	
Technologies								
Technologies to improve efficiency	x	x	x	x	x			
Technologies to reduce pollution					x			
Economic viability of technologies	x	x	x	x	x			
Policies								
Direct investment	x					x		
Access to financing								
Incentives/disincentives	x	x	x	x	x	x	x	x
Law and mandates	x	x	x	x	x	x		x
Capacity building and awareness raising	x	x	x	x	x	x		

Legend:

Available (x)

Estimated (o) based on available data

Not available, required assumptions

3.5 Scenarios

Several scenarios have been simulated to assess the potential contribution of a green industrial transition for the four subsectors analyzed. These scenarios were identified and defined with the support of local stakeholders, involving the private sector as well as government representatives, academia, and civil society.

The starting point in identifying scenarios was the review of indicators of economic performance of the subsectors. These include traditional accounting and balance sheet indicators, such as revenues and costs. Concerning revenues, emphasis was put on increasing the **export potential (EX)**, possibly connected to access to new markets that offer a premium price. Regarding costs, scenarios were tested for the possibility to reduce the cost of **labor, energy** (also through fuel switching, **EE-FS**), **water**, and **materials**. Further, emphasis was put on the social and environmental impacts of production, with scenarios assessing the outcomes of reducing **water pollution** and increasing the use of **RE**. Finally, all these interventions were tested when implemented in isolation and simultaneously, with the latter case representing a GI scenario. This last scenario shows synergies, specifically in the case of ME, which reduces solid waste generation and related costs; EE, which reduces the need to invest in RE to reach a target share of RE use as well as health impacts from emissions; WE, which reduces wastewater generation and related costs as well as health impacts.

Once the key areas of intervention were identified, the level of ambition was estimated. This entailed a review of existing national and international policy documents and technical reports, collecting information on the maximum potential for efficiency improvements (theoretical maximum and international best practices); the availability of future targets (10% improvement in energy and/or WE by 2025); allocation of investments for specific sectors and technologies, as capital investments or incentives; and implementation of a regulation or mandate (on water consumption and energy use).

Several policy documents were reviewed to better understand the current challenges and possible future opportunities for the industrial sector in Cambodia. These include the Cambodia Industrial Development Policy 2015-2025, the National Strategic Plan on Green Growth 2013-2030, the Climate Change Action Plan for Industry and Handicraft Sectors 2015-2018, the Climate Change Strategic Plan for Manufacturing Industry and Energy, ongoing work for the SDGs and Nationally Determined Contribution, Supreme National Economic Council (SNEC) Rectangular Strategy, National Energy Efficiency Policy and Action Plan, and Law on Taxation and Investment.

Table 11 provides an overview of the information collected that is relevant to the identification of the level of ambition for the scenarios analyzed. For all scenarios a range of values is considered, starting from no ambition (no change, which corresponds to the BAU scenario) to high ambition (the highest value found in the literature that is commercially viable). It is assumed that new interventions to reach stated targets start in 2020, and that all targets are reached by 2025. Specifically:

- **Exports (EX)**: Exports increase by up to 5% per year (above baseline), leading to higher revenues and profitability (when export prices are higher than local ones).
- **Labor intensity (LI)**: LI declines by 3% per year (above baseline), reducing labor costs and bringing labor productivity in Cambodia closer to other ASEAN countries.
- **Energy efficiency (EE) and energy efficiency with fuel switching (EE-FS)**: EE improves by 20% in 2025, following the actions included in the National Energy Efficiency Policy.
- **Water efficiency (WE)**: WE improves by 30% in 2025, realizing the potential identified in firm-specific and sector-wide studies in Cambodia.
- **Material efficiency (ME)**: ME improves by 20% in 2025 (with the exception of bricks manufacturing) based on sector-specific assessments, primarily from international sources.
- **Wastewater treatment (WWT)**: 100% of wastewater is treated by 2025 to lower health and environmental impacts.
- **Renewable energy (RE)**: Considering primarily existing targets in ASEAN countries, on-site RE (excluding hydropower) will represent 15% of electricity consumption by 2025.

The scenarios listed above are used to estimate the outcomes of reaching a stated target. Every scenario estimates the cost of reaching the target, resulting in avoided costs (from energy and water savings) and additional benefits (reduction of air emissions and water pollution). These results are presented in Section 4. If,

Table 11: Summary of the information collected on national and international targets.

	Cambodia	International Case studies
Increase export potential (target: 0% to 25%)	Increasing exports is an important opportunity for Cambodia. This is reflected in the potential to access premium markets and revive established sectors (e.g., garments) and to stimulate the growth of emerging ones (e.g., electronics).	80% of ASEAN exports of electronics are extra-ASEAN. The electronics sector makes up a large share of FDI, especially in South Korea. An increase in exports leads to higher production.
Labor intensity (target: 0% to 10%)	The increase in labor costs calls for higher labor productivity. Garments will see a 60% increase in total labor costs in the next few years.	Labor productivity (value added generated per employee) is generally higher in ASEAN countries than in Cambodia. Garments show Cambodia being at 25% relative to Thailand, 40% relative to the Philippines, and 80% relative to Pakistan.
Energy, water, and resource efficiency improvement (target: Energy 0% to 20%; Water 0% to 30%; Materials 0% to 20%)	Energy efficiency industrial sector: 25% relative to the BAU scenario by 2035. Potential EE improvement in the range of 28% for garments, 35% for rice mills, 18% for food industry, and 35% for bricks manufacturing. Water savings are estimated in the range of 8% to 40% in the food sector.	Energy costs range from 5% to 12% of total production costs for garments in most countries. This shows the potential to cut costs by 50% when the right technology and energy sources are used. Energy efficiency industrial sector, against BAU: Brunei Darussalam (10%), Indonesia (10-30%), Malaysia (30.8 Terawatt Hour, TWh), Myanmar (20%), the Philippines (541 kilo tons of oil equivalent, ktoe), Vietnam (23%). In electronics, the type of production (low cost vs upscale) greatly impacts water and energy consumption.
Water pollution reduction (treatment and discharge) (target: 0% to 20%)	Up to 47% reported by UNIDO in the Hot Spot and Test Case studies; possibly higher value if enforcement of water treatment is performed.	While no specific target is available, the ASEAN Strategic Plan of Action on Water Resources Management and the ASEAN Environmental Cooperation stress the need to improve water efficiency through water demand management.
Air quality improvement and GHG emissions abatement (target: linked to energy efficiency and fuel switching)	(National level) reduction of 28.5 million tons between 2017 and 2035, relative to the BAU scenario	EU, 15% by 2030 relative to 1990 values. Singapore (national level), 36% emission intensity reduction in 2036 compared to 2010. China, 10% or more reduction by 2017 relative to 2012.
Renewable energy use (target: 0% to 15%)	Use of solar power regulated by the General Conditions for Connecting Solar Generation Sources to the Electricity Supply System of National Grid or to Electrical System of a Consumer Connected to the Electricity Supply System of National Grid. Up to 50% of the existing consumption (or Contract Demand) is allowed, with limitations on total generation at the national level.	National level targets: Indonesia (15%), Malaysia (30% by 2025), Thailand (20% by 2022).

from an analysis of the investment required, it emerges that either the costs are too high or the payback time is too long, incentives could be introduced (either to reduce capital costs or provide access to financing, or to reduce variable costs). As a result, the simulation of these scenarios informs policy analysis, where the most suitable policy interventions will be identified among those available at the subsectoral level. This analysis is presented in Section 5.

3.6 Model and scenario assumptions

This section presents the scenario assumptions simulated with the model to generate the various scenarios presented above.

3.6.1 Business as Usual (BAU)

The BAU scenario assumes a continuation of the historical trends at the subsectoral level, without implementing new interventions or additional investments to improve efficiency and productivity.

This implies that production continues to increase (at a value consistent with the growth of the last years), and that energy, water, and material consumption follows the same trend. The pressures on the environment will continue to grow as a consequence of increasing production.

Model projections show that sectoral profit margins (the ratio of profits and revenues) tend to increase in the future at a different degree depending on the subsectors. This is because of the assumption that LI (the amount of jobs required per unit of production, like one ton of bricks) declines by 2% per year and that market prices increase, following historical trends. As a result, the cost of production is forecasted to decline, while revenues increase. This leads to an increase of the profit margin over time. All other model inputs, such as market prices and other production costs, are assumed to remain constant in real terms (i.e., inflation adjusted) going forward. Table 12 provides an overview of the average profit margins by sector between 2020 and 2030.

Table 12: Profit margins in the BAU scenario.

Sector	Unit	2020	2030
Garments	%	14.8	16.1
Bricks	%	28.6	34.8
Food processing	%	22.4	31.6
Electronics	%	24.3	26.1

3.6.2 Green Industry (GI)

The GI scenario assumes that all targets (export, labor and resource efficiency, and use of RE) are combined and implemented simultaneously. It provides an indication of the full potential costs and benefits emerging from the implementation of all targets. It also highlights where synergies and side effects emerge.

This section briefly describes the targets, and more details about each (including related assumptions) are presented in the next sections.

Table 13 provides a summary of the targets simulated in the GI scenario. Concerning their timing and trajectory, all resource efficiency improvements are assumed to be achieved between 2020 and 2025, growing linearly over time until the target is reached in 2025. After 2025, no additional improvements are assumed.

3.6.3 Export scenario (EX)

The study assumes an increase in exports, which differs depending on the sector. The increase in exports is assumed to start from the year 2020 and last until 2025, after which the baseline growth rate applies again.

Two assumptions are simulated concerning the market price for production: (i) one in which there is no change to the price charged and (ii) another in which a prime premium of 20% is paid for the additional export assumed in this scenario. Table 14 presents the assumptions used for this scenario, or the changes implemented in the model relative to the BAU scenario.

[9] *As indicated above, no material efficiency improvements are assumed for the bricks sector in this analysis.*

Table 13: Overview of efficiency measures in the GI scenario

Intervention	Assumed Target
Production increase (for export)	Garments: 5% per year Bricks: no change Food processing: 2.5% per year Electronics: 5% per year
Labor efficiency	3% per year between 2020 and 2025
Energy efficiency	20% above BAU by 2025
Water efficiency	30% above BAU by 2025
Material efficiency[9]	20% above BAU by 2025
Wastewater treatment	Reaching 100% by 2025 (20% more than BAU by 2025)
Renewable energy	15% by 2025

Table 14: Assumptions export scenario: annual growth rate of exports.

Subsector	Baseline growth rate of production	Alternative growth rate of production	Notes
Garments	7.5%	12.5%	Additional 5% increase (every year)
Bricks	6%	6%	No change, production for domestic market
Food processing	4%	6.5%	Additional 2.5% increase (every year)
Electronics	5%	10%	Additional 5% increase (every year)

Table 15: Assumptions labor productivity scenario

Assumption	Unit	Value	Source
Reduction LI garments	% / Year	5	This is a 3% increase relative to the BAU scenario.
Reduction LI bricks	% / Year	5	
Reduction LI food processing	% / Year	5	
Reduction LI electronics	% / Year	5	

3.6.4 Labor intensity scenario (LI)

The study assumes a reduction in sectoral LI starting from 2020. A reduction in LI normally takes place in all sectors, as mechanization increases and workers become more skilled. For this reason, a 2% decline in LI is assumed for all sectors in the baseline scenario. In addition, LI is assumed to decrease by 5% per year between 2020 and 2025. The reduction in LI leads to an increase in labor productivity, as the output generated remains unchanged while the employed workforce and related costs decrease.

Table 15 presents the assumptions used for this scenario. The same assumptions are used across all subsectors.

3.6.5 Energy efficiency scenario (EE)

The improvement of EE is assumed, through the adoption of energy efficient technologies. The improvement of EE is assumed to be linear, growing from the baseline level in 2020 (hence 0% increase) to 20% by 2025. It is further assumed that EE does not improve after 2025.

Table 16 presents the assumptions used for this scenario, or the changes implemented in the model relative to the BAU scenario.

The investment required to improve EE in the garments sector was estimated using various data sources, both national and international. Specifically, the value used in the model was calculated as the average investment implemented in various companies, as per information provided by UNIDO (2016). Other sources were used to validate this cost assumption, considering that the garments model has a higher level of aggregation (subsector instead of company)

3.6.6 Energy efficiency and fuel switching (EE-FS)

Both the reduction of energy intensity and fuel switching are assumed. This scenario is tested because often the technologies that improve EE also require different fuels of energy sources.

Fuel switching follows the trend of the improvement of EE. When half of the target for EE is achieved, half of the potential fuel switching is also assumed to have taken place. As a result, fuel switching is also assumed to be linear, growing from the baseline level in 2020 (hence 0% increase) to its maximum potential in 2025. Fuel switching takes place on the industry level, assuming that 100% of companies switch fuels towards, for instance, increased biomass use by 2025.

Table 17 presents the assumptions used for this scenario, and only presents the different energy mix (all the other assumptions presented for the EE scenario remain the same in the EE-FS case).

The cost assumption for investments is the same as for the EE scenario, based on the IEE and Hot Spot case studies (UNIDO, 2016). The addition in this scenario is fuel switching, and hence the total amount of energy consumed remains the same as in the EE case, but the energy source used differs.

3.6.7 Water efficiency scenario (WE)

The improvement of WE is assumed, through the adoption of water efficient technologies. The improvement of WE is assumed to be linear, growing from the baseline level in 2020 (hence 0% increase) to 30% by 2025. It is further assumed that WE does not improve after 2025.

Table 18 presents the assumptions used for this scenario, or the changes implemented in the model relative to the BAU scenario.

The investment necessary to improve WE was estimated using various data sources, both national and international. The value used in the model was calculated as the average investment implemented in various companies, as per information provided by UNIDO (2016). Other sources were used to validate this cost assumption, considering that the garments model has a higher level of aggregation (subsector instead of company).

3.6.8 Material efficiency scenario (ME)

The improvement of ME is assumed, through the adoption of more efficient technologies. The improvement of ME is assumed to be linear, growing from the baseline level in 2020 (hence 0% increase) to 20% by 2025. It is further assumed that ME does not improve after 2025.

Table 19 presents the assumptions used for this scenario, or the changes implemented in the model relative to the BAU scenario.

Table 16: Assumptions energy efficiency scenario

Assumption	Unit	Value	Source
Garments			
Improvement in energy efficiency by 2025	%	20	
Cost per TJ of energy avoided	USD / TJ	12,888	(UNIDO, 2016)
Social costs of carbon per ton of GHG	USD / Ton	31.00	(Nordhaus, 2016)
Valuation of emissions per ton	USD / Ton	10.00	Assumption
Share of energy sources used			
Electricity	%	24.5	(ILO & IFC, 2009)
Wood	%	43.4	
Diesel oil	%	27.9	
Heavy Fuel Oil	%	4.2	
Energy prices			
Electricity	mn. Riel / TJ	188	(Derbyshire , 2015)
Wood	mn. Riel / TJ	13.31	(UNIDO, 2016)
Heavy Fuel Oil	mn. Riel / TJ	70.61	
Diesel oil	mn. Riel / TJ	125.5	(Trading Economics, 2017)
Bricks			
Improvement in energy efficiency by 2025	%	20	
Cost per TJ of energy avoided	USD / TJ	5,818	(UNIDO, 2016)
Social costs of carbon per ton of GHG	USD / Ton	31.00	(Nordhaus, 2016)
Valuation of emissions per ton	USD / Ton	10.00	Assumption
Share of energy sources used			
Electricity	%	0.0	(UNIDO, 2016)
Wood	%	97.3	
Diesel oil	%	2.7	
Rice husk	%	0.0	

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Assumption	Unit	Value	Source
Energy prices			
Electricity	mn. Riel / TJ	188	(Derbyshire , 2015)
Wood	mn. Riel / TJ	6.65	(UNIDO, 2016)
Rice husk	mn. Riel / TJ	6.48	
Diesel oil	mn. Riel / TJ	125.5	(Trading Economics, 2017)
Food processing			
Improvement in energy efficiency by 2025	%	20	
Cost per TJ of energy avoided	USD / TJ	14,541	(UNIDO, 2016)
Social costs of carbon per ton of GHG	USD / Ton	31.00	(Nordhaus, 2016)
Valuation of emissions per ton	USD / Ton	10.00	Assumption
Share of energy sources used			
Electricity	%	3.1	(UNIDO, 2016)
Wood	%	73.4	
Diesel oil	%	18.3	
LPG	%	5.2	
Energy prices			
Electricity	mn. Riel / TJ	188	(Derbyshire , 2015)
Wood	mn. Riel / TJ	5.7	(UNIDO, 2016)
LPG	mn. Riel / TJ	98.68	
Diesel oil	mn. Riel / TJ	125.5	(Trading Economics, 2017)
Electronics			
Improvement in energy efficiency by 2025	%	20	
Cost per TJ of energy avoided	USD / TJ	12,888	(UNIDO, 2016)
Social costs of carbon per ton of GHG	USD / Ton	31.00	(Nordhaus, 2016)
Valuation of emissions per ton	USD / Ton	10.00	Assumption
Share of energy sources used			
Electricity	%	59.2	(Williams, 2009)
Wood	%	0.0	
Diesel oil	%	40.8	
Heavy Fuel Oil	%	0.0	
Energy prices			
Electricity	mn. Riel / TJ	188	(Derbyshire , 2015)
Diesel oil	mn. Riel / TJ	125.5	(Trading Economics, 2017)

Table 17: Assumptions for the energy efficiency + fuel switch scenario

Assumption	Unit	EE scenario	EE-FS scenario
Garments			
Share of energy sources used		(ILO & IFC, 2009)	(UNIDO, 2016)
Electricity	%	24.5	24.5
Wood	%	43.4	63.4
Diesel oil	%	27.9	11.9
Heavy Fuel Oil	%	4.2	0.2
Bricks			
Share of energy sources used		(UNIDO, 2016)	(UNIDO, 2016)
Electricity	%	0.0	0.2
Wood	%	97.3	60.0
Diesel oil	%	2.7	15.0
Rice husk	%	0.0	38.3
Food processing			
Share of energy sources used		(UNIDO, 2016)	(UNIDO, 2016)
Electricity	%	3.1	24.5
Wood	%	73.4	63.4
Diesel oil	%	18.3	11.9
LPG	%	5.2	0.2
Electronics			
Share of energy sources used		(Williams, 2009)	Assumption
Electricity	%	59.2	69.2
Wood	%	0.0	0.0
Diesel oil	%	40.8	30.8
Heavy Fuel Oil	%	0.0	0.0

Table 18: Assumptions water efficiency scenario

Assumption	Unit	Value	Source
Improvement of water efficiency by 2025	%	30	
Cost per m³ of water avoided			
Garments	USD / m³	0.19	(UNIDO, 2016)
Bricks	USD / m³	2.5	(Envirowise, 2001)
Food processing	USD / m³	1.78	(UNIDO, 2016)
Electronics	USD / m³	0.19	(UNIDO, 2016)
Water	USD / m³	0.37	National tariffs
Wastewater treatment			
Electricity consumption	kWh / m³	0.254	(Smith & Liu, 2017)
Capital cost	USD / m³	0.423	(MIWEA, N.D.)
O&M cost	USD / m³	0.724	

The investments to increase ME were estimated using various data sources, both national and international. The value used in the model was calculated based on information provided by the German Investment and Development Association (DEG, 2016). The calculated parameters were complemented with data provided by UNIDO (2016). Other sources were used to validate this cost assumption, considering that the garments model has a higher level of aggregation (subsector instead of company) than the information provided by case studies.

3.6.9 Wastewater treatment scenario (WWT)

The improvement of WWT is assumed, through the expansion of WWT capacity. The improvement of the amount of wastewater treated is assumed to be linear, growing from the baseline level of 80% in 2020 to 100% by 2025, indicating that all industrial wastewater would be treated on-site.

Table 20 presents the assumptions used for this scenario, or the changes implemented in the model relative to the BAU scenario. The same assumptions are used across all sectors.

Investments in WWT were estimated using various data sources, both national (based on current costs and use of wetlands for water filtration) and international (based on the cost of technology and related energy consumption). The value used in the model was calculated based on information provided by the Michigan Water Environment Association (MIWEA, N.D.).

3.6.10 Renewable energy (RE)

An increase in the use of RE for power generation is assumed. This is assumed to be internal power generation, for own consumption by companies. It is therefore assumed that the electricity generated by RE (e.g., solar power) reduces the amount of power purchased from the grid when compared with the BAU scenario. However, there is no net reduction in power purchased from the grid when comparing forecasts (BAU and GI) relative to the year 2018 and the power purchase agreement in force in that year.

The expansion of RE is assumed to be linear, growing from the baseline level in 2020 (hence 0% increase) to 15% of electricity consumption in the sector by 2025. It is further assumed that the penetration of RE in electricity

Table 19: Assumptions material efficiency scenario

Assumption	Unit	Value	Source
Garments			
Improvement ME by 2025	%	20	
Cost per ton of material avoided	USD / Ton	260.09	(DEG , 2016)
Bricks			
Improvement ME by 2025	%	-	No improvement assumed possible in bricks production
Cost per ton of material avoided	USD / Ton	-	
Food processing			
Improvement ME by 2025	%	20	
Cost per ton of material avoided	USD / Ton	216.33	(UNIDO, 2016)
Electronics			
Improvement ME by 2025	%	20	
Cost per ton of material avoided	USD / Ton	260.09	(DEG, 2016) – assumed to be the same as in the case of garments (gains obtained through reducing waste and rework)

Table 20: Assumptions water efficiency scenario

Assumption	Unit	Value	Source
Share of wastewater treated by 2025	%	100	Up from 80% in the baseline
Wastewater treatment			
Electricity consumption	kWh / m^3	0.254	(Smith & Liu, 2017)
Electricity cost	USD / TJ	46,615	(Derbyshire , 2015)
Capital cost	USD / m^3	0.423	(MIWEA, N.D.)
O&M cost	USD / m^3	0.724	
Health impact per m^3 untreated	USD / m^3	1,930	(WHO, 2004)

consumption does not increase after 2025, meaning that the share of RE remains at 15% moving forward.

Table 21 presents the assumptions used for this scenario, or the changes implemented in the model relative to the BAU scenario. The same assumptions are used across all subsectors.

The investment required to purchase, install, and operate power generation capacity, specifically solar power, was based on the review of several data sources. The primary one was the 2014 edition of the World Energy Investment Outlook (IEA, 2014), which was cross-checked with WWF's power sector vision for Cambodia (WWF, 2016) and with exchanges that took place with private sector companies that work in the region to install and operate solar panels.

Table 21: Assumptions renewable energy scenario

Assumption	Unit	Value	Source
Share of renewable energy used by 2025	%	15	
Cost per MW of renewable capacity	USD / MW	1,150,000	(IEA, 2014)
Load factor renewable capacity	%	20	
Cost per TJ of renewable energy	USD / TJ	32,631	Assuming the average cost of generation per MWh or TJ (i.e. the levelized cost of generation) is 30% cheaper than electricity purchased from the grid (approx. 12 cents/kWh); consistent with the generation cost estimates provided by WWF (WWF , 2016)[10]

[10] Even without subsidies, solar power can provide electricity at around USD 0.12/kWh. According to Mekong Strategic Partners (de Ferranti, Fullbrook, McGinley & Higgins, 2016), if 20% of the upfront capital cost can be met with grant funding, then solar can achieve parity with coal (which costs USD 0.9 or 0.10/kWh).

Text Box 1: Current state of grid-connected solar panels for industrial users

The assumption made in the RE scenario is that electricity produced by on-site solar panels costs 30% less than grid electricity. This is based on the cost of solar panels, mounting and balance of system equipment, the efficiency of solar panels, and the lifetime of the system. This is compared to the market price of electricity in Cambodia.

The new regulation on the use of RE provides specific information that can be used to compare our assumptions with the conditions to be met for purchasing and installing solar panels at the subsectoral level. Recent regulation introduces a fee for capacity (between USD 7/kWh/month and USD 10/kWh/month of power capacity installed) and a fee to be paid by producers (hence not a feed in tariff) for the generation of electricity (between USD 0.093/kWh and USD 0.12/kWh) applicable only for medium- and high-voltage users.

To illustrate with an example: if we consider production capacity of one kWh, 24 hours available each day, 365 days per year, and the solar radiation of the area, resulting in the potential use factor of 17.44%, the total amount of kWh produced per year is 1,528 and 127 per month.

- With this information, the capacity fee per kWh, estimated as dividing the capacity charge of USD 7 to 10/kWh/month by the estimated generation, would be USD 0.055/kWh to USD 0.078/kWh.
- As a result, the total cost per kWh produced would be USD 0.148/kWh (0.093 -generation fee- plus 0.055 -capacity fee-) or USD 0.198/kWh (0.12 -generation fee- plus 0.078 -capacity fee-).

These fee provisions set by the government indicate that there is no economic advantage for independent power producers. This is consistent with the government's rationale to introduce a new regulation that only finances the modernization of the grid to be able to absorb more solar capacity in the future, but does not allow for the growth of RE. This is because the above assumptions imply that, while there is cost saving from producing electricity with solar panels, the investment to purchase them will not be paid back (the payback time is longer than the lifetime of solar panels).

Therefore, while current regulation reduces the potential for the adoption of grid-connected solar RE, it ensures that any capacity added can be supported by the grid. The current regulation requires financing for the grid before capacity is added, with part of the investment to modernize the grid being subsidized by early adopters of solar panels

4. Findings

This section provides an overview of the results of the analysis. It starts with a summary by subsector, then provides details by area of intervention and scenario for (i) the investment required to reach stated targets, (ii) the resulting avoided costs (cost reductions relative to the baseline scenario, such as reduced energy costs), and (iii) an aggregation of these results into a firm-level and economy-wide CBA. Details are also provided by subsector to better understand how the new assumptions (when compared to the BAU case) lead to the results presented.

4.1 Summary of results

Reaching the targets described above for all subsectors in the GI scenario requires a total cumulative investment of Riel 16,948.4 Bn by the year 2030, and an additional Riel 15,352.7 Bn by 2040. This is equivalent to cumulative investments of USD 4.24 Bn by 2030 and USD 3.84 Bn by 2040, for a total of USD 8.08 Bn between 2020 and 2040.

These investments result in cumulative avoided costs and added benefits of Riel 77,182.1 Bn (USD 19.29 Bn) at the firm-level, and economy-wide impacts of Riel 94,147.2 Bn (USD 23.54 Bn) by 2030. These values increase to Riel 263,876.9 Bn (USD 65.97 Bn) at the firm-level and Riel 318,276.6 Bn (USD 79.57 Bn) economy-wide by 2040.

Concerning GDP, by 2030 these interventions are projected to generate a Riel 10,860 Bn (USD 2.71 Bn) increase in GDP over the baseline projections. This is an improvement of 46% for garments, 14.7% for bricks, 33% for food processing, and 35.5% for electronics. Regarding employment, although labor efficiency improvements are projected to decrease sectoral employment by 14%, net job creation in the GI scenario is projected at 512,000 additional jobs compared to 2020. Finally, total GHG emissions are projected to be 3.37 million tons and 6.59 million tons lower than the baseline values by 2030 and 2040, respectively. This is a reduction of 17.1% for garments, 0.9% for bricks, 1.9% for food processing, and 29.9% for electronics.

Table 22 presents a summary of the results, with an overview of the total investment required and resulting avoided costs and added benefits. Values are presented undiscounted and considered at a 6% discount rate.
To compare the amount of investments to the avoided costs and added benefits generated, a ratio is calculated (dividing the avoided costs and added benefits by the investment required). The table also provides an indication of the payback time for the investments, considering firm-level and economy-wide performance. Finally, changes relative to the baseline for the year 2030 are shown for GDP, employment, and GHG emissions.

4.1.1 Garments

The implementation of GI measures in the garments sector requires cumulative investments of Riel 12,174 Bn by 2030. Maintaining sectoral performance to 2040 requires an additional cumulative investment of approximately Riel 12,952 Bn. This is equivalent to cumulative investments of USD 3.04 Bn between 2020 and 2030, and USD 3.24 Bn between 2030 and 2040. Cumulative avoided costs and added benefits total Riel 56,890 Bn and Riel 63,780 Bn by 2030, and Riel 204,094 Bn and Riel 228,625 Bn by 2040 for firm-level and economy-wide impacts, respectively. This is equivalent to USD 14.22 Bn and USD 51.02 Bn for firm-level impacts and USD 15.95 Bn and up to USD 51.16 Bn in terms of economy-wide impacts by 2030 and 2040, respectively. The expected payback time for the cumulative investments required by 2030 is estimated at 4.63 years and 4.36 years for the firm-level and economy-wide CBA, which implies that net benefits start accruing from mid-2024.

By 2030, garments sector GDP in the GI scenario totals Riel 26,430 Bn, which is Riel 8,312 Bn, or 45.9% higher compared to the baseline scenario. Projections indicate that maintaining the implemented efficiency gains until 2040 contributes to an additional GDP of Riel 17,230 Bn in 2040, which is 42.3% higher compared to the baseline projections. Sectoral GDP growth in the GI scenario averages 10.5% between 2020 and 2040, which is 1.9% higher than the baseline projections of 8.6%.

In the GI scenario, the garments sector is projected to provide 1.35 million jobs in 2030 and 2.33 million jobs in 2040. Improvements in labor productivity reduce total

Table 22: Overview of results, year 2030.

Subsector	Investment (2030) – Bn Riel		Avoided cost and added benefits (2030) – Bn Riel		Avoided costs and added benefits to investment ratio		Payback time	% change in GI scenario versus BAU case in the year 2030		
	Undis-counted	Discounted (6%)	Undis-counted	Discounted (6%)	Undis-counted	Discounted (6%)		GDP & Tax revenue	Employ-ment	GHG
Garments	12,147.6	8,287.3	56,889.6 (firm-level) 63,779.2 (economy-wide)	34,952.4 (firm-level) 39,201.0 (economy-wide)	4.7x (firm-level) 5.3x (economy-wide)	4.2x (firm-level) 4.7x (economy-wide)	4.63 years (firm-level) 4.36 years (economy-wide)	+45.9%	-14.0%	-17.1%
Bricks	101.5	70.2	1,083.2 (firm-level) 1,147.1 (economy-wide)	666.1 (firm-level) 705.6 (economy-wide)	10.7x (firm-level) 11.3x (economy-wide)	9.5x (firm-level) 10.1x (economy-wide)	3.18 years (firm-level) 3.10 years (economy-wide)	+14.7%	-14.0%	-0.9%
Food processing	3'915.3	2'763.2	15'937.4 (firm-level) 19'598.4 (economy-wide)	9'904.5 (firm-level) 12'175.1 (economy-wide)	4.1x (firm-level) 5.0x (economy-wide)	3.6x (firm-level) 4.4x (economy-wide)	4.56 years (firm-level) 4.11 years (economy-wide)	+33.0%	-14.0%	-1.9%
Electronics	784.0	508.0	3,271.9 (firm-level) 9,622.5 (economy-wide)	2,021.0 (firm-level) 5,874.6 (economy-wide)	4.2x (firm-level) 12.3x (economy-wide)	4.0x (firm-level) 11.6x (economy-wide)	4.48 years (firm-level) 2.51 years (economy-wide)	+35.5%	-14.0%	-29.9%

sectoral employment by 14% relative to the baseline scenario. Nevertheless, by 2030 this represents a net job creation of 440,000 jobs compared to 2020.

Annual GHG emissions in the GI scenario total 11.6 million tons in the year 2030 and increase to 24.5 million tons in 2040. The total amount of GHG emitted is 17.1% lower than in the baseline scenario, which reduces GHG emissions in the year 2030 by 2.4 million tons and in the year 2040 by 5.1 million tons.

4.1.2 Bricks

The implementation of GI measures in the bricks sector requires cumulative investments of Riel 101.5 Bn by 2030. Maintaining sectoral performance to 2040 requires an additional cumulative investment of approximately Riel 83.2 Bn. This is equivalent to cumulative investments of USD 25.4 Mn between 2020 and 2030, and USD 20.8 Mn between 2030 and 2040. Cumulative avoided costs and added benefits total Riel 1,083.2 Bn and Riel 1,147.1 Bn by 2030, and Riel 3,341.4 Bn and Riel 3,551.2 Bn by 2040 for firm-level and economy-wide impacts, respectively. This is equivalent to USD 270.8 Mn and USD 835.3 Mn for firm-level impacts and USD 286.8 Mn and up to USD 878.8Mn in terms of economy-wide impacts by 2030 and 2040, respectively. The expected payback time for the cumulative investments required by 2030 is estimated at 4.18 years and 4.10 years for the firm-level and economy-wide CBA, which implies that net benefits start accruing from mid-2024.

By 2030, bricks sector GDP in the GI scenario totals Riel 1,165.9 Bn, which is Riel 149.7 Bn, or 14.7% higher compared to the baseline scenario. Projections indicate that maintaining the implemented efficiency gains until 2040 contributes to an additional GDP of Riel 234.7 Bn in 2040, which is 11.1% higher compared to the baseline projections. Sectoral GDP growth in the GI scenario averages 8.55% and is 0.55% higher than baseline projections of 8.0%.

In the GI scenario, the bricks sector is projected to provide 327,000 jobs in 2030 and 486,000 jobs in 2040. Improvements in labor productivity reduce total sectoral employment by 14% relative to the baseline scenario. Nevertheless, by 2030 this represents a net job creation of approximately 62,000 jobs compared to 2020.

Annual GHG emissions in the GI scenario total seven million tons in the year 2030 and increase to 12.7 million tons in 2040. The total amount of GHG emitted is 0.9% lower than in the baseline scenario, which reduces GHG emissions in the year 2030 by 60,000 tons and in the year 2040 by 110,000 tons.

4.1.3 Food processing

The implementation of GI measures in the food processing sector requires cumulative investments of Riel 3,915.3 Bn by 2030. Maintaining sectoral performance to 2040 requires an additional cumulative investment of approximately Riel 1,858.8 Bn. This is equivalent to cumulative investments of USD 978.8 Mn between 2020 and 2030, and USD 464.7 Mn between 2030 and 2040. Cumulative avoided costs and added benefits total Riel 15,937.4 Bn and Riel 19,598.4 Bn by 2030, and Riel 46,327.3 Bn and Riel 56,788 Bn by 2040 for firm-level and economy-wide impacts, respectively. This is equivalent to USD 3.98 Bn and USD 11.58 Bn for firm-level impacts and USD 4.90 Bn and up to USD 14.20 Bn in terms of economy-wide impacts by 2030 and 2040, respectively. The expected payback time for the cumulative investments required by 2030 is estimated at 4.56 years and 4.11 years for the firm-level and economy-wide CBA, which implies that net benefits start accruing from mid-2024.

By 2030, the GDP of the food processing sector in the GI scenario totals Riel 8,205.3 Bn, which is Riel 2,037.5 Bn, or 33% higher compared to the baseline scenario. The projections indicate that maintaining the implemented efficiency gains until 2040 contributes to an additional GDP of Riel 3,017.9 Bn in 2040, which is 22.7% higher compared to the baseline projections. Sectoral GDP growth in the GI scenario averages 9.9% and is 1.2% higher than baseline projection of 8.7%.

In the GI scenario, the food processing sector is projected to provide 75,500 jobs in 2030 and 92,200 jobs in 2040. Improvements in labor productivity reduce total sectoral employment by 14% relative to the baseline scenario. Nevertheless, by 2030 this represents a net job creation of 3,600 jobs compared to 2020.

Annual GHG emissions in the GI scenario total 34.8 million tons in the year 2030 and increase to 51.9 million tons in 2040. The total amount of GHG emitted is 2% lower than in the baseline scenario, which reduces GHG emissions in the year 2030 by 0.7 million tons and in the year 2040 by 1.03 million tons.

4.1.4 Electronics manufacturing

The implementation of GI measures in the electronics manufacturing sector requires cumulative investments of Riel 784 Bn by 2030. Maintaining sectoral performance to 2040 requires an additional cumulative investment of approximately Riel 458.7 Bn. This is equivalent to cumulative investments of USD 196 Mn between 2020 and 2030, and USD 114.7 Mn between 2030 and 2040. Cumulative avoided costs and added benefits total Riel 3,271.9 Bn and Riel 9,622.5 Bn by 2030, and Riel 10,114.2 Bn and Riel 29,312.4 Bn by 2040 for firm-level and economy-wide impacts, respectively. This is equivalent to USD 0.82 Bn and USD 2.53 Bn for firm-level impacts and USD 2.41 Bn and up to USD 7.33 Bn in terms of economy-wide impacts by 2030 and 2040, respectively. The expected payback time for the cumulative investments due by 2030 is estimated at 4.48 years and 2.51 years for the firm-level and economy-wide CBA. This implies that net benefits at the firm-level start accruing from mid-2024, and mid-2022 if assessed from an economy-wide perspective.

By 2030, electronics manufacturing sector GDP in the GI scenario totals Riel 1,376.4 Bn, which is Riel 360.8 Bn, or 35.5% higher compared to the baseline scenario. The projections indicate that maintaining the implemented efficiency gains until 2040 contributes to an additional GDP of Riel 581.1 Bn in 2040, which is 32.9% higher compared to the baseline projections. Sectoral GDP growth in the GI scenario averages 7.3% and is 1.5% higher than baseline projection of 5.8%.

In the GI scenario, the electronics manufacturing sector is projected to provide 48,400 jobs in 2030 and 65,200 jobs in 2040. Improvements in labor productivity reduce total sectoral employment by 14% relative to the baseline scenario. Nevertheless, by 2030 this represents a net job creation of approximately 6,700 jobs compared to 2020.

Annual GHG emissions in the GI scenario total 500,000 tons in the year 2030 and increase to 830,000 tons in 2040. The total amount of GHG emitted is 35.5% lower than in the baseline scenario, which reduces GHG emissions in the year 2030 by 210,000 tons and in the year 2040 by 350,000 tons.

4.1.5 Overall impacts on productivity

Table 23 to Table 26 present the impact of reaching stated targets on productivity. The results are consistent with the information presented in the earlier section at the sectoral level, in that these highlight the synergies emerging from the simultaneous implementation of investments.

This is evident in the GI scenario, where the increase in productivity for energy, water, material, labor, and GHG is always higher than the value achieved when targets are reached in isolation. The main reason for these results is that **productivity is defined as riel (of GDP, or value addition) divided by the resource use/consumption.** In other words, productivity tells us how much riel of GDP is generated through the use of one liter of water, or one person employed in the subsector, or each TJ of energy consumed. As a result, an improvement in efficiency (the assumption simulated with the model) leads to a reduction in the use of resources and in the cost of resource use, and an increase of GDP. Since production costs, and as a result GDP, are affected by various cost items simultaneously, any cost reduction (regardless of whether it is achieved in isolation or in conjunction with others) will lead to an increase in productivity.

The results show that the largest productivity increase results from material and water efficiency, followed by labor and water efficiency. Two exceptions also emerge: export and WWT. The former, as discussed earlier, does not imply any improvement of efficiency, and hence productivity. However, productivity will increase in a scenario in which premium prices would be paid for the additional export (e.g., to more upscale markets). On the latter, WWT, reaching the target implies higher costs (instead of lower ones, like in all other cases). As a result, the impact on overall productivity worsens in the WWT scenario.

The performance across sectors is similar, with water showing the largest gain, but with differences emerging according to the resource intensity (and relevance in terms of cost) of each subsector. For instance, the potential to reduce emissions from RE is higher for sectors that consume comparatively higher amounts of electricity (or, better, for sectors in which electricity represents a larger share of the energy mix). This is the case of electronics, where the gain in GHG productivity is the largest.

Table 23: Productivity indicators in the garments sector by scenario: 2030.

	EX	LI	EE	WE	ME	WWT	RE	GI
Energy productivity (Riel/TJ)	0.0%	6.9%	31.3%	0.6%	34.4%	-0.1%	0.6%	83.9%
Water productivity (Riel/liter)	0.0%	6.9%	5.1%	43.7%	34.4%	0.0%	0.6%	110.5%
Material productivity (Riel/ton)	0.0%	6.9%	5.1%	0.6%	68.0%	-0.1%	0.6%	84.2%
Labor productivity (Riel/person)	0.0%	42.1%	5.1%	0.6%	34.4%	0.0%	0.6%	95.9%
GHG productivity (Riel/Ton)	0.0%	0.0%	14.2%	0.0%	0.0%	-0.1%	7.7%	22.1%
Profit margin (%)	0.0%	6.9%	5.1%	0.6%	34.4%	0.0%	0.6%	47.4%

Table 24: Productivity indicators in the bricks sector by scenario: 2030.

	EX	LI	EE	WE	ME	WWT	RE	GI
Energy productivity (Riel/TJ)	0.0%	20.0%	29.3%	0.0%	0.0%	0.0%	0.0%	54.3%
Water productivity (Riel/liter)	0.0%	20.0%	3.5%	55.2%	0.0%	0.0%	0.0%	91.5%
Material productivity (Riel/ton)	0.0%	20.0%	3.5%	0.0%	0.0%	0.0%	0.0%	23.5%
Labor productivity (Riel/person)	0.0%	59.5%	3.5%	0.0%	0.0%	0.0%	0.0%	64.1%
GHG productivity (Riel/Ton)	0.0%	20.0%	4.4%	0.0%	0.0%	0.0%	0.0%	24.6%
Profit margin (%)	0.0%	20.0%	3.5%	0.0%	0.0%	0.0%	0.0%	23.5%

Table 25: Productivity indicators in the food processing sector by scenario: 2030.

	EX	LI	EE	WE	ME	WWT	RE	GI
Energy productivity (Riel/TJ)	0.0%	2.2%	36.1%	1.1%	21.6%	-0.1%	0.3%	67.4%
Water productivity (Riel/liter)	0.0%	2.2%	8.9%	44.4%	21.6%	-0.1%	0.3%	91.4%
Material productivity (Riel/ton)	0.0%	2.2%	8.9%	1.1%	52.0%	-0.1%	0.3%	67.5%
Labor productivity (Riel/person)	0.0%	35.8%	8.9%	1.1%	21.6%	-0.1%	0.3%	78.1%
GHG productivity (Riel/Ton)	0.0%	2.2%	10.7%	1.1%	21.6%	-0.1%	0.7%	36.6%
Profit margin (%)	0.0%	2.2%	8.9%	1.1%	21.6%	-0.1%	0.3%	34.0%

Table 26: Productivity indicators in the electronics sector by scenario: 2030.

	EX	LI	EE	WE	ME	WWT	RE	GI
Energy productivity (Riel/TJ)	0.0%	7.8%	31.3%	7.6%	18.8%	-3.3%	1.3%	72.2%
Water productivity (Riel/liter)	0.0%	7.8%	7.4%	49.4%	18.8%	-1.1%	1.3%	98.5%
Material productivity (Riel/ton)	0.0%	7.8%	7.4%	4.6%	48.5%	-1.1%	1.3%	73.6%
Labor productivity (Riel/person)	0.0%	43.3%	7.4%	4.6%	18.8%	-1.1%	1.3%	84.7%
GHG productivity (Riel/Ton)	0.0%	7.8%	30.0%	8.9%	18.8%	-4.2%	17.0%	98.2%
Profit margin (%)	0.0%	7.8%	7.4%	4.6%	18.8%	-1.1%	1.3%	38.9%

Text Box 2: Alternative discounting scenarios

The results presented in Section 4 are compared with scenarios that consider a 6% and 10% discount rate. These rates were chosen because (i) a value in the range of 6% is normally used in developed countries (the Dutch government uses 5.5% in all CBAs) and (ii) 10% was chosen because developing countries, with higher annual growth rates and comparatively higher cost of financing, generally require a higher discount rate in the range of 8% to 12%.

Discounting is applied to investments, avoided costs, and added benefits, with 2018 as the starting year for discounting. Table 27 presents the results by subsector. Investments, avoided costs, and added benefits are presented. The payback time is not shown since the values are very similar with and without discounting, given the short payback time observed for all investments.

Table 27: Summary of results, with 0%, 6%, and 10% discount rate for investments, avoided costs, and added benefits by 2030 (in billion riel)

Garments	Investments	Avoided costs and added benefits		Cumulative net benefits		Investment share in benefits (2030)	
		Firm-level	Economy-wide	Firm-level	Economy-wide	Firm-level	Economy-wide
Undiscounted	12,174.6	59,889.6	63,779.2	44,714.0	51,604.6	21.4%	19.1%
6% discounted	8,287.3	34,952.4	39,201.0	26,665.1	30,913.7	23.7%	21.1%
10% discounted	6,583.2	25,895.4	29,036.4	19,312.2	22,453.2	25.4%	22.7%

Bricks	Investments	Avoided costs and added benefits		Cumulative net benefits		Investment share in benefits (2030)	
		Firm-level	Economy-wide	Firm-level	Economy-wide	Firm-level	Economy-wide
Undiscounted	101.5	1,083.2	1,147.1	981.8	1,045.7	9.4%	8.9%
6% discounted	70.23	666.1	705.6	595.9	635.4	10.5%	10.0%
10% discounted	56.2	493.6	522.9	437.4	466.7	11.4%	10.8%

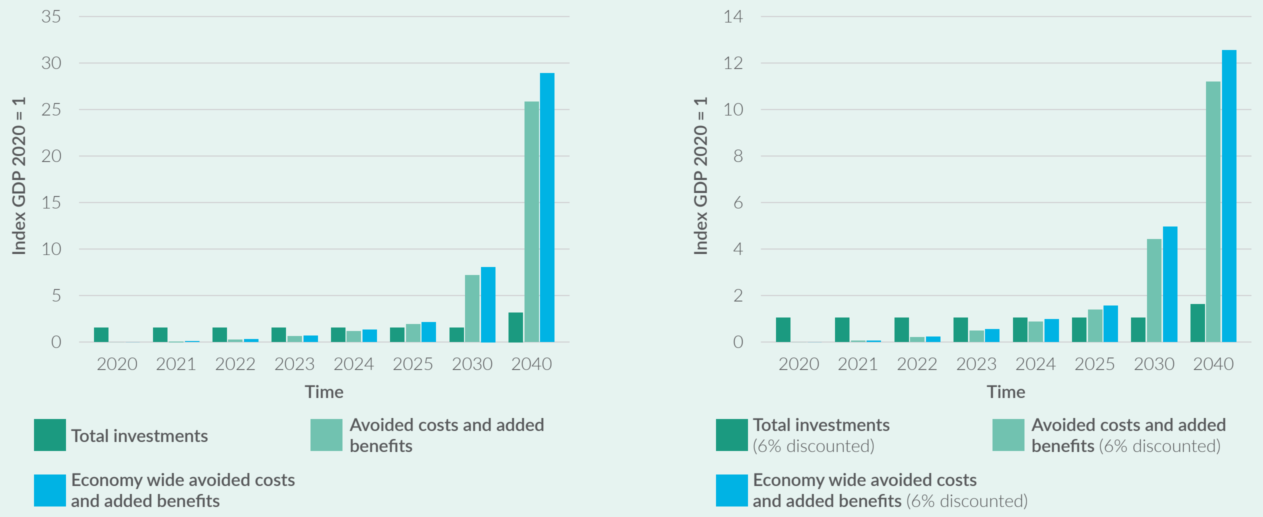
Food processing	Investments	Avoided costs and added benefits		Cumulative net benefits		Investment share in benefits (2030)	
		Firm-level	Economy-wide	Firm-level	Economy-wide	Firm-level	Economy-wide
Undiscounted	3,915.3	15,937.4	19,598.4	12,022.2	15,683.1	24.6%	20.0%
6% discounted	2,763.2	9,904.5	12,175.1	7,141.3	9,411.9	27.9%	22.7%
10% discounted	2,244.6	7,393.6	9,095.7	5,149.1	6,851.1	30.4%	24.7%

Electronics	Investments	Avoided costs and added benefits		Cumulative net benefits		Investment share in benefits (2030)	
		Firm-level	Economy-wide	Firm-level	Economy-wide	Firm-level	Economy-wide
Undiscounted	784.0	3,271.9	9,622.5	2,488.0	8,838.5	24.0%	8.2%
6% discounted	508.0	2,021.0	5,874.6	1,513.0	5,366.5	25.1%	8.7%
10% discounted	411.2	1,502.4	4,437.5	1,091.2	4,026.3	27.4%	9.3%

>>

Between 2020 and 2040, a significant amount of avoided costs and added benefits accumulates. Figure 20 presents undiscounted and discounted cumulative investments, and avoided costs and added benefits indexed based on projected sectoral GDP in 2020 (i.e. GDP2020 = 1) for garments. Other subsectors are presented next. Cumulative investments for 2030 are used for illustration purposes up to the year 2030. The value presented for 2040 represents cumulative investments, and avoided costs and added benefits up to the year 2040.

Figure 20: Undiscounted (left) and discounted (right) investments, avoided costs, and added benefits, GDP-indexed (GDP2020 = 1). Garments sector.



To support the correct interpretation of these figures, the charts show that undiscounted results indicate that by 2030, the GI interventions yield cumulative benefits in the magnitude of 7.2 and eight times the sectoral GDP of 2020 for the firm-level and economy-wide assessment, respectively. When considering 6% discounting instead, cumulative avoided costs and added benefits are in the magnitude of 4.4 and five times the sectoral GDP of 2020 by the year 2030 for firm-level and economy-wide assessment, respectively.

Figure 21: Undiscounted (left) and discounted (right) investments, avoided costs, and added benefits, GDP-indexed (GDP2020 = 1). Bricks sector.

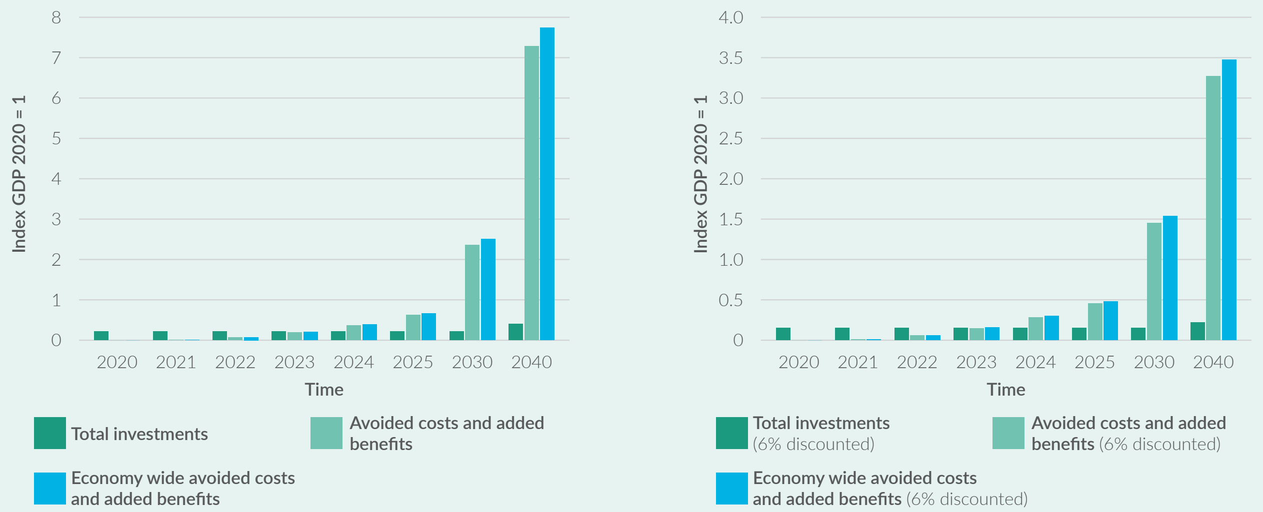


Figure 22: Undiscounted (left) and discounted (right) investments, avoided costs, and added benefits, GDP-indexed (GDP2020 = 1). Food processing sector.

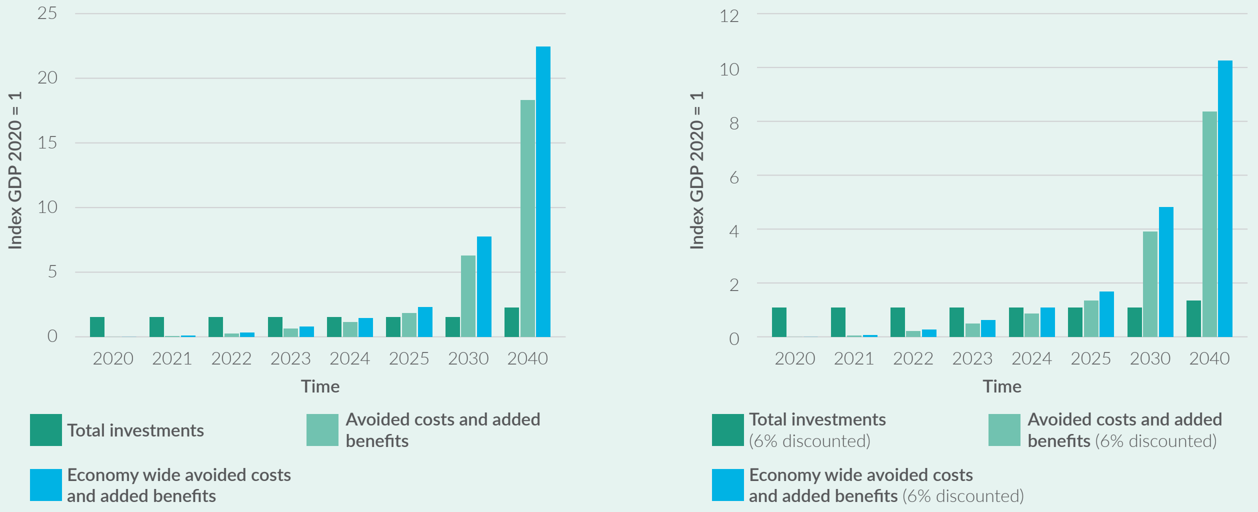
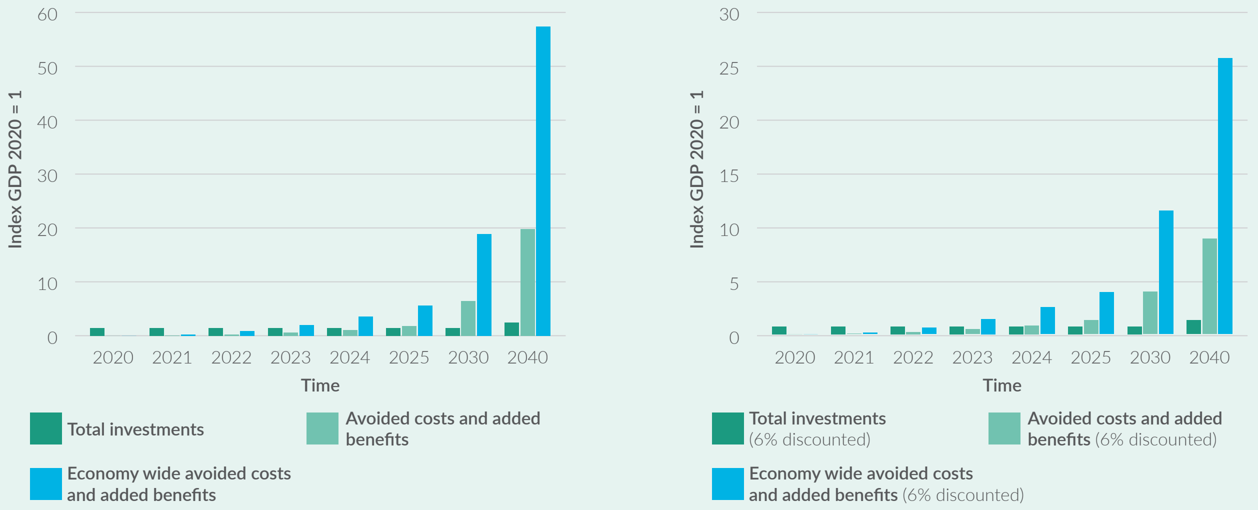


Figure 23: Undiscounted (left) and discounted (right) investments, avoided costs, and added benefits, GDP-indexed (GDP2020 = 1). Electronics sector.



Text Box 3: Impacts of heat on labor productivity and subsector profitability

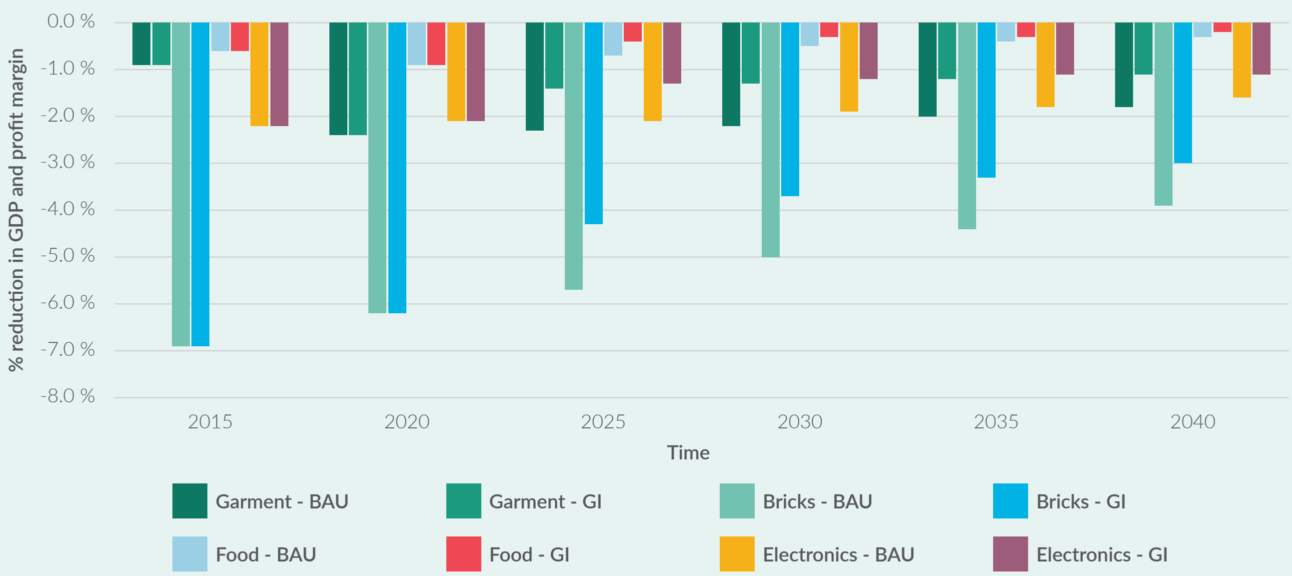
One of the manifestations of climate change is the increase in heat. This is particularly felt in the workplace, and its direct impact is reduced productivity (also measured as daylight work hours).

Using information from the National Council for Sustainable Development (NCSD) and the Cambodia Climate Change Alliance (CCCA) program (2018), it is assumed that the industry sector will see a reduction in labor productivity of 2% in 1995, 5.5% in 2025, and 7.1% by 2055 due to the effect of heat. When simulating the model with this assumption, applied both to the BAU and the GI scenarios, we observe increases in labor costs and reductions in profitability (e.g., taxable income, GDP, and profit margin), as presented in Figure 24.

Specifically, we note that the sectors most affected are the ones with labor representing the largest share of production costs, such as bricks manufacturing (-6.2% in 2020) followed by garments and electronics (-2.4% and -2.1%, respectively, in 2020). The impact of heat declines over time, primarily due to the reduction in LI as a result of technological improvements (especially for the GI scenario) and resulting decline of the labor cost share of total production costs.

In fact, the GI scenario shows reduced vulnerability to the heat effect, with bricks and garments showing respectively a 3.7% and 1.3% loss instead of 5.7% and 2.2% loss observed for the BAU scenario in 2030.

Figure 24: Impacts of heat on the profitability of industrial subsectors, selected years.



4.2 Cost Benefit Analysis (CBA)

This section presents results on investments and resulting avoided costs. It also provides information on aggregated outcomes for the payback time of investments. The CBA presented provides more details on the bankability of the investments required to reach stated targets, and sheds light on the potential effectiveness of a GI transition in Cambodia.

The first indicator presented is the investment required, followed by avoided costs and the payback time of the investment simulated. A longer list of indicators, both concerning the balance sheet (revenues and main cost items) for the four subsectors as well as related environmental impacts (e.g., GHG emissions) are presented in Appendix D.

4.2.1 Investment required

Achieving the targets presented above requires capital investments. This is because new equipment would need to be purchased, providing new technologies and processes to improve labor and resource efficiency and to reduce the environmental and health impacts of production.

Table 29 provides an overview of the estimation of the investments required to reach each of the targets, by subsector and for each scenario (assuming the achievement of one target at a time). In addition to the individual scenarios, the total investment required for reaching all targets simultaneously (i.e., the GI scenario) is presented.

The investment required to realize the GI scenario totals Riel 16,975 Bn (USD 4.24 Bn) between 2020 and 2030, or 19% of the current GDP of Cambodia. If we consider the annual investment required (over the period of 10 years), then the share of national GDP that should be reinvested to improve the performance and sustainability of the four subsectors would be smaller than 2%.

This investment corresponds to a share of the taxable income (defined as revenues minus costs of production) of 4.8% for bricks (which does not include ME) and grows to 25.4% for the garments sector, 27.3% for the electronics sector, and 30.7% for the food processing sector. On average, across all sectors, industries would need to invest 26% of their taxable income in resource efficiency to realize the GI scenario. Differences across subsectors emerge because the incidence of resource consumption changes from sector to sector. Further, the investment required to improve resource efficiency also differs across sectors, given that different technologies are required (with the only exception of RE).

The fact that the investment required is smaller than the taxable income, and hence of GDP, indicates that all four subsectors would still be profitable under the GI scenario. More details on the return on investment, estimated considering the benefits generated by reaching stated targets, are presented in Section 4.2.3.

Concerning specific scenarios, investments for the expansion of capacity, or the increase of the production capacity of plants and production lines (EX scenario), are not estimated, for two reasons: (i) first is the difficulty in finding reliable data on the required investment per unit of production; (ii) the second is related to the assumptions used: if additional capacity is added, with the same characteristics of current capacity, this investment will lead to the same return (or profit margin) that the sector is currently achieving. As a result, the estimation of investments is not required, because the return is already known. On the other hand, we do assess, in Section 4.2.2, the impact of increasing exports on revenues and on environmental and health impacts. Similar considerations can be made for labor. This is a case in which LI changes due to the adoption of new capacity (possibly increased mechanization) or where on the job training is provided to increase labor efficiency, and hence productivity. A third exception is fuel switching, where in all of the cases reviewed this is achieved at no extra cost relative to the EE scenario. As a result, the analysis distinguishes between the potential to increase EE and to switch fuels (EE-FS), but all costs are accounted for already in the EE scenario. As a result, the investment required in the EE and EE-FS scenarios is the same.

Concerning specific targets, Table 29 indicates clearly that ME is by far the most ambitious and most expensive target to achieve. This is because improving ME requires new and more advanced equipment and machineries, which carry high capital costs, but also lead to high savings. Overall, 73.1% of the total investment is required for ME, with the lowest value (58%) for food processing and the highest (80%) for the garments sector. The second and third largest areas of investment are, when considering all sectors, RE (11.5% of the total investment) and EE (11% of the total investment). WE and wastewater management follow with 2.7% and 1.7% of total investment, respectively.

Table 29 also shows that the GI scenario requires a smaller amount of investment than the sum of all the other scenarios. In other words, investing to achieve all targets simultaneously creates synergies. An example is the reduction in energy demand under the EE scenario, which contributes to reducing the investment required to reach the RE target in the RE scenario. Specifically, the investment in RE is Riel 398.71 Bn lower in the GI scenario, reaching a total of Riel 1,615 Bn by 2030. Similarly, investments in WE contribute to reducing investments in WWT capacity (lower by Riel 148.08 Bn by 2030 in the GI scenario).

Subsectoral investment estimates are presented in Table 30 for garments, Table 31 for bricks, Table 32 for food processing, and Table 33 for electronics. These tables are presented as a matrix to highlight the extent to which targets are interconnected. For instance, it is possible to see in Table 30 that both WE and WWT affect the investment in WWT, indirectly and directly.

Text Box 4: Notes on how to read and interpret tables on investments, avoided costs, and added benefits.

The impacts of reaching a thematic target across all cost items are presented in Table 28. A “+” sign indicates that reaching a given target would increase a specific cost item. Conversely, a “-“ sign indicates that a cost reduction can be expected when the target is reached. For instance, investments in wastewater treatment (WWT) are expected to increase the cost of energy for water treatment and air emissions (from energy use) and reduce health costs related to water pollution. "?" indicates uncertain impact on the cost item.

Table 28: Summary of the cross-impacts of reaching stated targets.

	Cost item									
Scenario	Capital and O&M	Materials	Labor	Water	Energy		Health	Emis-sions	Solid waste disposal	Waste water capacity
					Direct	Water treatment				
EX	+	+	+	+	+	+	+	+	+	+
LI	+		-							
EE	+				-		-	-		
EE – FS	+				-		?	?		
WE	+			-		-	-	-		-
ME	+	-							-	
WWT	+					+	-	+		-
RE	+				-	-	-	-		

Table 29: Investments in the alternative scenarios (see Section 3.5), all subsectors in billion riels: cumulative (2030) and average annual value (2020-2030).

Sector	EE and EE - FS	WE	ME	WWT	RE	Total	GI	GI investment % taxable income (avg 2020 – 2025)
Garments								
Total (Bn Riel)	783.32	72.78	9,975.58	107.06	1,607.97	**12,546.72**	**12,174.59**	**25.4%**
Average (Bn Riel/year)	293.86	27.30	3,742.29	40.16	705.13	**4,808.74**	**4,646.93**	
Bricks								
Total (Bn Riel)	100.27	1.13	N/A	0.04	0.01	**101.45**	**101.47**	**4.8%**
Average (Bn Riel/year)	41.29	0.46	N/A	0.02	0.00	**41.77**	**41.72**	
Food Processing								
Total (Bn Riel)	1,011.55	380.05	2,299.26	59.54	241.06	**3,991.47**	**3,915.26**	**30.7%**
Average (Bn Riel/year)	471.83	177.27	1,072.48	27.77	131.61	**1,880.97**	**1,822.78**	
Electronics								
Total (Bn Riel)	28.79	22.00	532.72	129.44	165.14	**878.09**	**783.97**	**27.3%**
Average (Bn Riel/year)	12.62	9.64	233.44	56.72	84.67	**397.08**	**305.22**	
Total investments								
Total (Bn Riel)	**1,923.94**	**475.96**	**12,807.56**	**296.08**	**2,014.19**	**17,517.73**	**16,975.30**	**26.0%**
Average (Bn Riel/year)	819.60	214.68	5,048.21	124.67	921.41	**7,128.56**	**6,816.65**	

Table 30: Investments in the garments sector by scenario: 2020-2030.

Garments	Unit	Investments in energy efficiency		Investments in water efficiency		Investments in material efficiency		Investment in wastewater treatment		Investment in renewable energy		Total investments Economy wide	
Scenario	bn. Riel	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**
EX	bn. Riel	-	-	-	-	-	-	-	-	-	-	**-**	**-**
LI	bn. Riel	-	-	-	-	-	-	-	-	-	-	**-**	**-**
EE	bn. Riel	538.84	783.32	-	-	-	-	-	-	-	-	**538.84**	**783.32**
EE – FS	bn. Riel	538.84	783.32	-	-	-	-	-	-	-	-	**538.84**	**783.32**
WE	bn. Riel	-	-	50.07	72.78	-	-	-88.37	-128.47	-	-	**50.07**	**72.78**
ME	bn. Riel	-	-	-	-	6,862.12	9,975.58	-	-	-	-	**6,862.12**	**9,975.58**
WWT	bn. Riel	-	-	-	-	-	-	73.64	107.06	-	-	**73.64**	**107.06**
RE	bn. Riel	-	-	-	-	-	-	-	-	1,253.51	1,607.97	**1,253.51**	**1,607.97**
Total (separate scenarios)	bn. Riel	538.84	783.32	50.07	72.78	6,862.12	9,975.58	73.64	107.06	1,253.51	1,607.97	**8,778.19**	**12,546.72**
GI	bn. Riel	539.88	784.83	50.07	72.78	6,862.12	9,975.58	36.82	53.53	1,003.97	1,287.87	**8,492.86**	**12,174.59**

Table 31: Investments in the bricks sector by scenario: 2020-2030.

Bricks	Unit	Investments in energy efficiency		Investments in water efficiency		Investments in material efficiency		Investment in wastewater treatment		Investment in renewable energy		Total investments Economy wide	
Scenario	bn. Riel	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**
EX	bn. Riel	-	-	-	-	-	-	-	-	-	-	**-**	**-**
LI	bn. Riel	-	-	-	-	-	-	-	-	-	-	**-**	**-**
EE	bn. Riel	74.33	100.27	-	-	-	-	-	-	-	-	**74.33**	**100.27**
EE – FS	bn. Riel	74.33	100.27	-	-	-	-	-	-	-	-	**74.33**	**100.27**
WE	bn. Riel	-	-	0.83	1.13	-	-	-0.06	-0.09	-	-	**0.83**	**1.13**
ME	bn. Riel	-	-	-	-	-	-	-	-	-	-	**-**	**-**
WWT	bn. Riel	-	-	-	-	-	-	0.03	0.04	-	-	**0.03**	**0.04**
RE	bn. Riel	-	-	-	-	-	-	-	-	0.01	0.01	**0.01**	**0.01**
Total (separate scenarios)	bn. Riel	74.33	100.27	0.83	1.13	-	-	0.03	0.04	0.01	0.01	**75.19**	**101.45**
GI	bn. Riel	74.33	100.28	0.83	1.13	-	-	0.05	0.07	-	-	**75.21**	**101.47**

Table 32: Investments in the food processing sector by scenario: 2020-2030.

Food processing	Unit	Investments in energy efficiency		Investments in water efficiency		Investments in material efficiency		Investment in wastewater treatment		Investment in renewable energy		Total investments Economy wide	
Scenario	bn. Riel	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**
EX	bn. Riel	-	-	-	-	-	-	-	-	-	-	**-**	**-**
LI	bn. Riel	-	-	-	-	-	-	-	-	-	-	**-**	**-**
EE	bn. Riel	828.39	1,011.55	-	-	-	-	-	-	-	-	**828.39**	**1,011.55**
EE – FS	bn. Riel	825.08	1,007.51	-	-	-	-	-	-	-	-	**825.08**	**1,007.51**
WE	bn. Riel	-	-	311.24	380.05	-	-	-58.51	-71.45	-	-	**311.24**	**380.05**
ME	bn. Riel	-	-	-	-	1,882.95	2,299.26	-	-	-	-	**1,882.95**	**2,299.26**
WWT	bn. Riel	-	-	-	-	-	-	48.76	59.54	-	-	**48.76**	**59.54**
RE	bn. Riel	-	-	-	-	-	-	-	-	223.72	241.06	**223.72**	**241.06**
Total (separate scenarios)	bn. Riel	828.39	1,011.55	311.24	380.05	1,882.95	2,299.26	48.76	59.54	223.72	241.06	**3,295.06**	**3,991.47**
GI	bn. Riel	829.17	1,012.50	311.24	380.05	1,882.95	2,299.26	24.38	29.77	179.75	193.68	**3,227.48**	**3,915.26**

Table 33: Investments in the electronics sector by scenario: 2020-2030.

Electronics	Unit	Investments in energy efficiency		Investments in water efficiency		Investments in material efficiency		Investment in wastewater treatment		Investment in renewable energy		Total investments Economy wide	
Scenario	bn. Riel	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**
EX	bn. Riel	-	-	-	-	-	-	-	-	-	-	**-**	**-**
LI	bn. Riel	-	-	-	-	-	-	-	-	-	-	**-**	**-**
EE	bn. Riel	22.43	28.79	-	-	-	-	-	-	-	-	**22.43**	**28.79**
EE – FS	bn. Riel	22.43	28.79	-	-	-	-	-	-	-	-	**22.43**	**28.79**
WE	bn. Riel	-	-	17.14	22.00	-	-	-121.01	-155.32	-	-	**17.14**	**22.00**
ME	bn. Riel	-	-	-	-	415.04	532.72	-	-	-	-	**415.04**	**532.72**
WWT	bn. Riel	-	-	-	-	-	-	100.84	129.44	-	-	**100.84**	**129.44**
RE	bn. Riel	-	-	-	-	-	-	-	-	145.81	165.14	**145.81**	**165.14**
Total (separate scenarios)	bn. Riel	22.43	28.79	17.14	22.00	415.04	532.72	100.84	129.44	145.81	165.14	**701.27**	**878.09**
GI	bn. Riel	23.85	30.61	17.14	22.00	415.04	532.72	50.42	64.72	118.24	133.92	**624.70**	**783.97**

4.2.2 Firm-level and economy-wide avoided costs

In addition to requiring investments, achieving the targets simulated generates benefits both for the industry and for society. Table 34 presents the results of all simulations, each accounting for a specific target and including the GI case for the four subsectors. It also presents the cumulative value of benefits (both avoided costs of production and extra benefits for the environment and human health) up to the year 2030 and average annual values for the period 2020-2030.

The first key finding that emerges from the simulations is that the benefits largely outweigh the required investments. While the investment requires a total of Riel 16,975 Bn in the GI scenario by 2030, the benefits reach Riel 113,960 Bn. The benefits are therefore 6.7 times larger than the investment required, and generate positive returns. Some of these benefits are for the industry, while others are for society (and do not represent a direct cost of production).

When comparing the additional benefits to the taxable income, the range goes from 19.9% for bricks to 120% for electronics. Garments and food processing reach 51.5% and 45.9%, respectively. On average, across all sectors, the value is 52.1%. The values of investments are 4.8% for bricks and range from 25%-30% for the other sectors. In this case as well, as presented above, it is clear that reaching stated targets and realizing a GI scenario will bring economic benefits, in addition to reducing environmental pressure and curbing health costs. A strong synergy therefore emerges when comparing forecasted investments with benefits.

Concerning specific scenarios, the EX case shows the largest increases in GDP of all simulations, while at the same time indicating that pressure on the environment will continue to grow. This is evident when considering energy and material consumption, as well as emissions and wastewater. Overall, by 2030, energy and material consumption will increase by 18.1% and 13.3%, respectively, compared to the baseline. In addition, total

GHG emissions increase by 8.86 million tons annually to 66.1 million tons GHG emitted per year in 2030, hence increasing by 15.5% compared to 57.24 million tons per year in the baseline. Furthermore, wastewater discharge increases by 25.2% from 175.12 billion liters per year to 219.29 billion liters per year by 2030. These increases in resource consumption and environmental impacts emerge because in the EX scenario, which is an exception compared to other cases, there is no improvement in resource efficiency. **Conversely, in all other scenarios the improvement of efficiency leads to positive outcomes both on specific cost items and on the overall performance of the subsector. Table 34 indicates that ME is the largest contributor to cost savings.** This is not surprising, given the very large share of investments required to improve ME (over 70%). Overall, 49.3% of the total benefits emerge from ME, followed by energy efficiency and fuel switching (reaching 25.7% combined, with 11.8% from EE and 13.9% from FS), labor and WWT (9% each), WE (4.9%), and RE (2.1%).

Table 34 also shows that the GI scenario generates a larger amount of benefits than the sum of all the other scenarios (Riel 113,964 Bn instead of Riel 111,616 Bn by 2030). For example, investments in EE and RE, on top of reducing energy costs (through reduced consumption and lower electricity generation price, respectively) also reduce emissions and air pollution costs. Another example is that investing in WE and WWT also reduces the untreated wastewater health cost. In other words, improving the performance of a subsector has positive impacts on the environment and society, and thus it lowers environmental remediation and health costs.

Subsectoral benefit estimates are presented in Table 35 for garments, Table 36 for bricks, Table 37 for food processing, and Table 38 for electronics. As in the case of investments, these tables are presented as a matrix to highlight the extent to which targets and resulting benefits are interconnected. For instance, it is possible to see in Table 35, which is divided into two main parts to account for all the avoided costs and benefits, that the WE scenario leads to avoided costs for water consumption, energy (because of reduced electricity consumption for water treatment), and WWT. These are costs directly related to production and even more in general operations in the garments sector. The bottom part of the table also shows that investing in WE leads to avoided costs from air emissions (which are related to energy use) and water pollution (which is related to wastewater discharge). These are avoided costs that do not appear in the balance sheet of companies, but are nevertheless relevant to society and the government.

Table 35 and the following also show that reaching certain targets will generate extra costs, in addition to benefits. This is the case of the EX scenario where, as mentioned earlier, increased production leads to higher resource use, environmental and health impact (and hence the negative sign in the table), as well as of the WWT scenario. In the latter case, increasing water treatment leads to higher energy costs for companies, but reduces the impact and cost of pollutants discharge for households and the government.

Table 34: Avoided costs and added benefits in the alternative scenarios, all subsectors in billion riels: cumulative (2030) and average annual value (2020-2030).

Sector	LI	EE	EE and EE - FS	WE	ME	WWT	RE	Total	GI	Avoided costs in the GI scenario as a % of the taxable income (avg 2020 – 2025)
Garments										
Total (Bn Riel)	7,832.45	6,995.60	8,300.65	2,075.49	43,336.20	3,409.98	895.85	**65,850.62**	**69,060.25**	**51.5%**
Average (Bn Riel/year)	885.62	766.38	1,136.08	164.61	4,747.58	380.33	194.44	**7,138.97**	**7,306.87**	
Bricks										
Total (Bn Riel)	1,055.68	313.59	369.79	130.30	0.00	1.43	0.00	**1,557.21**	**1,540.49**	**19.9%**
Average (Bn Riel/year)	118.73	34.19	42.10	0.16	0.00	0.16	0.00	**153.24**	**153.35**	
Food Processing										
Total (Bn Riel)	734.45	5,137.81	15,183.04	1,362.67	10,232.61	1,362.67	152.20	**29,027.64**	**33,579.26**	**45.9%**
Average (Bn Riel/year)	82.02	523.09	1,795.99	102.63	1,108.87	237.11	32.68	**2,086.41**	**2,171.85**	
Electronics										
Total (Bn Riel)	423.19	685.08	469.54	1,954.43	1,413.81	4,504.95	199.17	**8,965.09**	**9,783.74**	**120%**
Average (Bn Riel/year)	47.43	74.47	58.22	134.65	153.68	498.53	21.65	**930.40**	**1,098.81**	
Total benefits										
Total (Bn Riel)	10,045.77	13,132.08	28,651.19	5,522.89	54,982.62	10,061.68	2,352.09	**111,616.25**	**113,963.74**	**52.1%**
Average (Bn Riel/year)	1,133.80	1,398.13	3,032.39	402.05	6,010.14	1,116.13	248.76	**10,309.02**	**10,730.88**	

Table 35: Avoided costs and added benefits in the garments sector by scenario: billion riels, 2020-2030.

Garments	Avoided labor cost		Avoided energy cost		Avoided energy cost (Fuel Switch)		Avoided water cost		Avoided material cost		Avoided O&M wastewater	
Scenario	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
EX	-2,824.79	-12,116.71	-1,590.33	-7,262.85	-1,590.33	-7,262.85	-144.77	-661.15	-12,495.12	-57,063.54	-225.30	-1,028.90
LI	1,514.42	7,832.45	-	-	-	-	-	-	-	-	-	-
EE	-	-	1,450.05	5,466.35	1,450.05	5,466.35	-	-	-	-	-	-
EE – FS	-	-	2,351.06	8,300.65	2,351.06	8,300.65	-	-	-	-	-	-
WE	-	-	19.63	73.99	19.63	73.99	199.79	753.16	-	-	310.91	1,172.08
ME	-	-	-	-	-	-	-	-	11,495.67	43,336.20	-	-
WWT	-	-	-16.36	-61.68	-16.36	-61.68	-	-	-	-	-259.10	-976.73
RE	-	-	237.64	895.84	237.64	895.84	-	-	-	-	-2.94	-11.10
Total (separate scenarios)	1,514.42	7,832.45	1,690.95	6,374.50	1,690.95	6,374.50	199.79	753.16	11,495.67	43,336.20	48.87	184.25
GI	1,514.42	7,832.45	1,662.06	6,228.19	2563.07	9062.49	199.79	753.16	11,495.67	43,336.20	102.14	453.82
Synergies	**-**	**-**	**-28.89**	**-146.31**	**872.12**	**2687.99**	**-**	**-**	**-**	**-**	**53.27**	**269.57**

Garments	Avoided energy cost from renewable energy		Reduction in GHG emissions cost		Reduction in health cost (SCC)		Reduction in health costs (water pollution)		Total benefits	
Scenario	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
EX	-	-	-184.19	-841.16	-570.99	-2607.62	-257.57	-1176.27	**-19,883.38**	**-90,021.05**
LI	-	-	-	-	-	-	-	-	**1,514.42**	**7,832.45**
EE	-	-	98.94	372.99	306.72	1156.27	-	-	**1,855.71**	**6,995.60**
EE – FS	-	-	137.19	511.17	425.29	1,584.62	-	-	**2,913.53**	**10,396.44**
WE	-	-	1.41	5.32	4.37	16.47	355.45	1339.96	**555.74**	**2,095.00**
ME	-	-	-	-	-	-	-	-	**11,495.67**	**43,336.20**
WWT	-	-	-1.17	-4.42	-3.64	-13.72	1184.83	4466.53	**888.19**	**3,348.31**
RE	237.64	895.85	56.87	214.39	176.30	664.60	-	-	**943.13**	**3,555.41**
Total (separate scenarios)	237.64	895.85	156.05	588.27	483.75	1,823.61	1,184.83	4,466.53	**17,011.96**	**66,254.82**
GI	205.39	732.57	148.57	550.40	460.56	1706.24	1297.68	4579.39	**19,649.34**	**75,234.91**
Synergies	**-32.25**	**-163.28**	**-7.48**	**-37.86**	**-23.19**	**-117.37**	**112.86**	**112.86**	**2637.38**	**8980.10**

Table 36: Avoided costs and added benefits in the bricks sector by scenario: billion riels, 2020-2030.

Bricks	Avoided labor cost		Avoided energy cost		Avoided energy cost (Fuel Switch)		Avoided water cost		Avoided material cost		Avoided O&M wastewater	
Scenario	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
EX	-	-	-	-	-	-	-	-	-	-	-	-
LI	214.96	1,055.68	-	-	-	-	-	-	-	-	-	-
EE	-	-	69.91	251.76	69.91	251.76	-	-	-	-	-	-
EE – FS	-	-	104.55	369.79	104.55	369.79	-	-	-	-	-	-
WE	-	-	0.02	0.05	0.02	0.05	0.26	0.97	-	-	0.25	0.85
ME	-	-	-	-	-	-	-	-	-	-	-	-
WWT	-	-	-0.01	-0.03	-0.01	-0.03	-	1.87	-	-	-0.11	-0.41
RE	-	-	-	-	-	-	-	-	-	-	-	-
Total (separate scenarios)	214.96	1,055.68	69.92	251.79	69.92	251.79	0.26	2.84	-	-	0.13	0.43
GI	214.96	1,055.68	69.92	251.80	104.56	369.83	0.26	0.93	-	-	0.17	0.63
Synergies	**-**	**-**	**-**	**0.01**	**34.64**	**118.04**	**-**	**-1.91**	**-**	**-**	**0.04**	**0.19**

Bricks	Avoided energy cost from renewable energy		Reduction in GHG emissions cost		Reduction in health cost (SCC)		Reduction in health costs (water pollution)		Total benefits	
Scenario	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
EX	-	-	-	-	-	-	-	-	**-**	**-**
LI	-	-	-	-	-	-	-	-	**214.96**	**1,055.68**
EE	-	-	4.19	15.08	12.98	46.76	-	-	**87.08**	**313.59**
EE – FS	-	-	0.95	4.04	2.93	12.51	-	-	**212.98**	**756.13**
WE	-	-	-	-	-	0.01	0.28	0.97	**0.52**	**1.89**
ME	-	-	-	-	-	-	-	-	**-**	**-**
WWT	-	-	-	-	-	-0.01	0.52	1.87	**0.40**	**3.31**
RE	-	-	-	-	-	-	-	-	**-**	**0.01**
Total (separate scenarios)	-	-	4.19	15.08	12.98	46.77	0.52	1.87	**302.96**	**1,374.47**
GI	-	-	4.19	15.09	12.98	46.77	-0.61	-1.97	**301.87**	**1,368.93**
Synergies	**-**	**-**	**-**	**-**	**-**	**0.01**	**-1.13**	**-3.84**	**-1.09**	**-5.54**

Table 37: Avoided costs and added benefits in the food processing sector by scenario: billion riels, 2020-2030.

Food processing	Avoided labor cost		Avoided energy cost		Avoided energy cost (Fuel Switch)		Avoided water cost		Avoided material cost		Avoided O&M wastewater	
Scenario	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
EX	-143.91	-544.98	-653.47	-2,627.45	-653.47	-2,627.45	-48.64	-195.57	-1,572.74	-6,323.60	**-75.69**	**-304.35**
LI	160.03	734.45	-	-	-	-	-	-	-	-	-	-
EE	-	-	1,244.08	4,220.55	1,244.08	4,220.55	-	-	-	-	-	-
EE – FS	-	-	4,657.20	15,183.04	3,413.12	10,962.49	-	-	-	-	-	-
WE	-	-	13.75	46.64	13.75	46.64	139.92	474.69	-	-	**217.75**	**738.72**
ME	-	-	-	-	-	-	-	-	3,016.22	10,232.61	-	-
WWT	-	-	-11.46	-38.86	-11.46	-38.86	-	-	-	-	**-181.46**	**-615.60**
RE	-	-	44.87	152.20	44.87	152.20	-	-	-	-	**-2.06**	**-7.00**
Total (separate scenarios)	160.03	734.45	1,291.24	4,380.53	1,291.24	4,380.53	139.92	474.69	3,016.22	10,232.61	**34.23**	**116.12**
GI	160.03	734.45	1,287.64	4,364.06	139.92	474.69	139.92	474.69	3,016.22	10,232.61	**71.03**	**283.79**
Synergies	**-**	**-**	**-3.60**	**-16.47**	**-1151.32**	**-3905.84**	**-**	**-**	**-**	**-**	**36.80**	**167.66**

Food processing	Avoided energy cost from renewable energy		Reduction in GHG emissions cost		Reduction in health cost (SCC)		Reduction in health costs (water pollution)		Total benefits	
Scenario	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
EX	-	-	-86.54	-347.94	-875.28	-3519.19	-86.54	-347.94	**-4,196.27**	**-16,838.47**
LI	-	-	-	-	-	-	-	-	**160.03**	**734.45**
EE	-	-	43.6	147.92	135.18	458.63	-	-	**2,623.34**	**8,899.73**
EE – FS	-	-	105.5	346.77	327.11	1,075.06	-	-	**8,397.43**	**27,220.58**
WE	-	-	248.94	844.54	3.06	10.39	248.94	844.54	**637.18**	**2,161.63**
ME	-	-	-	-	-	-	-	-	**3,016.22**	**10,232.61**
WWT	-	-	-0.83	-2.79	-2.52	-8.61	829.80	2815.12	**1,452.72**	**4,928.31**
RE	44.86	152.20	-	-	33.28	112.94	-	-	**165.82**	**562.54**
Total (separate scenarios)	44.86	152.20	1,078.74	3,659.66	169.01	573.35	829.80	2,815.12	**6,764.06**	**23,138.74**
GI	38.95	125.19	911.13	2896.45	165.11	555.55	53.26	179.20	**5,843.30**	**19,845.99**
Synergies	**-5.91**	**-27.01**	**-167.61**	**-763.21**	**-3.89**	**-17.80**	**-776.54**	**-2635.92**	**-920.76**	**-3292.75**

Table 38: Avoided costs and added benefits in the electronics sector by scenario: billion riels, 2020-2030.

Electronics	Avoided labor cost		Avoided energy cost		Avoided energy cost (Fuel Switch)		Avoided water cost		Avoided material cost		Avoided O&M wastewater	
Scenario	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
EX	-166.39	-661.57	-193.06	-815.78	-193.06	-815.78	-51.44	-217.35	-438.55	-1,853.05	-320.21	-1,353.00
LI	89.15	423.19	-	-	-	-	-	-	-	-	-	-
EE	-	-	159.46	557.24	159.46	557.24	-	-	-	-	-	-
EE – FS	-	-	132.94	469.54	132.94	469.54	-	-	-	-	-	-
WE	-	-	27.97	97.76	27.97	97.76	71.18	248.75	-	-	443.10	1,548.44
ME	-	-	-	-	-	-	-	-	404.57	1,413.81	-	-
WWT	-	-	-23.31	-81.47	-23.31	-81.47	-	-	-	-	-369.25	-1,290.37
RE	-	-	28.77	100.53	28.77	100.53	-	-	-	-	-4.20	-14.66
Total (separate scenarios)	89.15	423.19	192.89	674.06	192.89	674.06	71.18	248.75	404.57	1,413.81	69.65	243.41
GI	89.15	423.19	193.99	679.05	193.99	679.05	71.18	248.75	404.57	1,413.81	144.84	596.23
Synergies	**-**	**-**	**1.10**	**4.98**	**1.10**	**4.98**	**-**	**-**	**-**	**-**	**75.18**	**352.83**

Electronics	Avoided energy cost from renewable energy		Reduction in GHG emissions cost		Reduction in health cost (SCC)		Reduction in health costs (water pollution)		Total benefits	
Scenario	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
EX	-	-	-11.12	-47.00	-34.48	-145.70	-366.07	-1546.80	**-1,581.32**	**-6,640.25**
LI	-	-	-	-	-	-	-	-	**89.15**	**423.19**
EE	-	-	8.92	31.18	27.66	96.66	-	-	**196.04**	**685.08**
EE – FS	-	-	4.34	16.03	13.46	49.70	-	-	**283.69**	**1,004.80**
WE	-	-	2.01	7.02	6.23	21.76	506.56	1770.23	**550.49**	**1,923.72**
ME	-	-	-	-	-	-	-	-	**404.57**	**1,413.81**
WWT	-	-	-1.67	-5.85	-5.19	-18.13	1688.55	5900.77	**1,289.13**	**4,504.95**
RE	28.77	100.53	6.88	24.06	21.34	74.58	-	-	**81.57**	**285.04**
Total (separate scenarios)	28.77	100.53	16.14	56.41	50.04	174.87	1,688.55	5,900.77	**2,610.95**	**9,235.79**
GI	25.14	83.34	15.61	53.89	48.40	167.05	1852.70	6064.91	**2,845.59**	**9,730.21**
Synergies	**-3.62**	**-17.19**	**-0.53**	**-2.52**	**-1.64**	**-7.82**	**164.15**	**164.15**	**234.64**	**494.42**

Text Box 5: EX scenario with premium price

This text box describes the results of a sensitivity analysis assessing the impact of a 20% premium price for additional exports in the EX scenario. This additional scenario is simulated for garments, food processing, and electronics. Table 39 provides an overview of the key sectoral performance indicators that are affected by the premium price assumption. The BAU scenario is first compared to the EX simulation, and then to the EX scenario including the premium price.

Results show that the average profit margin increases with the premium price by 3.5% for garments, 4.3% for food processing, and 3.1% for electronics.

Table 39: Summary of results for the use of premium price of 20% for additional exports in the EX scenario (total values in billion riel).

Garments	Revenues		Taxable income		GDP		Profit margin	
	2030	2040	2030	2040	2030	2040	2030	2040
BAU	112'481.7	237'707.0	21'669.6	48'709.2	18'115.8	40'720.9	16.1%	17.1%
Export	144'209.1	304'756.3	27'781.8	62'448.5	23'225.6	52'206.9	16.1%	17.1%
% Export vs BAU	*28.2%*	*28.2%*	*28.2%*	*28.2%*	*28.2%*	*28.2%*	*0.0%*	*0.0%*
Export + Premium price	152'140.6	321'517.9	35'713.3	79'210.1	29'856.3	66'219.6	19.6%	20.6%
% Export vs Export + premium price	*5.5%*	*5.5%*	*28.5%*	*26.8%*	*28.5%*	*26.8%*	*21.8%*	*20.2%*

Food processing	Revenues		Taxable income		GDP		Profit margin	
	2030	2040	2030	2040	2030	2040	2030	2040
BAU	19'547.9	33'862.2	7'377.7	15'888.7	6'167.8	13'282.9	31.6%	39.2%
Export	22'141.8	38'355.5	8'356.7	17'997.0	6'986.2	15'045.5	31.6%	39.2%
% Export vs BAU	*13.3%*	*13.3%*	*13.3%*	*13.3%*	*13.3%*	*13.3%*	*0.0%*	*0.0%*
Export + Premium price	22'729.4	39'373.4	8'944.3	19'014.9	7'477.4	15'896.5	32.9%	40.4%
% Export vs Export + premium price	*2.7%*	*2.7%*	*7.0%*	*5.7%*	*7.0%*	*5.7%*	*4.3%*	*2.9%*

Electronics	Revenues		Taxable income		GDP		Profit margin	
	2030	2040	2030	2040	2030	2040	2030	2040
BAU	3'893.9	6'415.0	1'214.8	2'115.1	1'015.6	1'768.2	26.1%	27.6%
Export	4'994.2	8'227.6	1'558.1	2'712.8	1'302.5	2'267.9	26.1%	27.6%
% Export vs BAU	*28.3%*	*28.3%*	*28.3%*	*28.3%*	*28.3%*	*28.3%*	*0.0%*	*0.0%*
Export + Premium price	5'276.4	8'692.5	1'840.3	3'177.7	1'538.5	2'656.6	29.2%	30.6%
% Export vs Export + premium price	*5.7%*	*5.7%*	*18.1%*	*17.1%*	*18.1%*	*17.1%*	*11.8%*	*10.9%*

4.2.3 Payback time

Table 40 presents the payback time, or the time required to fully pay back the investment implemented, for interventions in each subsector and for the ME, EE-FS, WE, WWT, and RE scenarios. These results should be used as reference, but do not necessarily reflect the reality confronted by policy makers when assessing the performance of policy interventions and investments across sectors. For that purpose, Table 41 and Table 42 provide more insightful results, in that these present the payback time for the period 2020-2030 (time-based rather than project-based), considering not a single project or investment but continued investments throughout 2030. Table 41 shows the payback time in months and Table 42 in years.

Two values are provided for the payback times: (a) one that considers only project-related investments and benefits (Project CBA) and (b) one that extends the analysis to economy-wide benefits. These values are estimated for all the investments implemented in the period 2020-2030, and include the assessment of the GI scenario, with the extra revenue as well as environmental and health impacts generated by increased exports -"GI (with EX)"- and without exports -"GI (no ex)."

Before assessing the results, it should be noted that the payback time could not be estimated for the EX and LI scenarios, due to the lack of reliable investment assumptions. Further, the payback time for WWT is only estimated for the economy-wide CBA case, because no revenues are generated for subsector operations. As a result, there is no return, or payback, for such investment.

Results of the simulations show first, that the payback time for the implementation of a single project is shorter (the investment seems to be more profitable) than those estimated when considering the timeframe 2020-2030. This is because in the latter case, we consider the total amount of investments up to 2030, the year when some of the investments will be paid back (certainly those that were implemented in 2020 and in the following years), while others will not (those implemented in 2028 or 2029 will require a few additional years to be fully paid back). As indicated above, these results are proposed to provide a more realistic view of the aggregated performance of a subsector when results are estimated over time (with a macroeconomic approach) rather on a project basis (with a bottom-up approach, company-driven).

Second, results show that the shortest payback time is generally realized for the WE scenario (as low as 4.8 months) and WWT (on average 19 months), followed by EE-FS (ranging between 2.2 and 4.9 years), and ME (ranging between 4.4 and 5.7 years). The longest payback time is for the RE scenario, ranging between 8.53 and 14.75 years (to be compared with an average lifetime of solar panels of 20-25 years). Overall, the payback time of the GI scenario is in the range of 2.51 years and 4.56 years, with the values slightly increasing when considering the extra impact of exports on the environment and human health.

Third, when considering the payback time of a project against economy-wide CBA, it emerges that the latter is always shorter. This confirms the analysis presented in the previous section, which shows that there are extra benefits to be accrued (that are not featured in the balance sheet of companies) when implementing GI interventions. The scenarios that show the largest gains are the RE and WWT cases.

Fourth, concerning subsectoral performance, the shortest payback times are observed for: (i) on a firm-level by bricks, thanks to the lack of expensive investments for ME, with all other subsectors showing similar values; and (ii) on an economy-wide basis by electronics, followed by bricks, food processing, and garments. Here the differences are more marked, as the economy-wide CBA captures environmental and health impacts as well.

Table 40: Payback time for an individual investment, across sectors.

	ME	EE-FS	WE	WWT	RE
	per ton	per TJ	per m^3	per m^3	per TJ
Garments					
Investment	4687.5	12900	0.19	0.423	182539.7
Avoided cost (price)	3595	16000	0.37		13984.5
Payback time (years)	**1.3**	**0.8**	**0.5**	**N/A**	**13.1**
Payback time (months)	15.6	9.7	6.2	N/A	156.6
Bricks					
Investment	0	5819	2.5	0.423	182539.7
Avoided cost (price)	0	2447	0.37		13984.5
Payback time (years)	**N/A**	**2.4**	**6.8**	**N/A**	**13.1**
Payback time (months)	N/A	28.5	81.1	N/A	156.6
Food processing					
Investment	216	14541	1.78	0.423	182539.7
Avoided cost (price)	150	9508	0.37		13984.5
Payback time (years)	**1.4**	**1.5**	**4.8**	**N/A**	**13.1**
Payback time (months)	17.3	18.4	57.7	N/A	156.6
Electronics					
Investment	4687.5	12900	0.19	0.423	182539.7
Avoided cost (price)	2000	40881	0.37		13984.5
Payback time (years)	**2.3**	**0.3**	**0.5**	**N/A**	**13.1**
Payback time (months)	28.1	3.8	6.2	N/A	156.6

Table 41: Payback time (in months) across sectors and scenarios.

Sector	Type CBA	EX	LI	EE	EE - FS	WE	ME	WWT	RE	GI (no EX)	GI (with EX)
Garments	Project CBA	N/A	N/A	45.21	35.37	24.16	55.97	No revenue	166.61	54.23	56.98
	Economy-wide CBA	N/A	N/A	40.22	31.39	15.57	55.97	22.11	113.35	51.36	54.05
Bricks	Project CBA	N/A	N/A	71.33	58.71	89.96	N/A	No revenue	176.99	38.14	38.14
	Economy-wide CBA	N/A	N/A	63.95	57.65	68.71	N/A	20.55	102.37	37.22	37.22
Food processing	Project CBA	N/A	N/A	54.08	27.71	84.39	52.47	No revenue	161.90	54.68	56.22
	Economy-wide CBA	N/A	N/A	50.85	26.61	44.80	52.47	18.17	104.07	49.37	50.25
Electronics	Project CBA	N/A	N/A	24.39	27.81	7.16	68.44	No revenue	163.53	53.81	56.62
	Economy-wide CBA	N/A	N/A	24.31	27.37	4.81	68.44	19.74	106.92	30.13	33.11

Table 42: Payback time (in years) across sectors and scenarios.

Sector	Type CBA	EX	LI	EE	EE - FS	WE	ME	WWT	RE	GI (no EX)	GI (with EX)
Garments	Project CBA	N/A	N/A	3.77	2.95	2.01	4.66	No revenue	13.88	4.52	4.75
	Economy-wide CBA	N/A	N/A	3.35	2.62	1.30	4.66	1.84	9.45	4.28	4.50
Bricks	Project CBA	N/A	N/A	5.94	4.89	7.50	N/A	No revenue	14.75	3.18	3.18
	Economy-wide CBA	N/A	N/A	5.33	4.80	5.73	N/A	1.71	8.53	3.10	3.10
Food processing	Project CBA	N/A	N/A	4.51	2.31	7.03	4.37	No revenue	13.49	4.56	4.68
	Economy-wide CBA	N/A	N/A	4.24	2.22	3.73	4.37	1.51	8.67	4.11	4.19
Electronics	Project CBA	N/A	N/A	2.03	2.32	0.60	5.70	No revenue	13.63	4.48	4.72
	Economy-wide CBA	N/A	N/A	2.03	2.28	0.40	5.70	1.64	8.91	2.51	2.76

5. Policy analysis and recommendations

5.1 National policy review

The Government of Cambodia has developed several policy documents that set the medium- to long-term vision and/or goals for the country's industrial sector. Examples include the National Strategic Plan on Green Growth 2013-2030 (GoC, 2013), Cambodia Industrial Development Policy 2015-2025 (GoC, 2015), the Climate Change Action Plan for Industry and Handicraft Sectors 2015-2018 (MIH, 2015), the Climate Change Strategic Plan for Manufacturing Industry and Energy (MIME, 2013), the National Energy Efficiency Policy 2018-2035 (GoC, 2017), and the Intended Nationally Determined Contributions (INDC) report (GoC, 2015). A full list of the documents reviewed is presented in Appendix E, with an indication of the main goals and targets, and indicated policy interventions.

Although these strategy documents set out high-level goals and sometimes provide a broad action plan to reach these goals, in the majority of cases, specific policy and regulatory provisions and quantitative targets are missing. Specific and actionable interventions are generally added after policy documents are approved by the Council of Ministers, such as in the case of the National Energy Efficiency Policy and Action Plan, whereby selected interventions are analyzed in great detail and where investments are considered for inclusion in the annual budget or discussed with development partners.

A review of these policy documents highlights that all available policy options-- such as investment, via incentives and mandates, and capacity building and awareness-- are considered in each of these policy documents, but do not provide specific intervention options and implementation modalities. Several important insights emerge from the review of these documents, especially in relation to the depth of the analysis carried out so far, and existing gaps.

Specifically, concerning incentives, the National Energy Efficiency Policy 2018-2035 (NEEP) (2017) focuses primarily on the promotion of best practices in energy consumption and generation, and the provision of financial incentives to companies interested in implementing EE strategies and measures, as well as manufacturing energy efficient equipment. Moreover, the Cambodia Climate Change Strategic Plan (CCCSP) (2013) focuses on the promotion of low-carbon planning and technologies to support sustainable development, while the INDC (GoC, 2015) outlines incentives related to the use of RE sources and EE improvements for garments factories, rice mills, and brick kilns. The incentives outlined in the INDC are expected to reduce total CO^2eq emissions by 727 Giga gram (Gg) in the year 2030, which represent a 7% reduction compared to the baseline (GoC, 2015), but information on the amount of the incentive to be provided is not available. The Climate Change Action Plan (CCAP)(MIH, 2015) provides several incentives for industry and handicraft businesses related to promoting GI for climate resilient low-carbon production in Cambodia, promoting RE generation on-site and co-generation for the industrial sector as well as special economic zones, using RE and energy diversification including promoting on-site RE captive generation for industrial production processes, and promoting waste management strategies, including hazardous waste management.

Regarding regulations and mandates, the CCAP foresees the development of a mandate related to the introduction of more path-breaking technologies for low-carbon production in the industry sector (MIH, 2015, S. 39) and another one to promote waste management strategies, and the development and enforcement of a national policy for industrial waste management. Two additional mandates have been introduced with the implementation of the NEEP (GoC, 2017): one for voluntary as well as compulsory standards on EE for large energy consumers and a second one for the enforcement of EE and conservation laws and regulations on industrial energy use.

Concerning capacity building and awareness raising, several national policy documents in Cambodia propose actions and policies to raise awareness on EE, the need to reduce GHG emissions, and waste management. The following list provides an overview of proposed policies that are most commonly found for awareness raising in the following documents: Cambodia Climate Change Strategic Plan 2014-2023 (CCCSP)(GoC, 2013), Climate Change Strategic Plan for Manufacturing Industry and Energy (CCSP) (MIME, 2013), Climate Change Action

Plan for Industry and Handicraft Sectors 2015-2018 (CCAP) (MIH, 2015), and the National Energy Efficiency Policy 2018-2035 (NEEP)(GoC, 2017). The proposed policies are: (i) transfer of knowledge, experience, and technology in GI and energy, (ii) develop compendia of EE and RE technology, as well as waste management for the industry sector, (iii) technical training for engineers and technicians in the field of EE, performing energy audits and implementing energy saving measures in the industry, and (iv) improve capacities, knowledge, and awareness for climate change responses.

The review of national policy documents shows that policy options are referred to but details are lacking alongside the parameters in which options are selected, costed out, and prioritized. The next section reviews international experience to identify more concrete policy and knowledge gaps.

5.2 International policy experience

There are several examples of policy options implemented internationally to support greening the industrial sector. This review focuses primarily on the experience of the ASEAN region, where industrial as well as economic contexts similar to the one of Cambodia can be found.

5.2.1 Examples of incentives

Incentives and disincentives, such as R&D subsidies, grants, and tax breaks, are important and commonly used to facilitate the development of new and emerging technologies, and to support the adoption and adaptation of existing technologies (UNIDO, 2011).

Concerning the adoption of new technologies, Malaysia's government provides direct and indirect tax incentives for the manufacturing sector which are provided in the following laws: Promotion of Investments Act 1986, Income Tax Act 1967, Customs Act 1967, Sales Tax Act 1972, Excise Act 1976, and Free Zones Act 1990(MIDA, 2017). Tax incentives for the high-tech sector are provided in the areas of new and emerging technologies, such as design, development and manufacture of high-density modules or systems, advanced displays, information and telecommunication products, and systems and devices (MIDA, 2012; MIDA, 2017). Specifically, incentives are provided if the company fulfills the following two criteria (MIDA, 2017):

1. Investment share in R&D must at least be 1% of gross sales. Compliance must be achieved within the first three years of business for the company to be eligible for the tax credit.

2. Scientific and technical employees should at least comprise 15% of the company's workforce, and must have scientific diplomas and work experience of at least five years in related fields.

Regarding the creation of higher value production chains, in 2010 the Minister of Finance of Singapore introduced the Land Intensification Allowance (LIA) incentive to promote the intensification of industrial land towards higher value-added activities (EDB, 2017). Since 2010, the LIA has been enhanced three times: in 2014, 2016, and 2017. Once approved, applicants will receive an initial allowance of 25% of the capital costs, followed by annual allowances of 5% on qualifying capital expenditure. Annual allowances will be granted until 100% of the qualifying capital expenditure is covered (EDB, 2017; IRAS, 2017).

In relation to financing, India has introduced the "Technology Development and Modernisation Fund," a special financial scheme operated by the Small Industries Development Bank of India and the Government of India. It provides concessional loans for technology upgrading, modernization, quality control, and environment management projects in the small-scale industrial sector (Narain, 2001).

In 2013, the Government of India reviewed its National Textile Policy 2000 to formulate the National Textile Policy 2013. The road map for the new trade policy includes a 3% interest subvention, inclusion of new markets, and an incremental export incentive scheme. India's government incentivized exporters to explore new markets to reduce the dependency on Western markets (Kar, 2015).

5.2.2 Examples of regulations and mandates

Regulations and mandates are used to place constraints on economic actors by restricting certain activities or behaviors with the use of enforceable legal instruments. These interventions set the context and conditions for actors within and across industries, and should facilitate and support the integration of environmental, economic, and development policies (UNIDO, 2011). In fact, mandates are often used to ensure that companies adopt more advanced practices and technologies that are economically viable, or reduce social and environmental impact, due to their high societal costs.

Bangladesh introduced mandates in its Sixth Five-year Plan (2011-2015), promoting EE and environmental sustainability in the bricks production sector by banning Fixed Chimney Kiln (FCK) production (ADB, 2017; Haque, 2017). The ADB supported this endeavor with a USD 50 million loan to provide targeted finance aimed at establishing energy efficient brick kiln replacement capacity that supports phasing out FCKs. The program was launched in 2012 (ADB, 2017).

Indonesia lifted a cap on foreign investments in May 2016 (Presidential Regulation 44 of 2016, PR44/2016) to allow for more foreign investments in Indonesia (Indonesia Investments, 2016). PR44/2016 relaxes the limits on foreign investments and opens up 35 sectors to 100% foreign ownership, including e-commerce, toll road operators, and telecommunications equipment (JLL, 2017). According to Jones Lang LaSalle IP (2017), the revision of the negative investment list encourages greater liberalization of the economy, supports greater foreign participation, and facilitates the development of specialty industrial parks and industrial estates in special economic zones.

Wage adjustments are also mandates used to complement industrial development policies. This is the case of the garments sector in ASEAN, including Cambodia and Myanmar. Particularly, in 2016 Myanmar became the latest country to introduce a minimum wage for the garments sector. However, labor costs are, compared to the region, still on the lower end (ILO, 2016).

5.2.3 Examples of capacity building and awareness raising initiatives

Capacity building refers to providing the technical know-how to innovate and adopt new technology solutions, and capitalize on the knowledge and skills of businesses, which ultimately determine economic and environmental performance (UNIDO, 2011).

An international example of capacity building activities is represented by the Brick Industry Association (BIA, 2006) of brick manufacturers in the U.S. Given the environmental impact of production, the industry has organized capacity building activities to raise awareness about the advantage of locating plants in close proximity to mines, and training for the incorporation of waste and recycled materials into brick manufacturing, along with information on the gains emerging from the implementation of energy and WE measures (BIA, 2006).

Similar policy initiatives have also been implemented in South Africa. Through the Accelerated and Shared Growth Initiative for South Africa and the Joint Initiative on Priority Skills Acquisition, the South African government aimed at increasing the number of artisans entering its labor market. In 2004, a skills audit of the Clothing, Textile, Leather, and Footwear (CTLF) sector yielded insights into the profile of the industry (HSRC, 2008), which paved the road for the preparation of the Sector Skills Plan 2005-2010 (CTFL SETA, 2006).

5.3 Shortlisting viable policy options

5.3.1 Summary of policy options

The review of national policy documents and international examples has highlighted the availability of many policy interventions to support GI. While national documents only list such options but rarely mention explicitly industrial subsectors, international case studies and literature provide insights on the type of policies best suited to certain subsectors. Table 43 highlights such differences across sectors and is an interpretation of policy options that are most often found to stimulate change in the four subsectors analyzed in this study. The following paragraphs explain how the subsectoral context (social, economic, and environmental) calls for different intervention options.

Food processing is primarily supported through direct investments and access to financing. This is where the expansion of production comes through investments in capital, rather than on the development of new products. For this reason, governments are primarily supporting the sector through direct investment or lowering the cost of financing (to increase private investment). A secondary area of intervention is cost reduction from operations, through infrastructure investment and audits for resource efficiency. The labeling of products and training of employees come next. The former supports a diversification of the offer, especially for higher value markets, while the latter can be found as a cross-cutting intervention across all sectors.

Construction is a sector where we primarily find regulation as the main intervention. This is also a maturesector, where there is little differentiation for the services offered (especially upstream, with bricks and cement manufacturing). Regulation is therefore required to ensure that appropriate materials are used, safety requirements are met, and that energy performance meets certain requirements. One of the main goals of this intervention is to mitigate the local impacts of production.

Garment is a more dynamic sector, with various levels of sophistication and a long supply chain. In this case, we find emphasis on trade facilitation. This is primarily to create demand for export products, which are normally of higher quality and provide a price premium. If demand is in place in the sector, investments follow. For this reason, the other areas of intervention are incentives (e.g., tax reduction for more advanced and more efficient equipment) and improved access to financing.

Electronics is an emerging sector in Cambodia and most of Southeast Asia, and is almost entirely export- oriented. Governments are primarily offering incentives to establish new companies, relocate them (or create subsidiaries), or expand production. Tax reductions are, for instance, provided based on the share of the revenues that is reinvested (rather than on the total annual investment). This implies that if a considerable share of revenues is reinvested in capacity expansion, a company is eligible for tax reductions. Foreign Direct Investment (FDI) promotion is also very common for emerging sectors to attract investments to the country. This is often coupled with land intensification schemes, as found in Singapore. In this case, the government provides incentives for the electronics industry because it is less land intensive (and so it generates a higher value per hectare of land used) than several other sectors. Audits for resource efficiency and training of employees are provided in this case as well, same as for all the other subsectors analyzed.

5.3.2 Method to identify viable intervention options in Cambodia

The results of the modeling exercise, presented in Section 4, provide an indication of whether achieving a certain GI target is economically viable or not. This information is used as a starting point for the analysis of what intervention options could be used to stimulate the investment required to reach the said targets. The method used to identify viable intervention options is presented in Figure 25, and presented in more detail next.

Figure 25 shows that if reaching a target is financially viable (i.e., the investment required is paid back by the resulting avoided costs and added benefits), three main areas are considered to identify intervention options. If there are no major constraints, mandates/regulations and awareness raising activities could be considered. This is

Table 43: Identification of policy options by subsector. Bold highlights indicate the most common policy interventions found in national and international policy documents.

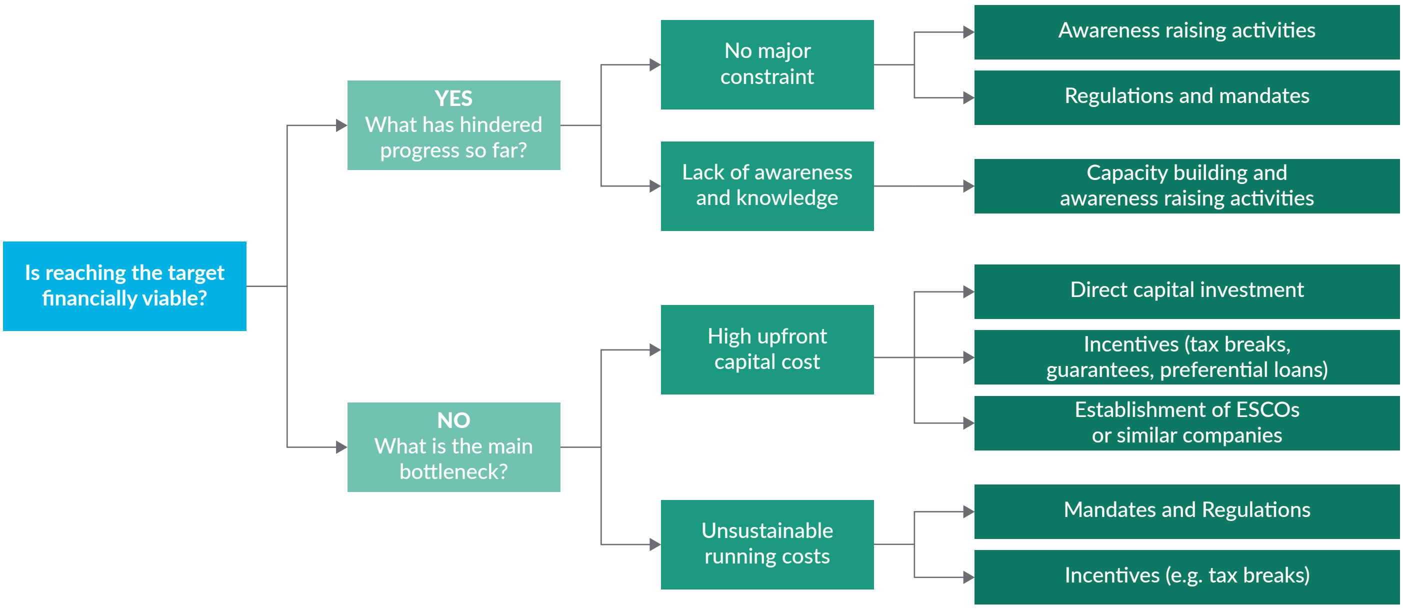
Food Processing	Construction	Garment	Electronics
• Direct investment (capital grants) • Access to financing (preferential loans and credit) • Infrastructure investment • Audits for resource efficiency • Labeling of products • Training of employees	• Regulation (licensing in relation to pollution, energy sources used • Access to financing (preferential loans) • Audits for resource efficiency • Training of employees	• Trade facilitation (export incentive schemes) • Incentives (e.g. profit tax exemptions) • Access to financing • Audits for resource efficiency • Training of employees	• Incentives (e.g. tax reductions, based on investment allocated as a share of revenues) • Land intensification schemes • FDI promotion • Audits for resource efficiency • Training of employees

because the investment is already economical, and its implementation would generate benefits for investors. If there is an economic return but the upfront capital cost is too high (i.e., if the savings of the private sector are not high enough to support an investment), governments can intervene by investing directly (e.g., on infrastructure), by providing incentives to reduce the burden of the initial investments (e.g., by providing collateral for loans, and hence reducing the cost of financing), or by establishing energy or other service companies (e.g., ESCO) that would cover the cost of capital and related risk. Finally, if the only constraint is lack of awareness, the main intervention envisaged is awareness raising. The rationale in this case is that if the investment is profitable, any economic actor with sufficient funding would proceed if he is aware of the opportunity.

This could be the result of (a) high upfront capital costs, for which policies include direct capital investments (on infrastructure, for example) and incentives (such as preferential loans to lower the cost of financing); or (b) unsustainable running costs, for which incentives could be provided (such as tax breaks) to lower annual costs as opposed to the upfront investment, or laws (regulation) could be introduced to stimulate investment. The latter is the case of interventions that would reduce societal impacts. For instance, treating wastewater on-site does not generate value for companies, but it generates costs (both health and monetary costs) for households and the government.

The following sections analyze each target reviewed and simulated in this study, and assess what policy options are available to stimulate investments, considering the financial viability for each subsector as well as for the project and economy-wide. Three main results from the modeling assessment are used: **payback time** (to assess if the investment is financially viable), capital investment (to assess whether the upfront cost is manageable), and **cost saving economy-wide** (to assess whether there are positive returns beyond the firm-level, i.e., for society). A summary of the main policy interventions identified as viable to stimulate investments to reach GI targets is presented in Table 44.

Figure 25:Tree diagram illustrating the process of shortlisting policy interventions for targets.



5.4 Informing policy development

The quantitative assessment carried out with subsectoral simulation models provides insights on whether the GI targets analyzed are economically viable. This assessment was carried out considering the payback time of the investment required. Payback time explicitly considers upfront capital costs, O&M costs, as well as the benefits of the investment implemented. The latter were divided into firm-level and societal benefits.

The identification of policy interventions, and the extent of support the government can provide (e.g., in the case of incentives), can be informed by the use of these three indicators. Specifically, as indicated in Figure 25, if upfront capital costs represent a challenge, incentives could be provided. Or, as in the case of Bangladesh, international experience indicates that when societal costs are high, mandates are a good option to tackle the problem at the source.

The next section presents the method used for the estimation of incentives, and the following one summarizes the results of the analysis.

5.4.1 Method to estimate incentives and mandates

Previous sections have highlighted that the investments required to achieve the GI scenario are profitable, i.e. the investment is fully paid back within a few years in most cases (see Table 41 and Table 42). However, actual investments lag behind in part due to the constraints highlighted in Figure 25. An important question in developing green incentive policy is: how much should the government be willing to invest to stimulate investments?

To answer this question, we consider the amount of avoided costs and added benefits that are directly related to societal performance (excluding firm-level performance) and we compare them to taxable income and required investment.

First, as presented in Figure 26, we distinguish between (a) the subset of avoided costs and added benefits that are directly related to budgetary items (e.g., avoided health costs from water pollution), and those (b) that are relevant to society but do not represent a cost for the government (e.g., market value of carbon).

- Item (a) is considered because, if the amount of support provided by the government reaches beyond the expected reduction in budgetary costs resulting from the implementation of GI investments, the government will be effectively subsidizing the industry sector.
- The assumption made in this case is that 10% of the actual cost of air and water pollution is sustained by the private sector, through the provision of health care services. The figure 10% is used because increases in air and water pollution do not always necessarily translate into higher direct costs.
- The aim is to highlight the potential maximum amount of support that could be provided without incurring extra net budgetary costs (the amount of funding that is saved from reduced health costs is reallocated to energy and WE interventions). As a result, only results for (a) are presented in the next sections.

Second, we compare the avoided costs for the government (A) to (i) taxable income and (ii) required investment in order to:

(i) Provide an indication to the government of the extent to which taxation could be reduced (as a form of foregone tax revenue).

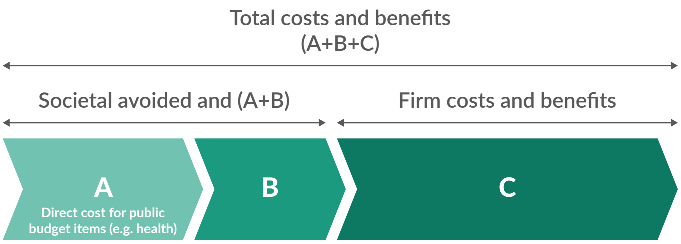
$$\textit{Possible tax reduction} = \frac{\textit{Avoided Cost (A)}}{\textit{Taxable Income}}$$

(ii) Provide an indication to the government of the extent to which direct incentives (as a form of cash transfer) could be implemented to lower capital costs for firms.

$$\textit{Possible incentive} = \frac{\textit{Avoided Cost (A)}}{\textit{Required Investment}}$$

Figure 26: Breakdown of avoided costs resulting from reaching GI targets.

Total avoided costs: A (avoided costs that reduce public budgetary expenditure) + B (avoided costs for society that do not reduce budgetary expenditure or household cost) + C (avoided costs for firms).



5.4.2 Informing the prioritization of policy interventions

Realizing GI targets requires investment and generates economy-wide avoided costs. This section discusses the prioritization of the aforementioned policy interventions so as to reduce costs and stimulate investments, and support the realization of economy-wide cost savings, as presented in Table 44.

The quantitative analysis carried out has generated results that can particularly inform two types of policies: incentives and regulations/mandates. This is because the GI scenario estimates investment requirements, as well as avoided costs and additional benefits by economic actors (government and firms) and can provide insights on the amount of funding that the government could reallocate (its avoided costs) to incentivize private sector investment. Also, estimating the effectiveness of capacity building and awareness raising investments with quantitative simulation models is difficult due to the uncertainty of the impact of such an investment.

Specifically:

- **Reducing capital investment and cost of financing:** The primary policy intervention available is the introduction of incentives to reduce capital costs when the capital cost is too high, access to financing is not available, or the cost of financing is prohibitive. Mandates and regulations are also viable options, especially when the payback time is short. Where there is little to no awareness of the advantages of investing, wide-scale capacity building and awareness raising would be required.
- **Realizing societal cost savings:** Available policy interventions for realizing societal cost savings are primarily mandates and regulations. This is because often companies are not requested to mitigate societal costs (e.g., compensating for air pollution). Capacity building and awareness raising could be considered as well, especially in urban areas where air quality is comparatively lower and where the impacts are felt firsthand.

Overall, when considering the **payback time (at firm-level)** the most effective policy options, when also considering fiscal sustainability of the public sector, are mandates/regulations (e.g., minimum efficiency standards and required audits) as well as capacity building and awareness raising, when the payback time is short. Incentives to reduce capital costs and the cost of financing would be required instead when the payback time is long (or longer than the conventional investments in the subsector).

The following sections present more detailed results, by intervention area and by subsector.

5.4.3 Incentives

Incentives are identified as a good intervention option to reduce capital costs and the cost of financing in the GI scenario. The results of the analysis are presented in Table 44.

Incentives can be provided as tax reductions (foregone revenue, rewarding performance) or as a direct contribution (budgetary expenditure, rewarding investment). Given the short payback time of most interventions, incentives should be temporary (implemented only in the short term) but should target investments with a long lifetime.

The amount of incentives that the government could provide, in the form of a reallocation of avoided costs in the GI scenario, is estimated as follows:

(iii) Tax reduction: total (cumulative) avoided cost for the government / taxable income

(iv) Direct budget contribution: total (cumulative) avoided cost for the government / total investment

Note: Cumulative avoided costs are calculated for the period 2020-2030; the cost to the government is assumed to be 10% of the estimated health cost of air and water pollution.

These two options can be used in isolation or combination, depending on the local context. For instance, tax reductions are preferred when fiscal sustainability (e.g., deficit) is a concern. Direct budget contributions are preferred when short-term results are required to lower upfront capital costs.

Combinations are found when an incentive is set based on the investment required (e.g., 20%), but it is delivered in the form of a tax reduction over five or 10 years. The results of the analysis, providing a range for the potential amount of incentives that could be provided by the government, are presented below:

Energy efficiency:

2% of tax reductions in case of foregone revenue OR 10% to 15% of the investment in the case of direct incentives

Water efficiency:

0.5% (for food processing, garments, and bricks) to 15% (for electronics) of tax reductions OR 10% to 20% (for bricks and food processing) or a higher value for garments and electronics of the investment

Wastewater treatment:

5% of tax reductions (in case of foregone revenues) OR a higher percentage of the investment in the case of direct incentives (with monitoring)

Renewable energy:

0.4% and 1.5% of tax reductions OR up to 60% of the investment in the case of direct incentives

Finally, it is estimated that value for money would be maximized if incentives were to be provided for reducing water pollution and for RE. These are areas that directly impact budgetary costs of the government.

5.4.4 Mandates

Mandates and regulations introduced by the government are identified as a good intervention option when large societal costs result from industrial production. There are two reasons to promote the use of regulation to realize the GI scenario:

- Competitiveness: The incremental costs of adopting technology that respects minimum sustainability standards (e.g., for EE) may generate more benefits than costs for companies (and the payback time is often short).

- Value for money: Mandates and regulations transfer costs from government (and households) to the industry. If there is a direct link between production and societal costs, a more cost-effective intervention is to act at the source (i.e., industrial level).

  Based on the GI analysis and literature review (see Appendix E), the following regulations and mandates are used to realize the GI scenario:

Energy efficiency:

- Implement building codes with minimum energy performance requirements

- Focus on energy services rather than sectors (e.g., mandate the use of LED lights, labelled and energy efficient heating/cooling units, ban the use of unsustainable fuel wood)

- Stimulate the use of more efficient and lower carbon intensive energy sources, through targeted mandates for the adoption of technologies and equipment that support fuel switching

Water efficiency:

- Strengthen water metering, monitor water losses and infrastructure efficiency

- Regulate the use of water efficient faucets, label products

Material efficiency:

- Regulate the import of equipment, allowing only medium- to highly-efficient technology

Wastewater treatment:

Enforce on-site WWT, with monitoring of performance

Table 44: Summary of the policy interventions identified as most viable, by target.

Payback time (firm-level)		Interventions to reduce capital investment	Interventions to realize cost saving economy-wide
EX	N/A	Export promotion Capacity building	Awareness raising Promotion of resource efficiency and renewable energy
LI	N/A	Incentives (i) professional training and (ii) modernizing equipment Capacity building	Mandates and regulations (for labor conditions)
EE-FS	2.2 to 4.9 years	Demonstration projects Capacity building Incentives for energy intensive sectors	Awareness raising Mandates and regulations
	Potential government support: 2% of tax reductions (in case of foregone revenues) or 10% to 15% of the investment in the case of direct incentives.		
WE	0.4 to 7.5 years	Incentives (to lower capital cost) Capacity building	Awareness raising Incentives (to reward good practice)
	Potential government support: 0.5% (for food processing, garments, and bricks) to 15% (for electronics) of tax reductions (in case of foregone revenues) or 10% to 20% (for bricks and food processing) or a higher value for garments and electronics of the investment in the case of direct incentives.		
ME	4.3 to 5.7 years	Export promotion to premium markets Incentives (to lower capital cost or reduce the cost of financing)	
WWT	1.5 to 1.8 years	Mandate or regulation (with enforcement) Tax (with water metering and monitoring of pollution)	Incentive to reduce running costs (with enforcement)
	Potential government support: 5% of tax reductions (in case of foregone revenues) or grow to a higher percentage of the investment in the case of direct incentives, provided that there is monitoring of the investment.		
RE	8.5 to 14.7 years	Incentives (to lower capital cost and increase access to financing) Awareness raising Clear regulation	
	Potential government support: 0.4% and 1.5% of tax reductions (in case of foregone revenues) or up to 60% of the investment in the case of direct incentives.		

Informing Export-related policy interventions

- **Payback time (firm-level)**: The payback time for an increase in export is the same as conventional production. This is also the case if we assume that the purchase of more expensive equipment is connected with the opportunity to realize a premium for the units sold. The subsectors with the largest potential for growth, and hence the ones with the shortest payback time, could be electronics and garments, with established markets.
  - Given the payback time observed, available policy interventions include **export promotion** (for the creation of demand), and hence **capacity building** and **awareness raising**, especially for electronics and garments.
- **Capital investment**: The average annual capital investment for expanding capacity is aligned with the current values, leading to positive profit margins for the sectors. As a result, capital investments (especially when there is a gradual replacement and expansion of machineries) are not going to negatively impact the profit margin in the medium term.
  - Given the required capital investment estimated, available policy interventions include **capacity building and awareness raising**, as well as **incentives to reduce capital costs** for specific technologies or equipment that would increase quality and productivity, and at the same time increase energy and material productivity and possibly also reduce wastewater generation.
- **Societal cost**: There are no specific avoided costs from expanding exports. In fact, there are additional costs.
  - Given that expanding exports is projected to increase economy-wide costs, support in the form of incentives could be provided to direct investment in low-impact technologies. This would still make economy-wide costs increase, but to a lesser extent, reducing health impacts and public expenditure.

What emerges from the considerations above is that expanding exports is an economic development policy. It should therefore be promoted to increase GDP and employment, and to create income. It has to be acknowledged than any increase of production is likely to lead to increased social and environmental, and hence economic, economy-wide costs. As a result, in addition to export promotion, awareness raising, and capacity building, efforts should be made to promote at the same time resource efficiency and the use of RE. This would mitigate the impact on human and environmental health. Export promotion should therefore be targeted to those markets that require certification, or a certain degree of technology advancement, and possibly offer a premium price.

Informing Labor Intensity-related policy interventions

- **Payback time (firm-level)**: The payback time for a decrease in LI is connected to the purchase of new equipment in the production line and modernizing production practices. For this reason, it is not easy to identify the net cost of decreasing LI as distinct from other investments in equipment. As a result, the payback time for the LI scenario was not estimated. Instead, avoided costs were calculated to provide information on the potential upside from reducing LI and the potential investment that could be allocated to this target. The subsectors with the largest labor LI, and hence the ones that may be prioritized for intervention, are bricks and electronics. These are very different sectors, with a higher potential for modernization in the latter.

- Given that the payback time was not estimated, the only policies available for intervention are **capacity building** and **regulation** (ensuring good working conditions).

- **Capital investment**: The costs related to labor efficiency are often related to the purchase of new equipment and the modernization of the production chain. As a result, the same policies identified to increase and modernize production are proposed, **capacity building** and **awareness raising**, as well as **incentives to reduce capital costs** for specific technologies or equipment that would increase quality and productivity.

- **Societal cost**: Labor costs decline when LI declines. The most labor-intensive sectors (or the ones with the largest cost share) are expected to see the largest benefits. In order of relevance, these are bricks, electronics, garments, and food processing.

  - **Incentives** could be provided for **training** and investing in new equipment. The impact is likely to be meaningful, especially considering that decreasing LI is forecasted to lead to larger savings than EE for garments, bricks, and electronics, and always larger than WE (due to the large cost share of labor).

What emerges from the considerations above is that decreasing LI can effectively reduce costs. If this is coupled with an increase in labor productivity, it would lead to higher salaries and a more empowered, better prepared, and innovative labor force. As a result, awareness raising and support for training are crucial, as are incentives to trigger investments in the modernization of the production chain (that would require a more skilled workforce). It is worth considering that reduced LI and higher productivity mean that more production and value will be created per worker. This results in job creation that is lower than in the BAU scenario, but in higher per capita income.

Informing Energy Efficiency-related policy interventions

- **Payback time (firm-level)**: The payback time for EE is short compared to other interventions. The values found in the literature for Cambodia range from as low as four months up to a few years. Simulations show average values, across subsectors, in the range of two to six years. The subsector with the shortest payback time is electronics, followed by garments, food processing, and bricks. When considering the potential for fuel switching associated with EE, electronics and food processing perform best, followed by garments and bricks.

  - Given the payback time observed, available policy interventions include **mandates/regulations (e.g., minimum efficiency standards and required audits),** as well as **capacity building and awareness raising**, especially for electronics, and in selected cases **incentives to reduce capital costs** (and hence improving the payback time), such as for bricks. Further, given the potential for fuel switching, which greatly lowers the payback time for food processing, emphasis could be put on this and other subsectors for the adoption of specific technologies, with more **targeted regulation and incentives to reduce unsustainable biomass consumption and emissions.**

- **Capital investment**: The average annual capital investment for EE and fuel switching ranges between 2% and 3% of the taxable income (pre-tax) of the four subsectors. As a result, the profit margin is not going to be heavily affected by these investments (considering the assumed goal of a 20% improvement in EE compared to the BAU scenario by 2025). When considering the profit margin of the sectors and the share of energy costs, it emerges that policy support could be provided to garments and food processing concerning profit margin, and for food processing and electronics concerning the high relevance of energy costs.

- Given the required capital investment estimated, available policy interventions include **capacity building** and **awareness raising**, as well as **incentives to reduce capital costs** for food processing and electronics. The latter is only determined by the high energy intensity of these two subsectors, and higher reliance on modern (and often more expensive) sources of energy. Mandates and regulations are also viable options, but if there is awareness of the advantages of investing in EE there should be no need for a further stimulus to invest.

- **Societal cost**: The main economy-wide cost avoided by improving EE is the reduction of air emissions. Moreover, a transition to modern forms of energy would reduce the use of biomass, especially unsustainable biomass, thereby reducing pressure on forest cover.
  - Given the estimated avoided costs from air emissions, available policy interventions remain to be **capacity building and awareness raising. Mandates/regulations** can be considered as well, especially in urban areas where air quality is comparatively lower. Incentives may be considered if other intervention options to reduce air emissions are not available, or are costlier. But these incentives would be economical only if the government has a strong commitment to emissions reduction.

What emerges from the considerations above is that improving EE is economically viable, has a relatively short payback time, and would not have excessive impact on the profitability of the sectors. As a result, mandates/regulations, coupled with awareness raising, demonstration projects, and capacity building, are suitable intervention options. **Overall, the potential contribution of the government could be in the range of 2% of tax reductions (in case of foregone revenues) and 10% to 15% of the investment required in the case of direct incentives.**

Incentives could be provided for bricks (given the longer payback time), and food processing and electronics (given the higher share of energy cost and hence higher capital investment required) to reduce capital costs. Overall, it is important to highlight the role of fuel switching in reducing environmental pressure. Although biomass is often cheaper, the switch to more modern forms of energy (e.g., electricity) would reduce air emissions and hence economy-wide costs.

Estimation of the potential public contribution to EE-FS

When comparing societal avoided costs and added benefits to (a) taxable income and (b) investments it emerges that:

a) Societal outcomes and taxable income, potential for foregone revenue: Food processing and garments generate economy-wide benefits (excluding benefits for companies) in the range of 1% to 2% of the taxable income pre-tax. Electronics and bricks follow, with values of 0.6% and 0.2%, respectively. This indicates that, on average, tax reductions could be offered for up to 2% if there is proof that investments are implemented.

b) Societal outcomes and investments, potential for direct incentives: The societal outcomes of reaching stated targets represent 20.2% for garments, 17.3% for electronics, 10.6% for food processing, and 1.2% for bricks. As a result, an incentive between 10% and 15% of the total investment could be provided.

Informing Water Efficiency-related policy interventions

- **Payback time (firm-level)**: The payback time for WE varies considerably across subsectors. The subsector with the shortest payback time is electronics (seven months), followed by garments (two years), food processing (seven years), and bricks (7.5 years).
  - Given the payback time observed, **incentives to reduce capital costs** (and hence improving the payback time) would be required for food processing and bricks. **Capacity building** and **awareness raising** can be applied to all sectors, with the highest effectiveness for electronics and garments.
- **Capital investment**: The average annual capital investment for WE is very low, reaching only 2.7% of the total investment of the GI scenario (with the highest value being 10% for food processing). As a result, the profit margin is not going to be heavily affected by these investments. The main constraint is the reduced cost saving and lack of additional value generation.
  - Given the required capital investment estimated, available policy interventions include **capacity building** and **awareness raising.** The contained investment required does not warrant support to reduce capital costs.
- **Societal cost**: The main economy-wide costs avoided by improving WE are reduced emissions, health costs from air quality and water quality, in addition to firm-level cost savings on reduced water use and electricity use for water treatment. The payback time is cut by more than 50% in the case of food processing and by, on average, a third when considering economy-wide impacts, making a strong case for public incentives.
  - Given the estimated avoided costs from air and water pollution, available policy interventions include **mandates (e.g., strengthening water metering), incentives**, and **awareness raising.** Incentives may be considered not only for capital, but also for proven WE improvement (if water metering is reliable). This is critical to ensure that additional benefits (e.g., reduced wastewater quantity and treatment cost) are achieved and synergies realized.

What emerges from the above is that improving WE becomes economically attractive when considering economy-wide synergies. The payback time is long for certain subsectors (such as bricks and food processing), and incentives could be provided both to lower capital costs in these instances, as well as to reward good practices based on proven performance (based on metered water use reductions). **Overall, the potential contribution of the government could be in the range of 0.5% (for food processing, garments, and bricks) to 15% (for electronics) of tax reductions (in case of foregone revenues) and 10% to 20% (for bricks and food processing) or an even higher value for garments and electronics of the investment required in the case of direct incentives**. Awareness raising and demonstration projects also remain viable intervention options to highlight the role that WE can play in reducing costs not only at the firm-level but also economy-wide, for the communities living near industrial activities.

Estimation of the potential public contribution to WE

When comparing societal avoided costs and added benefits to (a) taxable income and (b) investments, it emerges that:

a) Societal outcomes and taxable income, potential for foregone revenue: Electronics generates economy-wide benefits (excluding benefits for companies) in the range of 13.7% to 17.6% of the taxable income pre-tax. All other subsectors show smaller values, with 3% for food processing, 0.7% for garments, and 0.01% for bricks. This indicates that, on average, tax reductions could be offered for up to 15% for electronics, and in the range of 1% to 3%% for other subsectors.

b) Societal outcomes and investments, potential for direct incentives: The societal outcomes of reaching stated targets represent over 100% of the investment required for electronics and garments, indicating that the avoided cost of water pollution exceeds the investment required. This value declines to 22.2% for food processing and 8.6% for bricks. As a result, an incentive would need to be targeted by subsector.

Informing Material Efficiency-related policy interventions

- **Payback time (firm-level)**: The payback time ME is aligned with other interventions. Simulations show average values, across subsectors, in the range of 4.4 to 4.7 years. The subsector with the shortest payback time is food processing, followed by garments and electronics (the bricks sector was not assessed).
  - Given the payback time observed, available policy interventions include **incentives to reduce capital costs** (and hence improving the payback time). ME improvements are connected with the substitution and purchase of new equipment, and hence **capacity building and awareness raising** are also relevant interventions.
- **Capital investment**: The required capital investment for ME is the highest among all targets analyzed. ME requires on average 73% of the GI investment, being as high as 80% for garments and declining to 61% for electronics and 58% for food processing. The share of taxable income is in the range of 20% for the improvement in ME assumed, and the profit margin may be affected significantly in the short term by these investments. In this respect, the garments sector may require support, especially if the improved ME does not lead to increased access to premium markets.
  - Given the required capital investment estimated, available policy interventions include **incentives to reduce capital costs** and **access to financing** (e.g., with preferential loans or collateral). All subsectors could benefit from this support.
- **Societal cost**: The main economy-wide cost avoided by improving material efficiency is the potential reduction of waste generation. This has not been extensively assessed in this study (at least concerning possible toxic waste). The main saving estimated is a direct cost reduction for material use.
  - Given the limited potential to reduce economy-wide costs, as estimated in this study, there is no specific incentive to use public funding to support ME, aside from **regulations and labeling for the import of equipment**. The upside arises from increased profitability, employment, and GDP, and hence increased tax revenues. In this respect, the primary goal is economic development.

What emerges from the considerations above is that improving ME is generally economically viable (it has an average payback time, but the equipment purchased has a much longer lifetime), but requires high upfront capital costs. As a result, incentives could be provided to reduce the payback time for industries, either by lowering capital costs or by reducing the cost of financing. New regulations could be introduced to direct investment towards resource efficient equipment. In addition, it is important to note that the analysis above does not take into account the potential to reduce harmful waste through the improvement of ME. This could represent a significant public cost, and hence justify the allocation of more public resources to support improved ME.

- **Payback time (firm-level)**: The payback time for WWT, at the firm-level, is not estimated in the modeling exercise. This is because at the moment there are no costs (taxes, fees, or fines) for water pollution. What can be observed instead is an increase in costs (e.g., for electricity consumption) when treatment increases, in addition to the capital cost required to treat water. There is, on the other hand, regulation that mandates on-site WWT. As a result, there is no economic case for voluntary investments in WWT.
  - Given that there is no economic case for investing in WWT, the policy intervention currently available is **regulation**. A mandate is ineffective unless there is effective **enforcement**. The introduction of a tax (with water metering and monitoring of pollution), or an incentive (with enforcement) for rewarding good performance may be more effective as it would create avoided costs for companies.
- **Capital investment**: The investment required for WWT is generally very small (in the range of 1% of the total investment in the GI scenario). The capital cost is therefore not a relevant issue. What prevents the effective use of WWT capacity is the running cost (the high cost of electricity), coupled with lack of monitoring and enforcement.
  - Given the required capital investment estimated, available policy interventions include **capacity building** and **awareness raising**, both about the regulations and the impacts of water pollution on health. **Incentives** could be introduced to reduce operating costs.
- **Societal cost**: The increase in WWT leads to additional electricity consumption and emissions. However, it reduces the amount of wastewater discharged and the cost of health impacts. Overall, the avoided health costs are larger than the increased cost of energy and emissions, by a factor of four to five times.
  - Given the estimated avoided costs from wastewater discharge and water pollution, the introduction of **incentives** is justified. These may be considered to reduce the operation costs of WWT to reward good behavior. Alternatively, a **tax** could be introduced to penalize lack of action. Either way, effective **monitoring** and **enforcement** arrangements are required.

What emerges from the considerations above is that WWT is costly, does not add value to production, and hence cannot be assessed using a traditional payback time calculation. A mandate is therefore likely to be ineffective due to the lack of economic incentives and limited bankability for the investment, unless enforcement is ensured. As a result, the introduction of a tax (with water metering and monitoring of pollution), or an incentive to reduce running costs (also with enforcement) would be more effective. The introduction of a public incentive would be justified by savings on health costs. **Overall, the potential contribution of the government could be in the range of 5% of tax reductions (in case of foregone revenues) and grow to a higher percentage of the investment required in the case of direct incentives, provided that the investment is monitored.**

Estimation of the potential public contribution to WWT

When comparing societal avoided costs and added benefits to (a) taxable income and (b) investments it emerges that:

a) Societal outcomes and taxable income, potential for foregone revenue: Electronics scores the highest, with values in the range of 50%. Food processing follows, with 4.5%. Garments reach 2.3% and the bricks sector is close to zero. This indicates that, on average, tax reductions could be offered for up to 5%, with the exception of electronics, where the value could be higher.

b) Societal outcomes and investments, potential for direct incentives: The societal outcomes are, across all sectors, over four times larger than the investment. This indicates that support could be provided, especially in areas with the highest pollution concentration and population density.

Informing Renewable Energy-related policy interventions

- **Payback time (firm-level)**: The payback time for RE is the longest of all the targets considered. With no incentives, the payback time ranges from 13.5 to 14.75 years. Since the average lifetime of solar panels is in the range of 20 to 25 years, the investment is still bankable and worth implementing. The factors affecting the payback time are capital and O&M costs, and local electricity prices. Over the lifetime of the investment, considering the levelized cost of electricity generation (i.e., the cost per unit of electricity generation, calculated over the lifetime of the power generation plant), RE saves up to 20% to 30% of the annual electricity cost.
    - Given the payback time observed, available policy interventions include **incentives** to reduce capital costs, as well as to reduce the cost of financing. **Awareness raising** is also a viable option to stimulate investments.
- **Capital investment**: The capital investment required for RE is proportional to the extent to which electricity is used in the four subsectors. The garments and electronics subsectors are the most prominent with RE representing 13% and 19% of the total GI investment. Food processing follows with 6%, and bricks with less than 1%. As a result, the profit margin for garments and electronics could be affected.
    - Given the required capital investment estimated, available policy interventions include **incentives to reduce capital costs, and the cost of financing**. Given that the capital cost is the same for all sectors, and electricity rates are also aligned, there is no specific priority subsector for policy intervention.
- **Societal cost**: The main economy-wide costs avoided by increasing the use of RE for power generation are the reduction of air emissions and related health costs, and saving on power generation capacity (the public grid could be expanded to a lesser extent). When considering economy-wide impacts, the payback time for RE declines by four to six years, ranging between 8.5 and 9.5 years.
    - Given the estimated avoided costs from an economy-wide perspective, available policy interventions remain to be **incentives**, given the potential for savings on health and infrastructure costs, and **capacity building** and **awareness raising** due to the bankability of the investment.

What emerges from the considerations above is that expanding the use of RE (i.e., solar panels) for power generation has a long payback time, and comparatively high capital cost. However, there are consistent savings both from a project and from an economy-wide perspective. Adding the latter shortens the payback time to below 10 years, or about half the lifetime of solar panels. To stimulate investments in solar panels, and realize emission reductions and reduced health costs, incentives could be provided to lower the burden of capital cost and increase access to financing. **Overall, the potential contribution of the government could be in the range of 0.4% and 1.5% of tax reductions (in case of foregone revenues) and up to 60% of the investment required in the case of direct incentives**. Awareness raising is also necessary, since the cost saving is attractive but solar panels and electricity generation are distant from the core business of the four subsectors analyzed.

Estimation of the potential public contribution to RE

When comparing societal avoided costs and added benefits to (a) taxable income and (b) investments it emerges that:

a) Societal outcomes and taxable income, potential for foregone revenue: Values across subsectors are quite similar, in the range of 0.4% to 1.5%, given the comparable price of solar panels and purchased electricity. This indicates that, on average, tax reductions could be offered for up to 1.5%.

b) Societal outcomes and investments, potential for direct incentives: The societal outcomes of reaching stated targets represent approximately 60% for all subsectors. As a result, an incentive of up to 60% of the total investment could be provided, but the amount could actually be lower given that savings can be accumulated on a monthly basis from the use of RE.

6. Concluding remarks

The work presented in this study aims to inform policy making in Cambodia, especially in the context of industrial development. It does this by quantifying the outcomes of reaching stated GI targets. The targets include an increase in exports, reductions in LI, and improvements in resource efficiency. The outcomes include estimates of production costs and profitability of firms, as well as the impact of production on societal costs.

Results indicate that GI targets are economically viable. The study also highlights that synergies can be found across targets. For instance, improving resource efficiency reduces waste generation, which also reduces environmental and human health impacts and costs. Overall, the modeling assessment shows that implementing GI investment would reduce costs for firms and society, while increasing the industry's competitiveness. It also shows that GI investments have the potential to stimulate greener and more sustained lucrative industrial growth.

Two main policy options were analyzed in the study: incentives and regulation. It was found that incentives in the range of 15% of the investment required or 2% of taxable income, when using EE as an example, would be economically viable for the government (this incentive amount represents a reallocation of avoided budgetary expenditure). Concerning regulation, it was found that it would be effective when payback times are very short from a firm-level perspective (e.g., EE for the garments sector) and when societal costs from environmental impacts are high (e.g., WE for electronics).

These results provide much needed depth to existing policy analysis in Cambodia. The quantitative exercise presented in this study estimated the outcomes of reaching GI targets in four subsectors, using social, economic, and environmental indicators. It also identified where public support may be needed, and the extent to which the government could provide such support at no net cost (i.e., reallocating cost savings resulting from reaching GI targets). As a result, this analysis provides additional depth relative to what is currently found in national policy documents on industrial subsectors, on the cost of reaching GI targets, on the outcomes of reaching such targets, and on the budgetary implications for the government should similar targets be of interest.

7. Next Steps

The analysis presented in this study extends the knowledge available in the country. On top of providing quantitative estimates to advance the current policy debate on industrial development, this study proposes and applies a framework and method of analysis for industrial subsectors.

Specifically, key policies relevant to greening industry have referred to the incentives but do not provide further guidance on the process, parameters, and responsibilities in developing a green incentive policy and/or schemes (see Table 45). The Ministry of Economy and Finance will play a critical role as it updates the Revenue Mobilization Strategy which will shape any updates to laws on taxation and investment promotion.

As this study presents a strong economic case for GI, the insights emerging from this work can be used to inform related policy discussions and define, in close collaboration with the relevant ministries, specific measures for Cambodia to move to a GI scenario. The modeling method could also be applied to new sectors, and to estimate the likely outcomes of new policy options.

Further, data could be collected on the public expenditure that is directly related or caused by industrial pollution. This would allow to further refine and validate the estimation of the level of incentives that could be allocated to industrial subsectors by the government under a neutral fiscal strategy.

Table 45: Key policies highlighting the use of incentives

Lead Institution	Policy Document	References to the use of incentives
Council for the Development Cambodia	Industrial Development Policy	• Consider providing additional incentives for investment projects focusing on skills training, research and development, and innovation • Review the viability of providing support to SMEs for investment in machinery parts or production equipment as well as other incentives taking into consideration the local processing of raw materials, promoting quality of products, and modernizing their production chain to link up with multinational companies
National Council for Sustainable Development	Cambodia Climate Change Strategic Plan 2014-2023 National Strategic Plan for Green Growth 2013-2030	• Financial and fiscal incentives are some of the interventions to promote appropriate technology transfer for low-carbon development (e.g., improving EE, RE, and others) and facilitate their diffusion (Strategic Objective 4) • Preparing credit schemes – green loans based on green growth principles in the financial sector

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Appendix

Appendix A: Selection criteria and sector prioritization

This provides a summary of the prioritization performed at the highest level of aggregation (using national data for available industrial sectors). The following tables present the data collected and used to carry out this initial screening and prioritization.

Table 46: High-level prioritization of industrial subsectors.

	GDP	Employment	Energy	Natural resources	Waste	Climate change
Food, Beverages, and Tobacco	15%	15.8%	+	+++	++	+++
Textile, Wearing Apparel, and Footwear	66%	70.6%	++	+	+++	+
Wood, Paper, and Publishing	3%	1.6%	+++	+++	+	+
Rubber Manufacturing	3%	-	++	+++	+	+
Other Manufacturing						
Non-Metallic Manufacturing	*3%*	*5.4%*	+++	++	++	+
Basic Metal and Metal Products	*2%*	*3.1%*	+++	++	++	+
Other manufacturing	*8%*	*3.5%*	-	+	+	+

Legend: dark green: high relevance (high share of GDP and employment, high energy intensity, high use of natural resources and waste generation, and high exposure to climate change); green: medium relevance; light green: low relevance.

Table 47: Subsectoral share of manufacturing and industrial GDP.

	Share of manufacturing GDP	Share of industrial GDP
Food, Beverages, and Tobacco	15%	8%
Textile, Wearing Apparel, Footwear	66%	38%
Wood, Paper, and Publishing	3%	2%
Rubber Manufacturing	3%	2%
Other Manufacturing	13%	7%
Non-Metallic Manufacturing	3%	2%
Basic Metal and Metal Products	2%	1%
Other manufacturing	8%	4%

Source: Cambodia National Accounts (2015 values)

Table 48: Subsectoral share of manufacturing employment: 2000 and 2010.

	Share of manufacturing employment (2000)	Share of manufacturing employment (2011)
Food, Beverages, and Tobacco	1.5%	15.8%
Textile, Wearing Apparel, Footwear	83.9%	70.6%
Wood, Paper, and Publishing	0.7%	1.6%
Rubber Manufacturing	-	-
Other Manufacturing		
Non-Metallic Manufacturing	1.0%	5.4%
Basic Metal and Metal Products	0.3%	3.1%
Other manufacturing	12.6%	3.5%

Note: large manufacturing (2000), all manufacturing (2011)
Source: NIS, Survey of Industrial Establishment 2000; Economic Census of Cambodia 2011

Table 49: Subsectoral energy consumption per employee, per dollar of value added and per value of shipment: USA.

Code	Subsector and Industry	Consumption per Employee (million Btu)	Consumption per Dollar of Value Added (thousand Btu)	Consumption per Dollar of Value of Shipments (thousand Btu)
311	Food	871.7	4.3	1.8
312	Beverage and Tobacco Products	652.7	1.1	0.7
313	Textile Mills	847.0	7.1	3.3
314	Textile Product Mills	224.1	2.4	1.2
315	Apparel	78.9	0.9	0.5
316	Leather and Allied Products	77.3	1.0	0.4
321	Wood Products	1,508.3	16.3	6.9
322	Paper	6,021.8	26.4	12.1
325	Chemicals	5,007.7	7.3	3.9
326	Plastics and Rubber Products	417.2	3.2	1.6
327	Non-Metallic Mineral Products	2,220.3	15.7	8.3
331	Primary Metals	4,984.1	18.3	6.3
332	Fabricated Metal Products	285.3	1.9	0.9
333	Machinery	183.0	0.9	0.5
334	Computer and Electronic Products	151.9	0.7	0.4
335	Electrical Equip., Appliances, and Components	258.5	1.7	0.8
336	Transportation Equipment	253.0	1.0	0.5
337	Furniture and Related Products	110.1	1.1	0.6
	Total	**1,449.6**	**6.4**	**2.8**

Source: US DOE, 2010 MECS Survey

Table 50: Subsectoral reliance on natural resources and vulnerability to climate change.

	Reliance on natural resources	Vulnerability to climate change
Food, Beverages, and Tobacco	+++	+++
Textile, Wearing Apparel, and Footwear	+	+
Wood, Paper, and Publishing	+++	+
Rubber Manufacturing	+++	+
Other Manufacturing		
Non-Metallic Manufacturing	++	+
Basic Metal and Metal Products	++	+
Other manufacturing	+	+

Appendix B: List of data sources used, by subsector

Garments	
National data sources	UNIDO Hot Spot and TEST project
	UNIDO company EE analysis
	Improving Access to Finance and Technical Support for Energy Efficiency Investments in Cambodia (GGGI)
	Supporting the Development of Sustainable Supply Chains in the Garment Industry in Cambodia (GERES)
	Impediments to growth of the garment and food industries in Cambodia: Exploring potential benefits of the ASEAN-PRC FTA (ADB)
	Energy Performance in the Cambodia Garment Sector (ILO, IFC)
	Cambodia investment guidebook (CDC)
	Enhancing export competitiveness - The key to Cambodia's future economic success - Cambodia economic update (World Bank)
	Sustainable production and consumption of fuelwood and charcoal – Assessment of options for promoting sustainable charcoal and firewood consumption (GERES)
	Sustainable production and consumption of fuelwood and charcoal – Assessment of options for promoting sustainable charcoal and firewood production (GERES)
	Guide to the Cambodian Labor Law for the Garment Industry (ILO)
	Energy Efficiency NAMA in the Garment Industry in Cambodia (UNDP)
	Reducing Greenhouse Gas Emissions through Improved Energy Efficiency in the Industrial Sector-Cambodia (UNIDO, GEF)
	Estimating Industrial Pollution in the Kingdom of Cambodia Report (ADB)
	Improving trade competitiveness: Cambodian garment exports (WB)
	ILO (various publications)
	MEF Cambodia Macro Economic Monitoring (in EMC & ARUP, 2016)
	NIS (in EMC & ARUP, 2016)
International data sources	MECS (USA)
	IEA (OECD)
	Waste management in ASEAN countries (UNEP)
	Natural Resource Defense Council (NRDC)
	Bridging the skills gaps in developing countries: a practical guide for private sector companies (DEG)
	Energy Efficiency Developments and Potential Energy Savings in the Greater Mekong Subregion (ADB)
	Peer-reviewed papers

Food processing	
National data sources	NIS
	UNIDO Hot Spot and TEST project
	UNIDO company EE analysis
	Improving Access to Finance and Technical Support for Energy Efficiency Investments in Cambodia
	Reducing Greenhouse Gas Emissions through Improved Energy Efficiency in the Industrial Sector-Cambodia (UNIDO, GEF)
	Impediments to growth of the garment and food industries in Cambodia: Exploring potential benefits of the ASEAN-PRC FTA (ADB)
	National Strategic Development Plan Update 2009-2013 (GOC)
	Agricultural Sector Strategic Development Plan 2014-2018 (MAFF)
	Estimating Industrial Pollution in the Kingdom of Cambodia Report (ADB)
	Cambodian Intercensal Economic Survey 2014 (in EMC & ARUP, 2016)
International data sources	MECS (USA)
	FAOSTAT (Cambodia specific data)
	IEA (OECD)
	Promoting rural development, employment, and inclusive growth in ASEAN (ERIA)
	Best green business practices among MSMEs in the food processing industry of the Philippines (GGGI)
	FAO (various sources)
	ADB (various sources)
	Energy Efficiency Developments and Potential Energy Savings in the Greater Mekong Subregion (ADB)
	Agriculture and agro-processing sector in Cambodia - Taking stock: A detailed review of current challenges and investment opportunities (EuroCham)
	Peer-reviewed papers

Construction, bricks, and cement	
National data sources	UNIDO Hot Spot and TEST project
	Cambodia investment guidebook (CDC)
	Sustainable production and consumption of fuelwood and charcoal - Assessment of options for promoting sustainable charcoal and firewood consumption (GERES)
	Estimating Industrial Pollution in the Kingdom of Cambodia Report (ADB)
	NIS
International data sources	MECS (USA)
	UNIDO IEE - cement and iron and steel
	IEA (OECD)
	World Bank Cambodia Economic Update
	Cambodia: Exploring Opportunities in the Construction Sector (HKTDC)
	Energy Efficiency Developments and Potential Energy Savings in the Greater Mekong Subregion (ADB)
	Peer-reviewed papers
	USGS Mineral Industry of Cambodia (in EMC & ARUP, 2016)

Electronics	
National data sources	Cambodia Trade Integration Strategy 2014-2018 (GOC)
	ASEAN in transformation - How technology is changing jobs and enterprises (ILO)
	Estimating Industrial Pollution in the Kingdom of Cambodia Report (ADB)
International data sources	MECS (USA)
	IEA (OECD)
	UN Comtrade – International trade statistics database (Cambodia data)
	ASEAN Integration Report 2015 (ASEAN)
	GVC in ASEAN: A regional perspective (ASEAN)
	ASEAN in transformation - How technology is changing jobs and enterprises (ILO)
	Asian Development Outlook 2017 (ADB)
	Peer-reviewed papers

Appendix C: Estimation of unit investment assumptions

Garments

Hot Spot case studies		
Investment per m^3	USD/m^3	0.19
Investment per ton	USD/ton	97.50
Investment per kWh	USD/kWh	0.0675
Investment per TJ	USD/TJ	18,759.3
Investment per toe	**USD/toe**	**786**

Energy efficiency case studies		
Investment	USD	72610.67
Savings per year	Energy (GJ)	272.09
	Water (m^3)	4862.6
	Material (ton)	0
Monetary benefits	USD/year	138396.63
Payback time	**Year**	**0.73**
Investment per m^3	USD/m^3	3.9244
Investment per ton	USD/ton	N/A
Investment per GJ	USD/GJ	12.89
Investment per TJ	USD/TJ	12,888
Investment per toe	**USD/toe**	**540**

Fuels in use before and after intervention				
Diesel oil	0.6	1.6%	0.3	1.1%
Wood	27.5	76.9%	25.5	81.4%
Electricity	6.0	16.8%	25.5	81.4%
HFO	1.7	4.6%	0.2	0.6%
Sum	**35.7**	**100%**	**31.3**	**100%**

Bricks

Energy efficiency case studies		
Investment	USD	225950
Savings per year	Energy (MJ)	37650
	Water (m^3)	0
	Material (ton)	0
Monetary benefits	USD/year	195397
Payback time	**Year**	**1.30**
Investment per MJ	USD/MJ	5.82
Investment per TJ	USD/TJ	5,819
Investment per toe	**USD/toe**	**244**

Fuels in use before and after intervention				
Diesel oil	187.2	2.7%	65.0	1.5%
Wood	6868.7	97.3%	2498.5	58.0%
Electricity	0.1	0.0%	8.3	0.2%
Rice Husk	0.0	0.0%	1608.2	37.3%
Sawdust	0.0	0.0%	128.2	3.0%
Sum	**7056.0**	**100%**	**4308.2**	**100%**

Food processing

Hot Spot case studies		
Investment	USD	8129.3
Savings per year	Water (m^3)	4557.0
	Electricity (kWh)	7764.3
	Material (ton)	1158.7
Investment per m^3	USD/m^3	1.7839
Investment per ton	USD/ton	216.3385
Investment per kWh	USD/kWh	1.0470
Investment per TJ	USD/TJ	290,836
Investment per toe	USD/toe	12,179
Investment per kWh (over 20 years)	USD/kWh	0.052
Investment per TJ	USD/TJ	14541.80
Investment per toe	**USD/toe**	**609**

Energy efficiency case studies		
Investment	USD	5765.5
Savings per year	Energy (MJ)	6000
	Water (m^3)	0
	Material (ton)	117991
Monetary benefits	USD/year	1
Payback time	**Years**	**1.00**
Investment per m^3	USD/m^3	5.24
Investment per ton	USD/ton	937.5
Investment per GJ	USD/GJ	58.32
Investment per TJ	USD/TJ	58,317
Investment per toe	**USD/toe**	**2,442**
Investment per GJ (over 20 years)	**USD/GJ**	**2.916**
Investment per TJ	USD/TJ	2915.836
Investment per toe	**USD/toe**	**122.104**

Fuels in use before and after intervention				
Diesel oil	1.3261	18.3%	0.1723	3.4%
Wood	5.3067	73.4%	4.5396	88.3%
Electricity	0.2235	3.1%	0.1244	2.4%
LPG	0.3735	5.2%	0.0000	0.0%
Rice husk	0.0000	0.0%	0.3074	6.0%
Sum	**7.2**	**100%**	**5.1**	**100%**

Appendix D: Subsectoral results (balance sheet and environmental impact indicators)

Summary tables: revenues and costs, environmental impact indicators

Table 51: Summary indicators, garments GI scenario.

Garments

Time (Year)	Unit	2000	2010	2015	2020	2030	2040
GDP Electronics	Billion Riel/year	1,237	3,764	7,711	7,906	27,116	61,286
Government Tax Revenue	Billion Riel/year	99	451	1,447	1,551	5,319	12,023
Taxable Income	Billion Riel/year	1,336	4,215	9,158	9,457	32,435	73,308
Revenues	Billion Riel/year	5,738	15,687	36,995	53,226	112,482	237,707
Production Costs							
Capital and Variable Cost	Billion Riel/year	3,930	10,284	24,350	36,859	70,243	148,444
Labor Cost	Billion Riel/year	297	456	1,759	4,396	5,721	7,327
Energy and Water Cost	Billion Riel/year	175	732	1,728	2,514	4,082	8,627
Energy Cost	Billion Riel/year	153	674	1,589	2,304	3,772	7,971
Water Cost	Billion Riel/year	22	59	139	210	310	656
-							
Electronics Profit Margin	Percent	21.6%	24.0%	20.8%	14.9%	24.1%	25.8%
-							
Share of Labor Costs	Percent	6.7%	4.0%	6.3%	10.0%	7.1%	4.5%
Share of Water and Energy Cost	Percent	4.0%	6.4%	6.2%	5.7%	5.1%	5.2%
-							
Labor Productivity	Million Riel/ employee	9	12	12	9	23	41
Energy Productivity	Million Riel/TJ	324	377	326	221	448	479
Water Productivity	Riel/liter	77.4	90.0	77.9	52.8	122.4	130.9
-							
Solid Waste Generation	Ton/year	5,325.1	13,932.7	32,990.9	49,938.9	84,428.5	178,422.2
Total GHG Emissions	Ton/year	705,554.0	1,846,023.4	4,371,161.0	6,616,705.0	11,588,768.0	24,490,476.0
GHG Emissions Intensity	Ton CO^2e/Ton	6.6	6.6	6.6	6.6	5.5	5.5
Total Toxic Metal Discharges	Ton/year	45.1	96.7	207.2	283.7	295.4	378.3
Total Toxic Discharges	Ton/year	1,006.4	2,155.7	4,618.3	6,325.2	6,585.3	8,434.3
Total Water Pollutants	Ton/year	762.0	1,632.2	3,496.7	4,789.1	4,986.0	6,386.0

Table 52: Summary indicators, bricks GI scenario.

Bricks

Time (Year)	Unit	2000	2010	2015	2020	2030	2040
GDP Electronics	Billion Riel/year	126	417	259	459	1,255	2,725
Government Tax Revenue	Billion Riel/year	10	50	49	90	246	535
Taxable Income	Billion Riel/year	136	467	308	549	1,501	3,260
Revenues	Billion Riel/year	516	972	1,029	1,602	2,916	5,308
Production Costs							
Capital and Variable Cost	Billion Riel/year	79	119	180	280	510	928
Labor Cost	Billion Riel/year	278	342	467	658	737	813
Energy and Water Cost	Billion Riel/year	24	44	75	116	169	308
Energy Cost	Billion Riel/year	24	44	74	116	169	307
Water Cost	Billion Riel/year	0	0	0	0	0	1
-							
Electronics Profit Margin	Percent	24.3%	42.8%	25.2%	28.6%	36.6%	41.7%
-							
Share of Labor Costs	Percent	73.0%	67.6%	64.7%	62.4%	52.1%	39.7%
Share of Water and Energy Cost	Percent	6.2%	8.8%	10.3%	11.0%	11.9%	15%
-							
Labor Productivity	Million Riel/ employee	1	4	2	2	5	10
Energy Productivity	Million Riel/TJ	38	83	34	39	73	88
Water Productivity	Riel/liter	2,561.8	5,652.0	2,331.1	2,649.7	6,177.8	7,373.1
-							
Solid Waste Generation	Ton/year	1,929.8	2,902.1	4,374.4	6,814.3	12,402.6	22,573.7
Total GHG Emissions	Ton/year	1,098,571.9	1,652,031.9	2,490,154.3	3,879,127.8	6,997,657.0	12,736,264.0
GHG Emissions Intensity	Ton CO^2e/Ton	2.85	2.85	2.85	2.85	2.82	2.82
Total Toxic Metal Discharges	Ton/year	353.8	435.5	593.9	837.1	750.6	828.0
Total Toxic Discharges	Ton/year	1,245.0	1,532.6	2,090.2	2,946.0	2,641.6	2,913.9
Total Water Pollutants	Ton/year	22,213.1	27,345.4	37,293.7	52,563.9	47,132.3	51,990.1

Table 53: Summary indicators, food processing GI scenario.

Food processing

Time (Year)	Unit	2000	2010	2015	2020	2030	2040
GDP Electronics	Billion Riel/year	425	1,183	1,655	2,531	8,263	16,499
Government Tax Revenue	Billion Riel/year	34	142	311	496	1,621	3,237
Taxable Income	Billion Riel/year	459	1,325	1,965	3,027	9,884	19,736
Revenues	Billion Riel/year	2,986	6,143	8,604	11,285	19,548	33,862
Production Costs							
Capital and Variable Cost	Billion Riel/year	1,909	3,381	4,393	5,346	6,377	9,508
Labor Cost	Billion Riel/year	194	145	261	525	482	436
Energy and Water Cost	Billion Riel/year	423	1,292	1,984	2,387	2,805	4,182
Energy Cost	Billion Riel/year	364	1,188	1,848	2,221	2,632	3,925
Water Cost	Billion Riel/year	59	105	136	165	173	257
-							
Electronics Profit Margin	Percent	14,2%	19,3%	19,2%	22,.4%	42,3%	48,7 %
-							
Share of Labor Costs	Percent	7,7%	3,0%	3,9%	6,4%	5,0%	3,1%
Share of Water and Energy Cost	Percent	16,8%	26,8%	29,9%	28,9	29,0%	29,6%
-							
Labor Productivity	Million Riel/ employee	7	18	25	35	125	276
Energy Productivity	Million Riel/TJ	21	32	35	44	120	160
Water Productivity	Riel/liter	10.1	15.8	17.1	21.4	67.0	89.8
-							
Solid Waste Generation	Ton/year	860,589.1	1,524,104.0	1,980,647.6	2,410,034.0	2,874,844.5	4,286,622.0
Total GHG Emissions	Ton/year	8,497,262.0	15,048,658.0	19,556,468.0	23,796,132.0	34,792,064.0	51,877,736.0
GHG Emissions Intensity	Ton CO^2e/Ton	2.96	2.96	2.96	2.96	2.90	2.90
Total Toxic Metal Discharges	Ton/year	144.09	149.79	150.00	165.14	121.31	109.63
Total Toxic Discharges	Ton/year	1,600.30	1,663.59	1,665.59	1,834.12	1,347.32	1,217.54
Total Water Pollutants	Ton/year	2,165.12	2,250.74	2,253.97	2,481.46	1,822.85	1,647.27

Table 54: Summary indicators, electronics GI scenario.

Electronics

Time (Year)	Unit	2000	2010	2015	2020	2030	2040
GDP Electronics	Billion Riel/year	73	76	281	574	1,411	2,480
Government Tax Revenue	Billion Riel/year	6	9	53	113	277	486
Taxable Income	Billion Riel/year	79	85	333	686	1,688	2,966
Revenues	Billion Riel/year	287	314	1,225	2,364	3,894	6,415
Production Costs							
Capital and Variable Cost	Billion Riel/year	122	134	523	1,008	1,433	2,361
Labor Cost	Billion Riel/year	54	44	162	282	287	286
Energy and Water Cost	Billion Riel/year	31	51	207	387	487	802
Energy Cost	Billion Riel/year	21	40	165	305	393	648
Water Cost	Billion Riel/year	10	10	42	81	94	155
-							
Electronics Profit Margin	Percent	25,4%	24,3%	22,9 %	24,3 %	36,2 %	38,7 %
-							
Share of Labor Costs	Percent	26,1 %	19,4 %	18,1 %	16,8 %	13,0 %	8,3 %
Share of Water and Energy Cost	Percent	15,1 %	22,0 %	23,3 %	23,0 %	22,1 %	23,3 %
-							
Labor Productivity	Million Riel/ employee	9	12	12	14	33	59
Energy Productivity	Million Riel/TJ	306	320	293	310	573	612
Water Productivity	Riel/liter	9,8	10,2	9,3	9,9	21,1	22,5
-							
Solid Waste Generation	Ton/year	500.0	500.0	2,014.5	3,887.5	5,123.5	8,440.6
Total GHG Emissions	Ton/year	56,081.8	56,081.8	225,950.8	436,032.2	503,532.2	829,537.3
GHG Emissions Intensity	Ton CO^2e/Ton	5.61	5.61	5.61	5.61	3.93	3.93
Total Toxic Metal Discharges	Ton/year	54.36	44.50	162.22	283.24	229.88	229.52
Total Toxic Discharges	Ton/year	412.80	337.93	1,231.86	2,150.85	1,745.66	1,742.93
Total Water Pollutants	Ton/year	18.40	15.06	54.91	95.87	77.81	77.69

Table 55: Key balance sheet indicators in the garments sector, by scenario. Changes relative to baseline Garments

GI, no export growth	2025	2030	2035	2040
GDP	48%	50%	50%	51%
Revenues	0%	0%	0%	0%
Costs	-11%	-12%	-13%	-13%
Capital and O&M	0%	0%	0%	0%
Labor	-13%	-25%	-35%	-44%
Energy	-23%	-23%	-23%	-23%
Water	-30%	-30%	-30%	-30%
Waste management cost	-20%	-20%	-20%	-20%
Water treatment cost	-13%	-12%	-13%	-13%
Air emissions cost	-17%	-17%	-17%	-17%
Health cost	-17%	-17%	-17%	-17%

GI, no export growth	2025	2030	2035	2040
GDP	80%	140%	209%	296%
Revenues	25%	60%	105%	163%
Costs	11%	41%	79%	129%
Capital and O&M	25%	60%	105%	163%
Labor	9%	20%	33%	47%
Energy	-3%	24%	59%	104%
Water	-13%	12%	44%	84%
Waste management cost	0%	28%	64%	110%
Water treatment cost	9%	40%	80%	130%
Air emissions cost	3%	33%	70%	118%
Health cost	3%	33%	70%	118%

Table 56: Key balance sheet indicators in the bricks sector, by scenario.

Bricks

GI, no export growth	2025	2030	2035	2040
GDP	16%	23%	27%	29%
Revenues	0%	0%	0%	0%
Costs	-10%	-17%	-22%	-26%
Capital and O&M	0%	0%	0%	0%
Labor	-13%	-25%	-35%	-44%
Energy	-20%	-20%	-20%	-20%
Water	-35%	-36%	-36%	-36%
Waste management cost	0%	0%	0%	0%
Water treatment cost	-39%	-39%	-39%	-39%
Air emissions cost	-1%	-1%	-1%	-1%
Health cost	-1%	-1%	-1%	-1%

GI, no export growth	2025	2030	2035	2040
GDP	16%	23%	27%	29%
Revenues	0%	0%	0%	0%
Costs	-10%	-17%	-22%	-26%
Capital and O&M	0%	0%	0%	0%
Labor	-13%	-25%	-35%	-44%
Energy	-20%	-20%	-20%	-20%
Water	-35%	-36%	-36%	-36%
Waste management cost	0%	0%	0%	0%
Water treatment cost	-39%	-39%	-39%	-39%
Air emissions cost	-1%	-1%	-1%	-1%
Health cost	-1%	-1%	-1%	-1%

Table 57: Key balance sheet indicators in the food processing sector, by scenario.

Food processing

GI, no export growth	2025	2030	2035	2040
GDP	41%	34%	28%	24%
Revenues	0%	0%	0%	0%
Costs	-20%	-21%	-21%	-21%
Capital and O&M	0%	0%	0%	0%
Labor	-13%	-25%	-35%	-44%
Energy	-21%	-21%	-21%	-21%
Water	-30%	-30%	-30%	-30%
Waste management cost	-20%	-20%	-20%	-20%
Water treatment cost	-12%	-12%	-12%	-12%
Air emissions cost	-2%	-2%	-2%	-2%
Health cost	-2%	-2%	-2%	-2%

GI, export growth	2025	2030	2035	2040
GDP	58%	52%	46%	41%
Revenues	12%	13%	13%	13%
Costs	-10%	-10%	-11%	-11%
Capital and O&M	0%	0%	0%	0%
Labor	-2%	-15%	-27%	-37%
Energy	-11%	-10%	-10%	-10%
Water	-22%	-21%	-21%	-21%
Waste management cost	-11%	-9%	-9%	-9%
Water treatment cost	-2%	-1%	-1%	-1%
Air emissions cost	10%	11%	11%	11%
Health cost	10%	11%	11%	11%

Table 58: Key balance sheet indicators in the electronics sector, by scenario.

Electronics

GI, no export growth	2025	2030	2035	2040
GDP	37%	39%	40%	40%
Revenues	0%	0%	0%	0%
Costs	-16%	-18%	-19%	-20%
Capital and O&M	0%	0%	0%	0%
Labor	-13%	-25%	-35%	-44%
Energy	-22%	-22%	-22%	-22%
Water	-30%	-30%	-30%	-30%
Waste management cost	-20%	-20%	-20%	-20%
Water treatment cost	-13%	-13%	-12%	-13%
Air emissions cost	-30%	-30%	-30%	-30%
Health cost	-30%	-30%	-30%	-30%

GI, no export growth	2025	2030	2035	2040
GDP	71%	78%	80%	80%
Revenues	25%	28%	28%	28%
Costs	5%	6%	4%	3%
Capital and O&M	25%	28%	28%	28%
Labor	9%	-4%	-17%	-29%
Energy	-2%	0%	0%	0%
Water	-13%	-10%	-10%	-10%
Waste management cost	0%	3%	3%	3%
Water treatment cost	9%	12%	12%	12%
Air emissions cost	-12%	-10%	-10%	-10%
Health cost	-12%	-10%	-10%	-10%

Appendix E – Review of national policy documents

Document title	Sector	Page	Intervention option	Type of intervention	Target (if available)
National Energy Efficiency Policy 2018-2035	Industry	8	Energy efficiency		GHG emission reduction: 25% relative to baseline by 2035
		55	Promotion of best practices in energy consumption and generation	incentive	2%
		55	Implementation of voluntary as well as of compulsory standards on energy efficiency for large energy consumers	mandate	5%
		55	Implementation of energy efficiency/conservation laws/ regulations on industrial energy use, and on distribution standards	mandate	10%
		55	Technical training for engineers and technicians in the field of energy efficiency, performing energy audits, establishing EMS, and implementing energy saving measures in the industry	awareness	1%
		55	Development of a compendium of energy efficiency and waste management for the manufacturing and handicraft sector	awareness	1%
		55	Increase consumer awareness of rural electrification options and energy efficiency	awareness	1%
		55	Organization of awareness raising campaigns about energy efficiency in industry	awareness	1%
		55	Provision of financial incentives to companies interested in the implementation of energy efficiency strategies and measures, and to manufacture energy efficient equipment	incentive	2%
		55	Development of a green industry award program		2%
Cambodia Climate Change Strategic Plan 2014 – 2023	Government	13	Promote climate resilience through improving food, water, and energy security		
		14	Reduce sectoral, regional, gender vulnerability, and health risks to climate change impacts		
		15	Ensure climate resilience of critical ecosystems, biodiversity, protected areas, and cultural heritage sites		
	Industry	15	Promote low-carbon planning and technologies to support sustainable development	incentive	
		16	Improve capacities, knowledge, and awareness for climate change responses	awareness	
		17	Promote adaptive social protection and participatory approaches in reducing loss and damage due to climate change		
	Government	18	Strengthen institutions and coordination frameworks for national climate change responses		

Document title	Sector	Page	Intervention option	Type of intervention	Target (if available)
Cambodia National Adaptation Plan Financing Framework and implementation Plan	Government	1	To bring the NAP process in Cambodia closer to its execution phase by analyzing and articulating the financing dimensions (scoping demand, existing gaps, funding options at domestic and international levels) and offering an implementation plan for the NAP financing framework.		
Cambodia NDC	National target	6	Reduction as Tons CO^2eq and % in the year 2030 compared to the baseline by sector		3,100 (27%)
	Manufacturing	6	Promoting use of renewable energy and adopting energy efficiency for garment factories, rice mills, and brick kilns	incentive	727 Gg of CO^2eq in the year 2030 compared to the baseline (7%)
	Energy Industries	6	National grid connected renewable energy generation (solar energy, hydropower, biomass and biogas) and connecting decentralized renewable generation to the grid. Off-grid electricity such as solar home systems, hydro (pico, mini, and micro). Promoting energy efficiency by end users.	mandate	1,800 (16%)
	Transport	6	Promoting mass public transport. Improving operation and maintenance of vehicles	mandate	390 (3%)
	Other	6	Promoting energy efficiency for buildings and more efficient cook stoves.	awareness	155 (1%)
	Forest cover	7	Cambodia intends to undertake voluntary and conditional actions to achieve the target of increasing forest cover to 60% of national land area by 2030	awareness	emission reductions 4.7
		7	The objective is to improve forest governance and promote international trade in verified legal timber		Increase forest cover to 60% of the national land area by 2030
Climate Change Action Plan for Industry and Handicraft Sectors 2015-2018	Industry and Energy	13	Promoting green industry for climate resilient low-carbon production in Cambodia	incentive	
		13	Development of resource and energy efficiency guidelines for the industry and	awareness	
		13	Training of national experts and industrial personnel on resource and energy	awareness	
		13	Resource and energy efficiency assessment of industries and SMEs	investment	
		13	Development of best resource and energy efficiency practices for industries and SMEs	investment	
		13	Development of a green industry policy and green industry award program		
		13	Development of Nationally Appropriate Mitigation Actions (NAMAs)		
		13	Establishment of an information system to support resilient low-carbon industrial development	awareness	

Document title	Sector	Page	Intervention option	Type of intervention	Target (if available)
Cambodia National Adaptation Plan Financing Framework and implementation Plan	Government	1	To bring the NAP process in Cambodia closer to its execution phase by analyzing and articulating the financing dimensions (scoping demand, existing gaps, funding options at domestic and international levels) and offering an implementation plan for the NAP financing framework.		
Cambodia NDC	National target	6	Reduction as Tons CO^2eq and % in the year 2030 compared to the baseline by sector		3,100 (27%)
	Manufacturing	6	Promoting use of renewable energy and adopting energy efficiency for garment factories, rice mills, and brick kilns	incentive	727 Gg of CO^2eq in the year 2030 compared to the baseline (7%)
	Energy Industries	6	National grid connected renewable energy generation (solar energy, hydropower, biomass and biogas) and connecting decentralized renewable generation to the grid. Off-grid electricity such as solar home systems, hydro (pico, mini, and micro). Promoting energy efficiency by end users.	mandate	1,800 (16%)
	Transport	6	Promoting mass public transport. Improving operation and maintenance of vehicles	mandate	390 (3%)
	Other	6	Promoting energy efficiency for buildings and more efficient cook stoves.	awareness	155 (1%)
	Forest cover	7	Cambodia intends to undertake voluntary and conditional actions to achieve the target of increasing forest cover to 60% of national land area by 2030	awareness	emission reductions 4.7
		7	The objective is to improve forest governance and promote international trade in verified legal timber		Increase forest cover to 60% of the national land area by 2030
Climate Change Action Plan for Industry and Handicraft Sectors 2015-2018	Industry and Energy	13	Promoting green industry for climate resilient low-carbon production in Cambodia	incentive	
		13	Development of resource and energy efficiency guidelines for the industry and	awareness	
		13	Training of national experts and industrial personnel on resource and energy	awareness	
		13	Resource and energy efficiency assessment of industries and SMEs	investment	
		13	Development of best resource and energy efficiency practices for industries and SMEs	investment	
		13	Development of a green industry policy and green industry award program		
		13	Development of Nationally Appropriate Mitigation Actions (NAMAs)		
		13	Establishment of an information system to support resilient low-carbon industrial development	awareness	

Document title	Sector	Page	Intervention option	Type of intervention	Target (if available)
		12	Create information and data system of source and level of impact related to climate change		
		12	To foster and encourage the researcher and technology creator who will participate to support in preventing and reducing climate change	incentive	
		12	To foster and encourage the private sectors' participation and vulnerable groups and gender main streaming into climate change	incentive	
		12	To motivate and encourage the establishment of R&D institutions	investment , incentive	
		12	To evaluate and do a gap analysis of the existing legal aspects and guidelines in order that the climate change of the two sectors (industry and energy) will be integrated and consolidated into the new regulation and technical guidelines establishment		
		13	To make the request for new preparation and establishment of law, sub-decree ministerial notices, technical norms and guidelines related to climate change of the two sectors and long-term legal support for the implementation		
		13	Establish and implement the legislation and regulation including technical standard in green industry and energy		
Cambodia Industrial Development Policy 2015 – 2025	Industry	13	Address structural challenges and to invest in key industrial infrastructure, both hard and soft, to be in line with the potentials, competitive advantage, and development of the Cambodian industry	investment	Increase the GDP share of industrial sector to 30% by 2025
National Policy on Green Growth	Government	2	Developing an economy in balance with environment, society, and culture;		
		2	Create a favorably enabling environment for green growth in equity, balance, fraternity, and quality of socioeconomic systems and ecology that uphold national culture value;		
		2	Enhancing education and training on green growth;		
		2	Strengthening information exchange, knowledge, good experiences, technology, and investment related to green growth;	awareness	
		2	Stimulating green growth cooperation at a national and subnational level, in the region and the world.		
National Strategic Development Plan 2014-2018 EN	Government	3	NSDP Update 2009-2013		7% growth in GDP and reduce the poverty rate by at least one percentage point each year.

Document title	Sector	Page	Intervention option	Type of intervention	Target (if available)
National Strategic Plan on Green Growth 2013-2023	Government	4	Green investment and green job creation		
		4	Green economy management in balance with environment		
		4	Blue economy development with sustainability		
		4	Green environment and natural resource management		
		4	Human resource development and green education		
		4	Effective green technology management		
		4	Promotion of a green social safety system		
		4	Uphold and protect green social safety system		
		4	Uphold and protect green cultural, heritage, and national identity		
		4	Good governance on green growth		
Rectangular Strategy-Phase III	Government	7	Ensuring an average annual economic growth of 7%. This growth should be sustainable, inclusive, equitable, and resilient to shocks through diversifying the economic base to achieve a more broad-based and competitive structure with low and manageable inflation, stable exchange rate, and steady growth in international reserves.		7% growth in GDP
		8	Creating more jobs for people especially the youth through further improvement in Cambodia's competitiveness to attract and encourage investments.		
		8	Achieving more than one percentage point reduction in poverty incidence annually, including the realization of other Cambodia Millennium Development Goals targets, while placing higher priority on the development of human resources and sustainable management and use of environmental and natural resources.		
		8	Further strengthening institutional capacity and governance, at both national and subnational levels, and ensuring the effectiveness and efficiency of public services to better serve the people.		

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