amee
Agence Marocaine pour l'Efficacité Energétique

# Net Zero Roadmap

## Agro-industry

## Morocco

Study carried out by AMEE with the support of UNEP and a group of key players in the Moroccan sector

**Publication date:**
*February 2024*

UN environment programme

Study carried out by AMEE
with the support of UNEP
and a group of key players
in the Moroccan sector.

amee
Agence Marocaine
pour l'Efficacité Energétique

UN environment programme

# Net Zero Roadmap
# Agro-industry in Morocco

For several years, Morocco has demonstrated a strong commitment to addressing climate change. The kingdom has embraced a proactive approach toward environmental and climate policies, specifically emphasizing the reduction of greenhouse gas emissions and the implementation of measures to adapt to the effects of climate change. Several national strategies and roadmaps have been drawn up to put Morocco on the path to decarbonization within the framework of international agreements. This net zero roadmap for the agrifood sector stands as one of the pioneering sectoral roadmaps, not only at the national level but also as the first of its kind within the international agro-industrial sphere.

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF ABBREVIATIONS

**UNEP**

United Nations Environment Programme

**AMEE**

Moroccan Energy Efficiency Agency

**MTEDD**

Ministère de la Transition Energétique et du Développement Durable - Ministry of Energy Transition and Sustainable Development

**GHG**

Greenhouse Gas

**CDN**

Contribution Déterminée Nationale

**SNDD**

Stratégie Nationale de Développent - Durable National Strategy for Sustainable Development

**MIC**

Ministry of Industry and Commerce

**FENAGRI**

Fédération Nationale de l'Agroalimentaire - National Agrifood Federation

**LT LEDS**

Long Term Low Emission Development Strategies (stratégie bas carbone)

**PCN**

National Climate Plan

**BAU**

Business As Usual

**IAA**

Industrie Agro-Alimentaire - Food processing industry

# 1 INTRODUCTION

For several years, Morocco has demonstrated a strong commitment to addressing climate change. The kingdom has embraced a proactive approach toward environmental and climate policies, specifically emphasizing the reduction of greenhouse gas emissions and the implementation of measures to adapt to the effects of climate change. Several national strategies and roadmaps have been drawn up to put Morocco on the path to decarbonization within the framework of international agreements. This net-zero roadmap for the agrifood sector stands as one of the pioneering sectoral roadmaps, not only at the national level but also as the first of its kind within the international agro-industrial sphere.

This study is carried out by AMEE (Moroccan Energy Efficiency Agency) with the support of UNEP (United Nations Environment Program) and the financial backing of the Climate Emergency Collaboration Group (CEGG), as well as the involvement of key players in the sector in Morocco. It covers the industrial processing sector as part of the agri-food value chain. The steering committee was made up of representatives from the Ministry of Energy Transition and Sustainable Development (MTEDD), the Ministry of Industry and Trade (MIC), AMEE, the agro-industry trade federation FENAGRI, the LT LEDS team, UNEP and the consultants.

*The study's scope focuses specifically to the processing phase, excluding the preceding agricultural and fishing phases, as well as the subsequent marketing stages of agri-food products. The baseline for analysis is anchored in the year 2014, aligning with the latest national census data available. Scopes 1 and 2 emissions were considered in the analytical framework.*

## Why the agri-food sector?

The agricultural sector is one of the pillars of the Moroccan economy, accounting for 15% of GDP and employing around 40% of the working population*.
According to the report "Etat des lieux de l'agro-industrie marocaine" published by the Moroccan Institute of Strategic Intelligence (IMIS) in September 2022, the agri-food industry (IAA) in Morocco is an essential pillar of the economy.

*Source : RESAGRO - February 2023 - N°135*

It accounts for 26% of industrial GDP, brings together almost 2 000 companies and employs more than 150 000 people, representing around 25% of the industrial sector (or almost 5% of national GDP).

Morocco's agri-food sector is diversified and includes a wide variety of products thanks to its favorable climate, ranging from citrus fruits, vegetables, dried fruits, cereals, meats, and seafood. Morocco has implemented a strategic policy framework to foster the growth of its agrifood sector, with the objectives of enhancing production and productivity, elevating product standards, boosting competitiveness, and expanding export capabilities. This policy entails a variety of initiatives, including programs focused on the modernization of agricultural infrastructure, support for research and development in agriculture, and the promotion of private sector investments within the industry.
Additionally, the country has entered into numerous trade agreements with various countries and regions, including the European Union, the United States, Russia, and China.

Morocco is also committed to a policy of promoting sustainable agriculture, aimed at preserving natural resources and improving agricultural productivity while minimizing environmental impacts through water-saving management and the promotion of efficient irrigation.

Lastly, Morocco has formulated an export promotion strategy for agri-food products, with the objectives of broadening export market diversification and increasing export earnings. This initiative is geared towards facilitating the export of its agri-food products to these targeted markets.

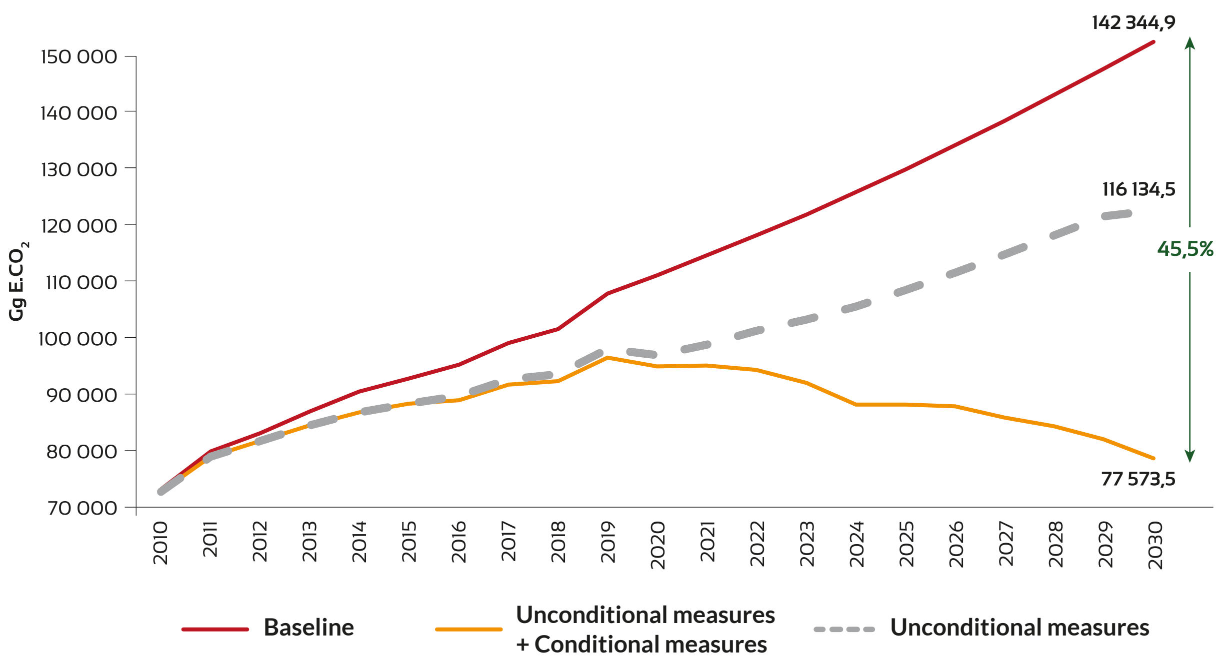
# 2 NATIONAL EMISSIONS

## 2.1. National context

Morocco has actively engaged in combating climate change and has affirmed its commitment to the Paris Agreement. The agreement seeks to mitigate global warming by striving to restrict the temperature rise to well below 2 degrees Celsius above pre-industrial levels, with a particular emphasis on limiting the increase to 1.5 degrees Celsius. In fact, since then Morocco has recognized the significant impacts of climate change on its economy, society, and environment and has taken concrete steps to honor its commitments, including reducing its greenhouse gas emissions, increasing the share of renewable energies in its energy mix, and implementing many climate adaptation measures.

For example, Morocco launched a national electricity generation strategy with a target of 52% of installed capacity from renewable energies by 2030. The country has also implemented a comprehensive climate change adaptation plan, notably by investing in sustainable agriculture and water resource management.

**Figure 1 : National emission reduction targets**
*(Source : CDN-Maroc Report, Nationally determined contribution, June 2021)*



Overall, Morocco's commitments to the Paris Agreement demonstrate the country's determination to meet the global challenge of climate change and build a sustainable future.

Morocco's first commitment is in the form of its **revised 2021 Nationally Determined Contribution (NDC)**, in which it undertakes **to reduce its emissions by 45.5%** compared with the BAU scenario.

According to its NDC, Morocco is committed to 34 unconditional actions, 10 of which are in the industrial sector, and 27 conditional actions, 5 of which concerns industry. The industrial sector accounts for 25% of national measures, mainly driven by the phosphate sector.

Morocco has set itself numerous ambitious objectives, including the following measures with an impact on the agri-food sector:

- Achieve 52% of installed electricity capacity from renewable sources, including 20% solar, 20% wind and 12% hydro by 2030.
- Achieve energy savings of 20% by 2030, compared with the current trend.
- Install an additional 450 MW of capacity by 2030 based on combined-cycle technology using imported natural gas.
- Supply large-scale industries with energy from imported, regasified liquefied gas.

Morocco has formulated a **National Climate Plan 2030 (NCP)** as a foundational framework for orchestrating and developing a medium- to long-term climate strategy. This plan is instrumental in guiding proactive and ambitious responses to the climate challenges specific to Morocco's context. The most relevant strategic objectives of the NCP are listed below:

- Achieve 52% of installed electrical capacity from renewable sources by 2030
- Reduce energy consumption by 15% by 2030
- Increase the volume of water resource mobilization
- Optimizing irrigation techniques
- Increase the recovery rate for solid and liquid waste
- Install efficient, high-performance equipment in buildings

In 2017, Morocco published its **National Sustainable Development Strategy (SNDD)**, which is currently undergoing a comprehensive overhaul. The two main challenges of the SNDD linked to decarbonization of the agri-food sector are challenges 2 (successfully transition to a green economy) and 4 (accelerate implementation of the national policy to combat climate change).

## 2.2. Estimated national emissions by major sector to 2050

Industry accounts for **over 22% of total energy consumption in Morocco***. Petroleum-based fuels account for almost 70% of the final consumption in the industrial sector. The building materials sector leads the way in terms of consumption, followed by food processing, textiles, mining, and metal processing.

From a global perspective, the industrial sector represents a potential reduction in consumption of around 17%** by 2030, reaching 48% in some industrial companies. The industrial sector is responsible for **13%*** of national greenhouse gas emissions**.

## The industrial sub-sectors with the highest GHG emissions in Morocco are:

**Cement and phosphate sub-sector**

more than three-quarters of total emissions from Moroccan industry

**Construction sub-sector, agri-food industry, textiles and leather, paper, capital goods, mining, etc...**

sectors using mainly fossil fuels (fuel oil, diesel, LPG, natural gas)

*Sources :*
**Website AMEE (amee.ma)*
***Website Energiewende-maroc.org*
****Clima-Med Report "Recommendations for a Coordination Strategy for Climate Action - Morocco CAS"*

The agrifood sector emitted 2.2 million Teq $CO_2$ in 2023, i.e. 12.3% of total industrial emissions and 3.6% of national emissions.

Final energy consumption at national level (all sectors combined) rose from 15,211 ktoe in 2014 to 18,573 ktoe in 2022 and will rise to 38,390 ktoe in 2050.

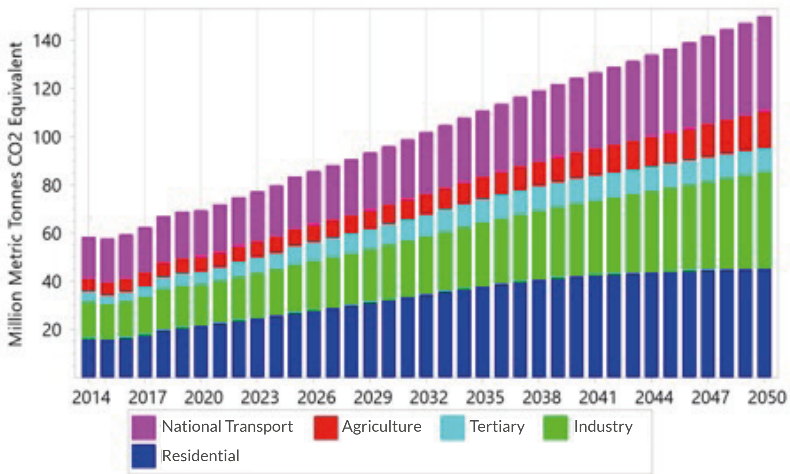
Industry consumed 3,530 ktoe in 2022, i.e. more than 19% of national energy consumption.
GHG emissions (energy sector) are expected to rise from 58 million Teq $CO_2$ in 2014 to 150.03 million Teq $CO_2$ in 2050 (BAU).

Emissions from the industrial sector are set to increase in line with the country's industrial and economic development and represent one of the three sectors that contribute most to national emissions, along with transport and residential.

## In Morocco, by 2050...

Emissions from the industrial sector are set to increase in line with the country's industrial and economic development.

**Figure 2 : Energy-related GHG emissions (direct and indirect emissions)**



## 2.3. The agri-food sector

GHG emissions trends for the various food industry sectors are shown below. These emissions include direct and indirect emissions (electricity).

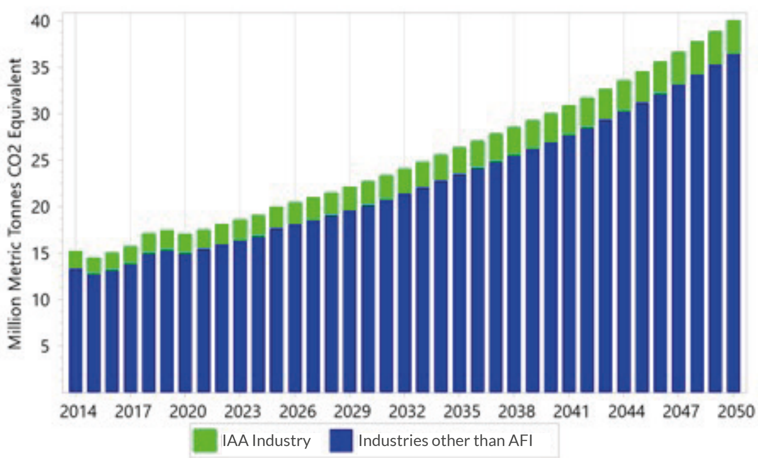
In 2022, the food industry consumed 397 ktoe, equivalent to 11.2% of industry consumption and 2.1% of national energy consumption. The agrifood sector emitted 2.2 million Teq $CO_2$ in 2023, equivalent to 12.3% of total industry emissions and 3.6% of national emissions.

The evolution of emissions in the agri-industry is closely linked to population growth and industrial expansion to meet food security requirements.

Over time, as national and global food demand continues to rise due to population growth, the agri-industry will have to step up its activities to meet this growing demand.

Growth is constant and constantly evolving. In 2020, during the COVID-19 crisis, the sector was not greatly impacted, as the restrictions did not apply to the agri-food sector.

**Figure 3 : Industrial GHG emissions at national level**



# 3 GHG EMISSIONS BASELINE FOR THE AGRI-FOOD SECTOR

## 3.1. Methodology

The project was carried out in two main phases:
• firstly, the development of the agri-food sector baseline
• and secondly the identification and quantification of mitigation measures.

The following diagram summarizes the key stages of the first phase, namely segmentation into sub-sectors, compilation of representative and available data for each segment, data analysis and programming in the LEAP software to obtain the baseline.

**Figure 4 : Study methodology**

1 SEGMENTATION

By activity: according to the categorization of the Ministry of Industry and Commerce

2 COLLECT OF DATA

• Data available at national level
• Data on key players in the various segments

3 DATA ANALYSIS

• Emissions by segment
• Contextualizing basic data

4 BASE LINE

• Data programming in LEAP software
• Extrapolation of data to 2050

*The segmentation into sub-sectors is as follows:*


SUGAR
INDUSTRY


MILK PROCESSING
INDUSTRY


INDUSTRIAL
FLOUR MILLS


BEER
INDUSTRY


FISHING
INDUSTRY


OLIVE
INDUSTRY


COOKIE
INDUSTRY


LIVESTOCK FEED
INDUSTRY


MEAT
INDUSTRY


TABLE OIL AND
GREASE INDUSTRY


BEVERAGE
INDUSTRY

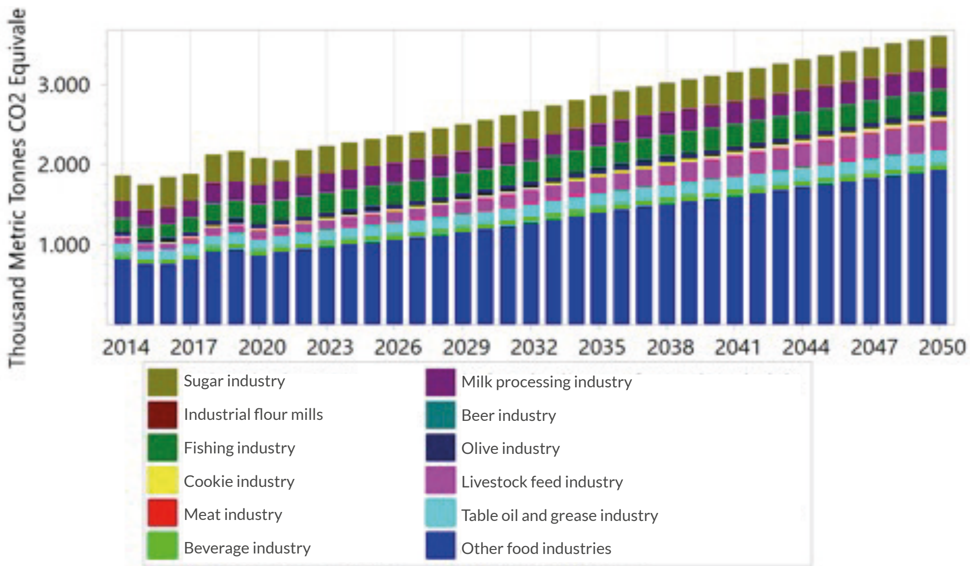

OTHER FOOD
INDUSTRIES

The collection of data from various companies in Morocco's agri-food sector was carried out in close collaboration with the Ministry of Industry and Trade, AMEE, and federations such as FENAGRI. More than fifty energy audits and studies carried out by national and international agencies/companies were used to draw up a detailed baseline for the national agri-food sector. The data was modeled using the LEAP software, considering national models already established as part of the NDC development and national communications.

## 3.2. Food industry baseline

Emissions from the identified sub-sectors show that the sugar industry (15% in 2023), fish processing (11% in 2023) and milk processing (11% in 2023) have the highest emissions. (*The other AFI sub-sector includes activities not included in the data collection but whose emissions have been quantified at the time of drawing up the national balance sheet. The calculation is therefore the national emissions balance minus the emissions calculated are based on the data collected during the study*).

Figure 5 : GHG emissions in the food industry




Modelling has shown that **electricity consumption is the main source of emissions**, followed by the **consumption of heavy fuel oil**, mainly used in boilers.

The sugar industry in Morocco uses several types of fuel: heavy fuel oil, petcoke, anthracite, bagasse, and electricity. Consumption is mainly due to heavy fuel oil, which accounts for an average of 94% of thermal energy consumption.
Fuel oil is used both to produce steam and to generate electricity (cogeneration) during the 14-week beet sugar campaign.

On average, energy consumption represents the equivalent of 100 ktoe/year, and varies from one campaign to the next.
The evolution of energy consumption has been correlated with population growth, which is forecast by the World Bank to increase by 0.71% per year by 2040.
Emissions from this sub-sector were 345 $kTeqCO_2$ in 2023 and are forecast to rise to 408 $kTeqCO_2$ in 2050.

The fishing industry contributed 24 ktoe in 2014. By fuel type, the fish industry consumes 41% electricity and 59% fuel oil. Emissions from this sub-sector are 238 kTeqCO2 in 2023 and are forecast to grow to 250 $kTeqCO_2$ in 2050.

Milk production represented 1,304 million tons in 2014 and will reach 1,728.8 million liters in 2050, an increase of 0.71%. Emissions from this sub-sector were 345 $kTeqCO_2$ in 2023 and are forecast to rise to 408 $kTeqCO_2$ in 2050.

# 4 MITIGATION SCENARIOS

## 4.1. Selected measures

The baseline shows the evolution of greenhouse gas emissions without reduction actions and before the implementation of national renewable energy and energy efficiency programs.

Analysis of emission reduction targets, key transformation sectors, and the timetable for implementing the policies and technologies needed to achieve carbon neutrality has enabled us to map out a trajectory towards a sustainable, low-carbon future.

**Three scenarios were selected based on their feasibility and the impact of their implementation on the sector's decarbonization:**

### Scenario 1

Electricity generation scenarios included in the NDC at national grid level, which have an indirect impact on the food industry via the electricity mix.

### Scenario 2

Mitigation scenarios at the level of the LPNs themselves, which are already included in the NDC.

### Scenario 3

Mitigation scenarios for the food industry (additional measures) involving biomass, heat recovery and $CO_2$ capture.

## 4.2. Scenario 1: Implementation of NDC measures

Scenario 1 (CDN) groups together 8 actions that concern the decarbonization of electricity production in Morocco, namely:

### Unconditional projects

**Project #1**

Wind power generation with a capacity of 1,467 MW

**Project #2**

Solar power generation with a capacity of 827 MW

**Project #3**

Combined-cycle power generation with a capacity of 23 MW

**Project #4**

Hydroelectric power generation with a capacity of 1098 MW

**Project #5**

Electricity generation by solar farms: phosphate industries

## Conditional projects

### Project #7

Solar power generation with a capacity of 4000MW

### Project #6

Wind power generation with a capacity of 2180 MW

### Project #8

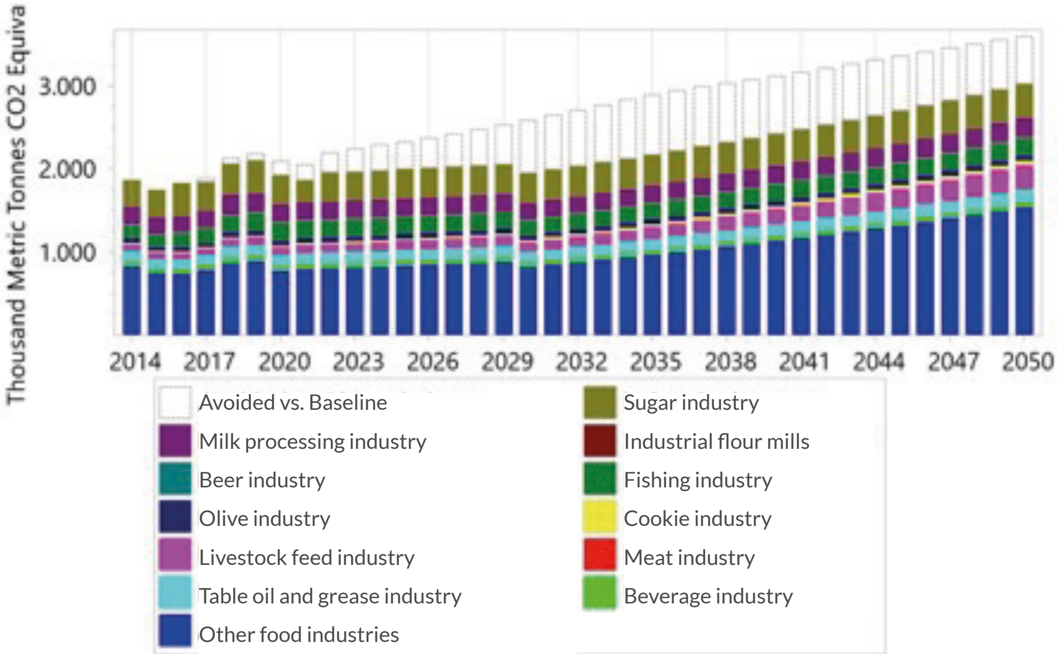
PV power generation at the 1000 MW building

The NDC measures applied to the baseline are shown below for conditional and unconditional projects. The impact of these projects is on GHG emissions (change in the Moroccan electricity mix).

GHG emissions for CDN projects (unconditional + conditional) range from 1.862 million tones $CO_2$ equivalent in 2014 to 3.017 million tones $CO_2$ equivalent in 2050.

As a reminder, baseline emissions are 3.601 million tones of $CO_2$ equivalent. Cumulative emissions avoided between 2014 and 2050 would be 17.808 million tones $CO_2$ equivalent.

Figure 6 : Modeling scenario 1




## 4.3. Scenario 2: Mitigation measures in the agri-food sector

The general NDC measures considered in the first scenario mainly concern the decarbonization of electricity consumed by the sector's manufacturers.

The second scenario takes into account the national commitments directly applicable to projects specific to the food industry, and concerns the following projects:

**MEPS (MINIMUM ENERGY PERFORMANCE STANDARDS)**

applicable to electric motors over 75 kW in the food industry

**ENERGY EFFICIENCY OF 17% SAVINGS**

by 2030 applicable to the agri-food sector

**INSTALLATION OF PHOTOVOLTAIC PANELS**

on the roofs of plants in the sector (.20% renewable energy by 2030 and 50% by 2050)

The MEPS electric motor scenario involves replacing IE1 class electric motors over 75 kW with IE3 class electric motors by 2030. This action depends on the MEPS decree currently being drawn up. MEPS, which stands for Minimum Energy Performance Standards, are regulations or standards set by governments to ensure that products sold on a given market meet minimum energy efficiency requirements.

In the industrial sector, MEPS generally apply to various types of equipment and machinery to promote energy efficiency and reduce overall energy consumption.

## Here are some examples of industrial equipment and machinery commonly subject to MEPS:

### ELECTRIC MOTORS

MEPS for electric motors aim to improve motor efficiency by setting minimum efficiency levels. Motors are widely used in industrial applications for a variety of purposes, such as driving pumps, compressors, and conveyor systems. MEPS encourage the use of high-efficiency motors, resulting in energy savings and reduced operating costs.

### PUMPS

MEPS for pumps target energy-saving designs and performance standards. Pumps are widely used in industries for fluid handling processes such as water supply, wastewater treatment and chemical processing. MEPS for pumps promote the adoption of efficient pumping technologies, including variable-speed drives and optimized hydraulic designs.

### AIR COMPRESSORS

MEPS for air compressors aim to improve compressor efficiency and reduce energy consumption. Air compressors are essential in industrial operations to generate compressed air used in various applications such as pneumatic tools, manufacturing processes and air conditioning systems. MEPS promotes the use of efficient compressor technologies and control strategies.

### BOILERS AND HEATING EQUIPMENT

MEPS for boilers and heating equipment target improvements in energy efficiency and reductions in emissions. Boilers are commonly used in industrial facilities to produce steam or hot water for heating, process heating and power generation. MEPS promote the adoption of high-efficiency boiler designs, combustion control systems and heat recovery technologies.

## REFRIGERATION AND AIR-CONDITIONING EQUIPMENT

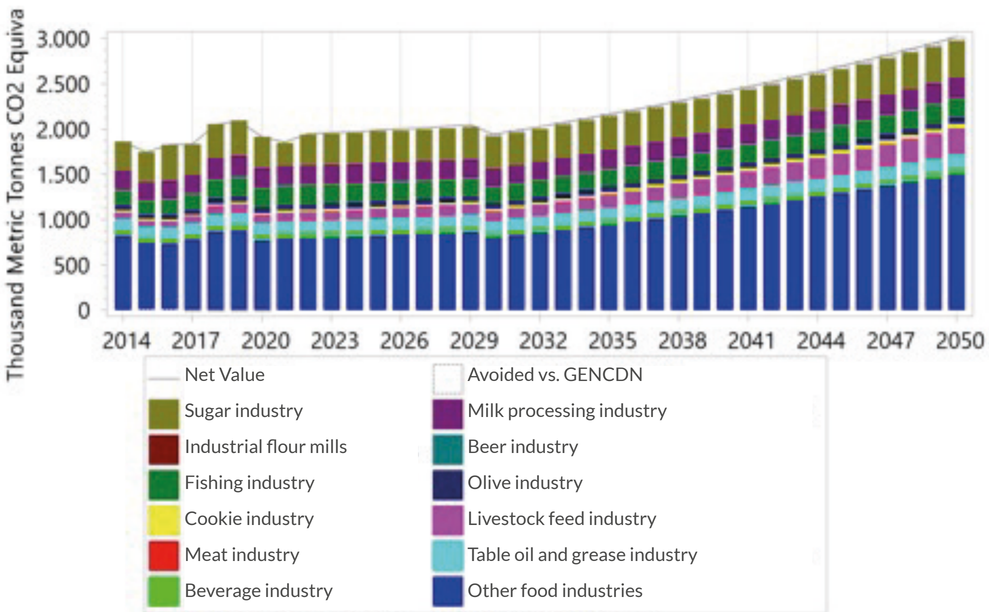
MEPS for refrigeration and air-conditioning equipment aim to improve energy efficiency and reduce greenhouse gas emissions. These systems are widely used in industrial settings for cooling and temperature control. MEPS encourage the use of energy-efficient refrigeration and air-conditioning technologies, including advanced compressor designs, heat exchangers and refrigerants with low global warming potential.

## INDUSTRIAL LIGHTING

MEPS for industrial luminaires focus on improving lighting efficiency and reducing energy consumption. Lighting systems are essential in industrial facilities to provide illumination in production areas, warehouses, and outdoor spaces. MEPS encourage the adoption of energy-saving lighting technologies such as LED luminaires, high-efficiency fluorescent lamps and lighting controls.

**This action would reduce GHG emissions by 0.8 million Teq $CO_2$ compared with the CDN scenario (between 2014 and 2050).**

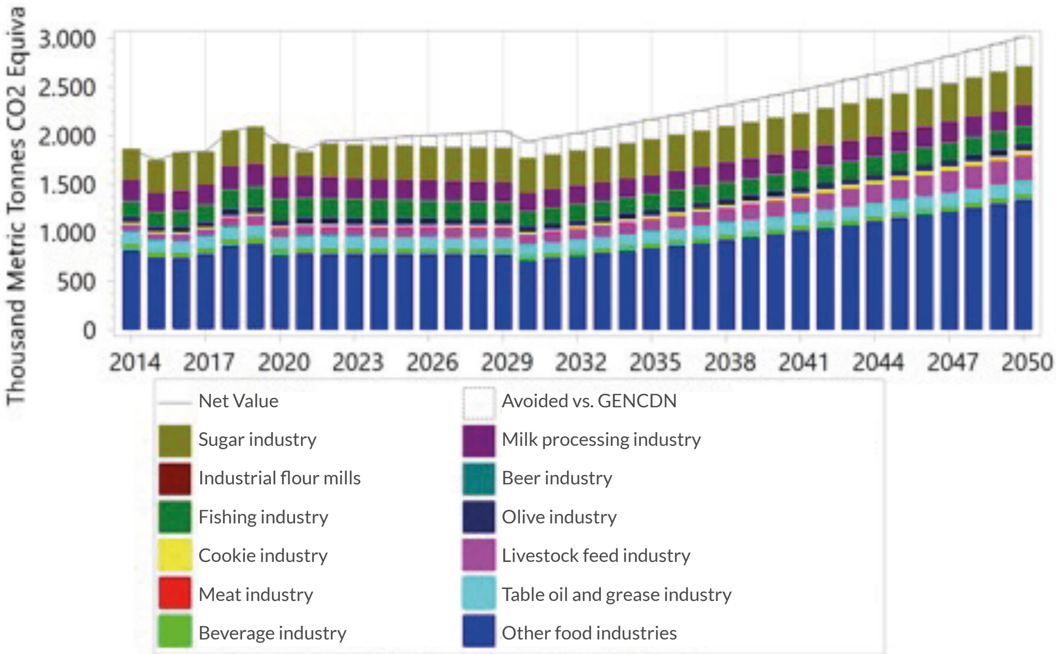
Figure 7 : IAA GHG emissions (CDN baseline and MEPS scenario)



The energy efficiency scenario for the food industry by 2030 would have a positive impact on GHG emissions. This efficiency concerns both heat and electricity.

**This action would reduce GHG emissions by 5.889 million Teq $CO_2$ compared to the CDN scenario (between 2014 and 2050).**

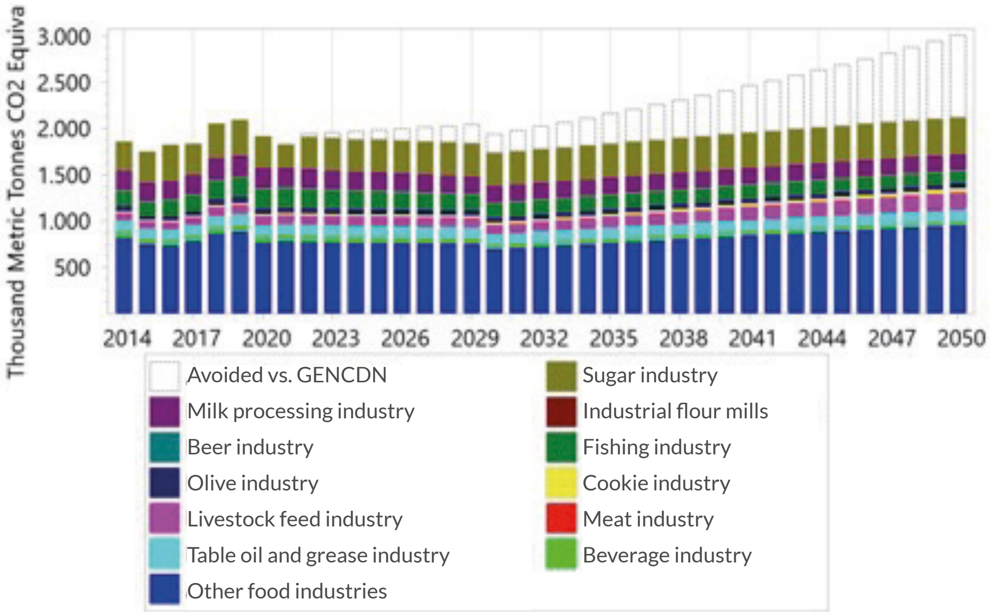
Figure 8 : IAA GHG emissions (CDN baseline and energy efficiency scenario)




This scenario consists of installing photovoltaic panels for self-consumption in the IAA industry. The project involves installing PV panels to satisfy 20% of electricity consumption by 2030 and 50% by 2050.

**This action would reduce GHG emissions by 11.758 million Teq $CO_2$ compared to the CDN scenario (between 2014 and 2050).**

Figure 9 : IAA GHG emissions (CDN baseline and PV scenario)




## 4.4. Scenario 3: Complementary solutions

### BIOMASS: BIOMASS BOILER PROJECTS (100% BY 2050)

The biomass scenario for the food industry in 2050 would have a positive impact on GHG emissions. This action only concerns the thermal aspect, and more specifically the conversion of biomass boilers to replace fossil fuel boilers. Biomass boilers use organic materials as fuel to generate heat or electricity. There are several technologies used in biomass boilers, each with its own advantages and applications.

Here are some of the most important, each with its own advantages and limitations depending on factors such as scale, fuel type and application requirements:

#### MOVING GRATE BOILERS (STOKER)

Stoker boilers use a mechanical system to feed biomass fuel into the combustion chamber. The fuel is usually in the form of wood chips, pellets, or logs. Stoker boilers are renowned for their reliability and ability to handle a variety of biomass fuels.

#### FLUIDIZED-BED BOILERS

Fluidized-bed boilers suspend biomass fuel particles in a bed of inert material (such as sand or lime) and use air or other gases to fluidize the mixture. This technology enables efficient combustion and reduces emissions of nitrogen oxides (NOx) and sulfur dioxide ($SO_2$).

#### BUBBLING FLUIDIZED BED (BFB) BOILERS

Bubbling fluidized bed boilers operate at lower temperatures than circulating fluidized bed boilers and are suitable for smaller-scale applications. They offer good fuel flexibility and can process a wide range of biomass feedstocks.

#### CIRCULATING FLUIDIZED BED (CFB) BOILERS

Circulating fluidized bed boilers are like bubbling fluidized bed boilers, but operate at higher temperatures and pressures, enabling greater efficiency and larger-scale applications. They are commonly used in industrial environments for heat and power generation.

## COMBUSTION GRATE BOILERS

Combustion grate boilers use a fixed or moving grate to burn biomass fuel. These boilers are suitable for burning biomass with a high moisture content and are often used in district heating systems and industrial processes.

## GASIFICATION BOILERS

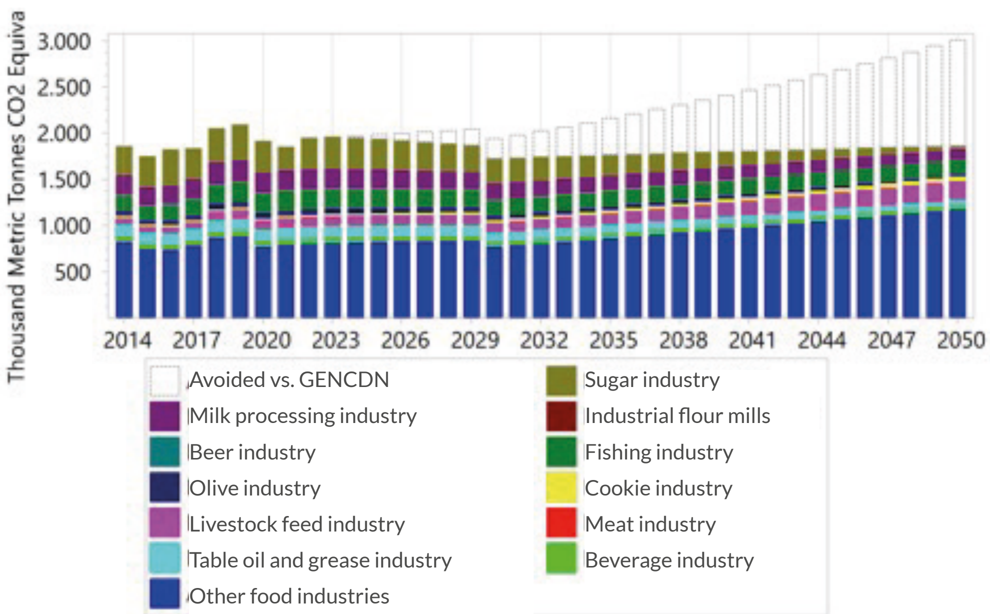
Gasification boilers convert biomass into a combustible gas (syngas) through a thermo-chemical process involving high temperatures and limited oxygen. The syngas is then burned in a boiler to produce heat or electricity. Gasification boilers offer high efficiency and can use a wide range of biomass feedstocks.

## PYROLYSIS BOILERS

Pyrolysis boilers heat biomass in the absence of oxygen, breaking it down into biochar, biooil and syngas. The bio-oil and syngas can be burned directly in a boiler or refined for use in engines or turbines. Pyrolysis boilers are still in the development phase, but offer the potential for efficient, clean biomass utilization.

**This action would reduce GHG emissions by 14.188 million Teq $CO_2$ compared to the CDN scenario (between 2014 and 2050).**

Figure 10 : IAA GHG emissions (CDN baseline and biomass scenario)

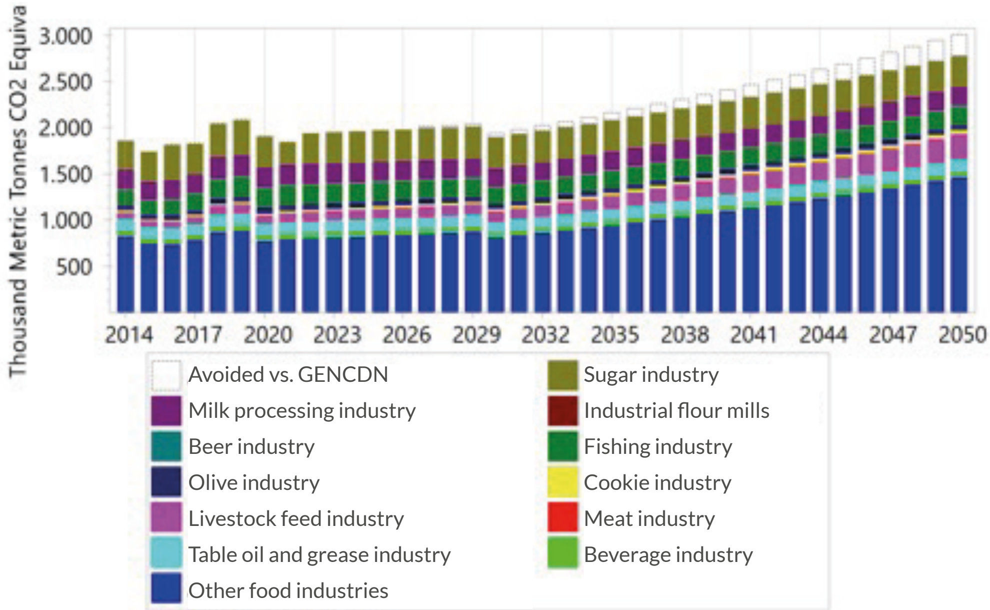


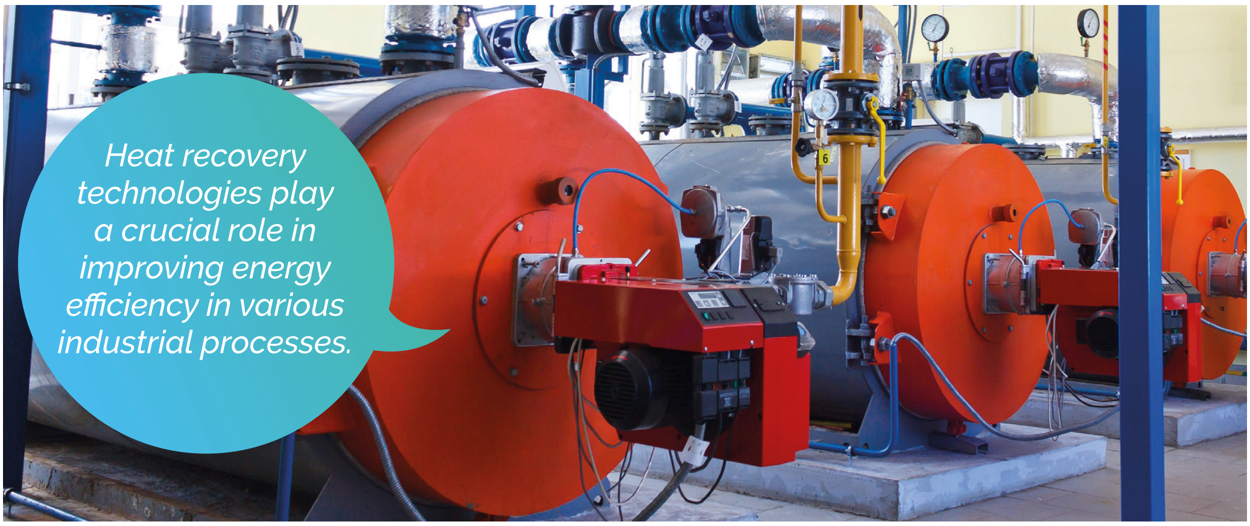
## HEAT RECOVERY: 20% BY 2050

The heat recovery scenario for the food industry in 2050 would have a positive impact on GHG emissions. This action only concerns heat recovery.

**This action would reduce GHG emissions by 3.555 million Teq $CO_2$ compared to the CDN scenario (between 2014 and 2050).**

Figure 11 : IAA GHG emissions (CDN baseline and heat recovery scenario)



## Here are some of the technologies commonly used for heat recovery in industry:

### HEAT EXCHANGERS

**Shell-and-tube heat exchangers**

widely used for heat transfer between two fluids.

**Plate heat exchangers**

compact and efficient, they feature thin plates to facilitate heat exchange.

**Air-to-air heat exchangers**

used to recover heat from exhaust air and transfer it to incoming fresh air.

### COMBINED HEAT AND POWER (CHP) SYSTEMS

simultaneous production of electricity and useful heat from the same energy source.

### HEAT RECOVERY BOILERS

**Heat recovery steam generators (HRSG):**
used to recover waste heat from the exhaust gases of gas turbines or internal combustion engines to generate steam.

### ORGANIC RANKINE CYCLE (ORC) / ORC SYSTEMS

use low-temperature heat sources to generate electricity via a thermodynamic cycle with an organic working fluid.

### THERMOELECTRIC GENERATORS

convert waste heat directly into electricity using the Seebeck effect.

### ADSORPTION CHILLERS

**Adsorption cooling systems:**
use waste heat to drive the adsorption process for cooling purposes.

### HEAT PIPE HEAT EXCHANGERS

transfer heat efficiently over long distances with minimal temperature drop..

### VAPOR COMPRESSION HEAT PUMPS

**Heat pump systems:** :
extract heat from low-temperature sources and raise it for use in industrial processes.

### REGENERATIVE BURNERS - REGENERATIVE THERMAL OXIDIZERS (RTO)

recover heat from exhaust gases in combustion processes.

### FLUIDIZED-BED COMBUSTION (FLUIDIZED-BED BOILERS)

use the heat of combustion for a variety of industrial purposes.

### THERMAL ENERGY STORAGE (SENSIBLE AND LATENT)

store excess heat for later use during periods of high demand.

### ABSORPTION CHILLERS

**Absorption cooling systems:**
use waste heat to drive the absorption process for cooling purposes.

### CONDENSING ECONOMIZERS

**Condensing heat exchangers:**
recover heat from flue gases to preheat boiler feed water.

### DIRECT-DRAFT THERMAL OXIDIZERS (DFTO)

recover heat from waste gas combustion.

### HYBRID SYSTEMS (INTEGRATION OF SEVERAL TECHNOLOGIES)

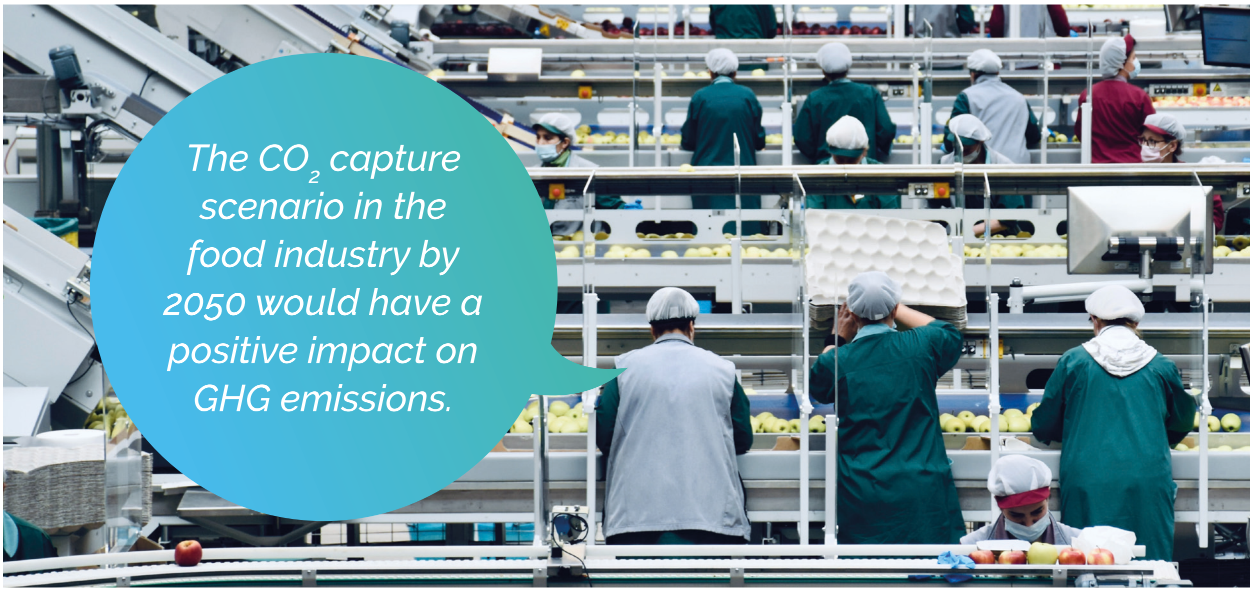
combining various heat recovery methods to optimize energy efficiency.

The choice of a specific heat recovery technology depends on factors such as the temperature of the waste heat, the nature of the industrial process and economic considerations.

In addition, technological advances continue to bring new heat recovery solutions to the industrial sector.

## $CO_2$ CAPTURE : 100% SUGAR INDUSTRY AND 20% FISHING INDUSTRY BY 2050

Carbon capture refers to the process of capturing carbon dioxide ($CO_2$) emissions produced by industrial sources such as power plants and manufacturing facilities, before they are released into the atmosphere. This technology plays a crucial role in mitigating climate change by reducing the concentration of greenhouse gases in the air. Typically, carbon capture involves the use of specialized equipment to capture $CO_2$ emissions, followed by transportation and secure storage, often in underground geological formations. By preventing the release of large quantities of $CO_2$ into the atmosphere, carbon capture contributes to global efforts to limit the impacts of climate change and move towards a more sustainable, low-carbon future.
Despite its potential, the widespread implementation of carbon capture faces various technical, economic and political challenges that require ongoing research and development efforts for effective integration into the global climate change mitigation strategy.




The $CO_2$ capture scenario in the food industry by 2050 would have a positive impact on GHG emissions. This action concerns only the sugar industry and the fishing industry and begins in 2030. These sub-sectors are the only ones with direct emissions and where the size of the companies means that the necessary investments can be made for $CO_2$ capture.

**This action would reduce GHG emissions by 45.73 million Teq $CO_2$ compared with the CDN scenario (between 2014 and 2050).**
**The action consists of capturing 100% of thermal emissions from the sugar industry and 20% from the fishing industry, starting in 2023.**

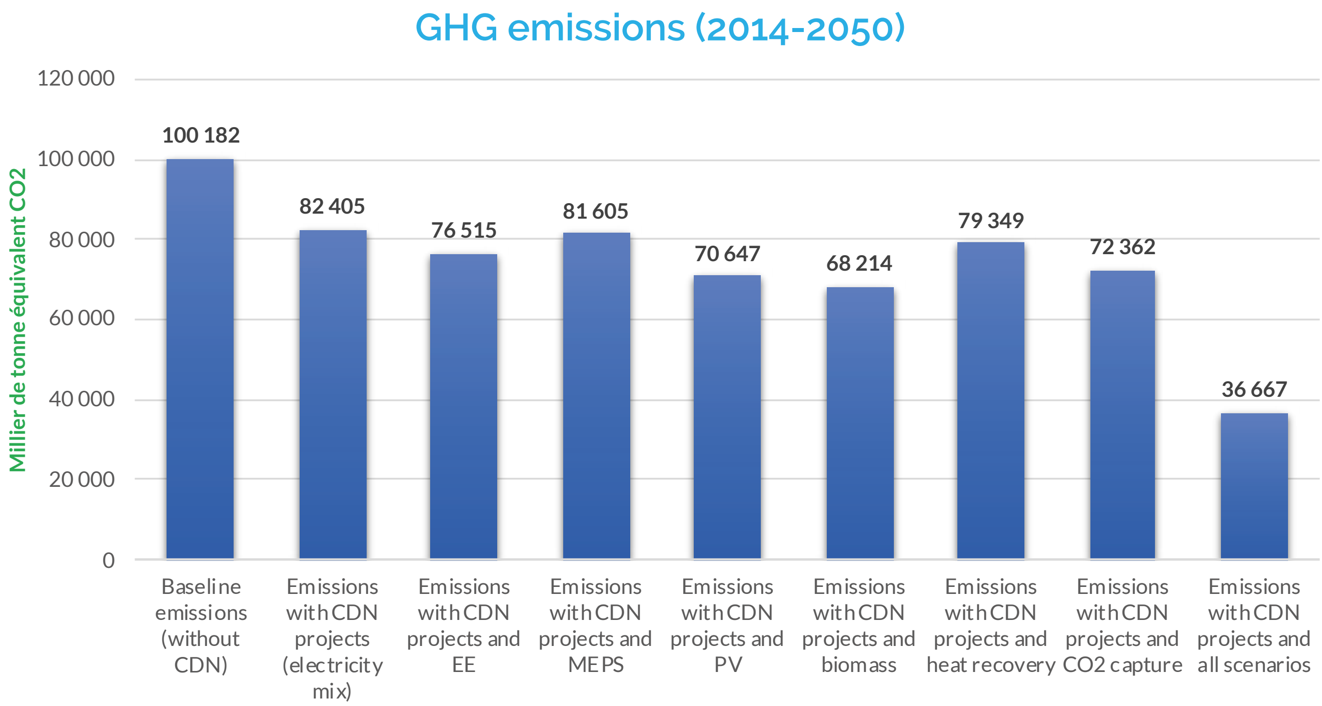
## 4.5. Combined scenarios

Emissions from all actions are shown in the diagram below.

It can be seen that it is the biomass action that reduces the IAA industry's GHG emissions, followed by PV, $CO_2$ capture , EE, heat recovery and finally MEPS.

**Implementation of all scenarios would reduce GHG emissions by 63.4% between 2023 and 2050, compared with the baseline.**

Figure 12 : Émissions de GES IAA (Ligne de base CDN et tous les scénarios)



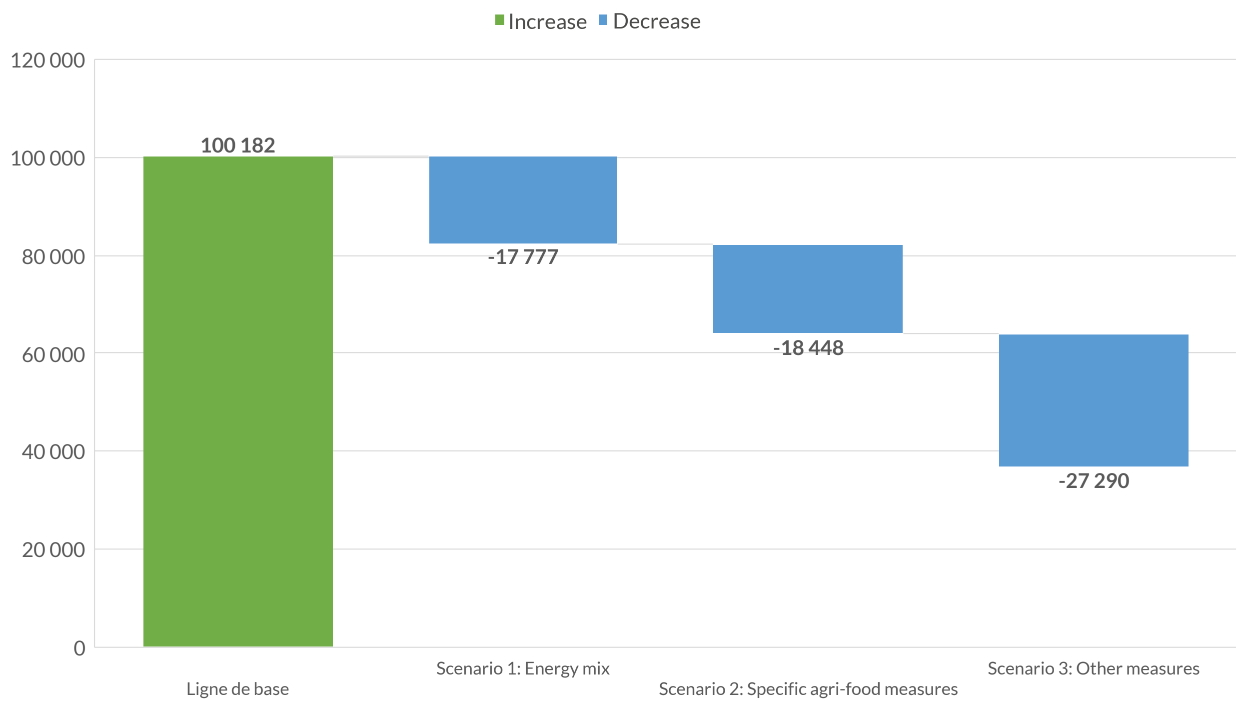
By grouping the actions into scenarios, the first scenario considers the impacts of measures linked to decarbonizing the national energy mix, reducing emissions from the agrifood sector by 17.7%. A net-zero scenario for the national energy mix could further reduce emissions from electricity consumption. The impact of the first scenario depends solely on actions taken at national level.

The second scenario takes into account MEPS, energy efficiency measures and the installation of photovoltaic panels, with a reduction potential of 18.5%. This scenario considers national commitments at NDC level, which will be implemented by food manufacturers. Their impact will depend mainly on the commitment of the sector's manufacturers and stakeholders who can support companies in their low-carbon transition.

The final scenario takes into account additional emission reduction measures that also depend on technological development, namely the replacement of oil-fired boilers by biomass boilers, heat recovery and $CO_2$ capture . This last scenario could reduce emissions by 27.3%.

## The combination of the various measures is summarized in the following figure:

Figure 13 : Mitigation scenarios



# 5 FINANCING MITIGATION MEASURES

The implementation of the net-zero roadmap for the agri-food sector takes into account two types of action:

• actions at national level planned within the framework of the NDC
• and actions specific to the agri-food sector to be implemented by the sector's manufacturers.

It should be noted that other decarbonization measures may also be envisaged, such as the production of green hydrogen, solutions arising from the National Low Carbon Strategy, waste recovery, etc. The development of new processes and technologies could also contribute to the decarbonization of the agri-food sector.

## The funding requirements for each measure are summarized in the table below :

| Mitigation measures | Avoided emissions | Cost M USD |
|---|---|---|
| Impact on the energy mix | 17 777 | 17 081.5 |
| Impact Energy efficiency | 5 890 | 20 |
| MEPS impact | 800 | N/A |
| Impact of PV roofing | 11 758 | 9 |
| Biomass impact | 14 191 | 200 |
| Impact of heat recovery | 3 056 | 30 |
| Impact of $CO_2$ | 10 043 | 200 |

# 6 ROADMAP IMPLEMENTATION

## 6.1. Barriers

The implementation of a roadmap can be hampered by various organizational, technical and human barriers.

On the organizational front, resistance to change can be a major obstacle, with teams reluctant to abandon their usual methods. In addition, the limited availability of resources, both human and financial, can hamper the implementation of planned initiatives. On the technical side, incompatibility of existing systems, technological constraints and interoperability issues can make it difficult to integrate new solutions. Human aspects, such as the lack of necessary skills within the team or ineffective communication, can also constitute significant obstacles.

In addition, the lack of management support and a clear understanding of objectives can compromise the success of the roadmap. Overcoming these barriers requires a holistic approach, combining change management, appropriate resource allocation and transparent communication at all levels of the organization.

## 6.2. Action plan and recommendations

To overcome the barriers to implementation, companies operating in this sector will need technical and financial support to help them make the transition to net zero.

As a first step, each company needs to carry out its own carbon footprint to identify the emission sources specific to its activity.

Each company can then implement projects and investments in energy efficiency, renewable energies and process digitization, in order to track the necessary reduction in its carbon footprint.

## Support programs available

Support programs are available and can be used to provide technical assistance to companies wishing to decarbonize.

## Green financing guide

A green financing guide developed by AMEE is available for an exhaustive list of financing lines available in Morocco.*

## Mobilization of key players

The mobilization of key players in the sector is essential for successful implementation.

*Source : *AMEE Report "Decarbonization and the green economy - A guide to financing and support programs for Moroccan businesses"*

As part of this study, a toolbox has been developed to support companies in their decarbonization journey.

## Below are the potential decarbonization measures for manufacturers in the agri-food sector:

| Transmitter station | Technological solutions | Technology examples | $CO_2$ redution |
|---|---|---|---|
| Energy | Boiler | Biomass hot water boilers with a maximum continuous rated output of 300 kW | **100% reduction** compared with oil/gasoil/gas-fired boilers, with an **average IRR of 3 years** |
| | | Hot-water biomass boilers with continuous rated output > 300 kW | |
| | | Condensing economizer | **9 % reduction** |
| | | Combustion air preheating | **3 % reduction** |
| | Electric motors | IE3 or IE4 energy-class motors with variable speed drive. | **≥ 20% reduction** with an **average IRR of 2 years** |
| | Air-to-water heat pumps | Efficient low-temperature heat pumps (EER > 3.30) | **≥ 20 % reduction** |
| | | Efficient high-temperature heat pumps (EER > 3.30) | |
| | Air-to-air heat pumps | Efficient gas-fired split and multi-split heat pumps (EER > 1.10) | |
| | | Efficient packaged heat pumps (EER > 2.80) | |
| | Cooling equipment | Efficient air-cooled condensing units (high COP) | **≥ 20% reduction with an average IRR of 3 years** |
| | | Efficient cooling equipment (single and double split systems) (COP > 3.30) | |
| | Energy management equipment and centralized technical management | Metering equipment (electrical, thermal, compressed air meters, dataloggers, connected sensors, current transformers, gateways) | **≥ 15 % reduction** |
| | | Supervision software (SIME: Système d'Information de Management de l'Energie) | |
| | Solar energy | Photovoltaic system | **1.3 teq $CO_2$ /year/kWp with an average IRR of 5 years** |

<table>
<tr><th>Transmitter station</th><th>Technological solutions</th><th>Technology examples</th><th>$CO_2$ redution</th></tr>
<tr><td rowspan="4">Inputs</td><td rowspan="4">Use of low-carbon raw materials</td><td>Recycled plastic</td><td>3 teq $CO_2$ / ton recycled</td></tr>
<tr><td>Recycled cotton</td><td>640 kgeq $CO_2$ /ton cotton, i.e. 64% less than virgin cotton</td></tr>
<tr><td>Recycled steel</td><td>1.27 teq $CO_2$ /ton recycled, i.e. 57% less than virgin steel.</td></tr>
<tr><td>Recycled aluminum</td><td>9.3 teq $CO_2$ / ton recycled, i.e. 94% reduction compared with virgin aluminum</td></tr>
<tr><td rowspan="3">Waste</td><td rowspan="3">Industrial waste recovery</td><td>Methanization</td><td>77 kgeq $CO_2$ /ton of methanized waste</td></tr>
<tr><td>Composting</td><td>11 kgeq $CO_2$ /ton of waste sent for composting</td></tr>
<tr><td>Recycling and reuse</td><td>≥ 40% reduction</td></tr>
<tr><td rowspan="2">Personnel and freight transport</td><td rowspan="2">Introduction of electric transport vehicles</td><td>Electric bus powered by renewable energy</td><td rowspan="2">100% reduction compared with combustion engine buses</td></tr>
<tr><td>PV charging station</td></tr>
</table>

## 6.3. Conclusion

In conclusion, it is essential to emphasize that achieving net zero emissions hinges significantly on decarbonizing the electricity grid and corporate commitments to substituting fossil fuel-based heat generation with renewable energy sources, such as biomass.

Acknowledging the imperative for capacity enhancement and financial backing is crucial to ensuring the effectiveness of this crucial transition.

Through strategic investments in sustainable solutions, fostering the uptake of clean technologies, and facilitating and providing appropriate financial support and technical assistance, we can actualize the vision of a sustainable, environmentally conscious future.

amee
Agence Marocaine
pour l'Efficacité Energétique


**Authors:**
*Abdellatif Touzani*
*Hiba Rizk*
*Zineb Lahlou*



**Publication:**
*February 2024*


UN
environment
programme