Research and analysis on potential investment through advanced technologies towards decarbonized society

- One case study with Preliminary Emission Scenario Analysis for Tunisia-

August 25, 2022　UNIDO and Japan TICAD8 Side Events

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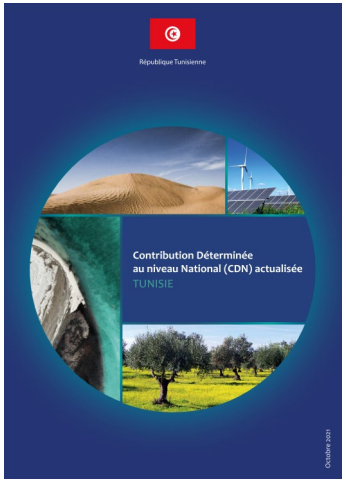
Key Mitigation Plans and Strategies in Tunisia

- Tunisia submitted its updated Nationally Determined Contribution to UNFCCC in October 2021, **pledged 45% carbon intensity reduction by 2030 compared to 2010**.
- Tunisia also has developed Long Term Strategy to achieve **carbon neutral by 2050**, support by German government. (**not submitted to UNFCCC**)

Nationally Determined Contribution

- **Title**
  Contribution Déterminée au niveau National (CDN) actualisée
- **2030 Target**
  [Conditional]
  45% carbon intensity reduction by 2030
  compared to 2010
  [Unconditional]
  27% carbon intensity reduction by 2030 compared to 2010
- **Covered Sector**
  Energy, Industrial Process, AFOUL, Waste



UNFCCC (2021) Contribution Déterminée au niveau National (CDN) actualisée

Draft Long Term Strategy (not submitted)

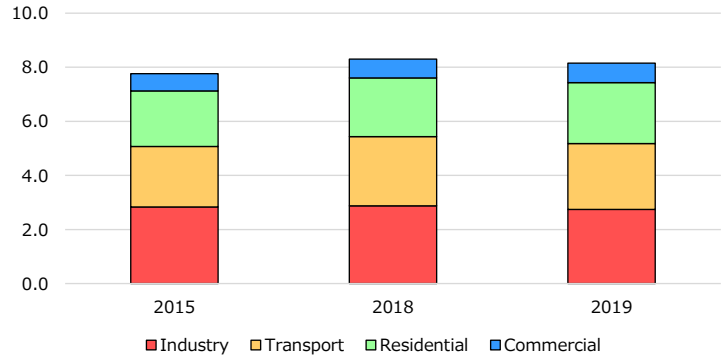
- **Title**
  Stratégie de neutralité carbone et de résilience au changement climatique à l'horizon 2050
- **2050 Target**
  Carbon neutral by 2050
- **Covered Sector**
  Energy, Industrial Process, AFOUL, Waste

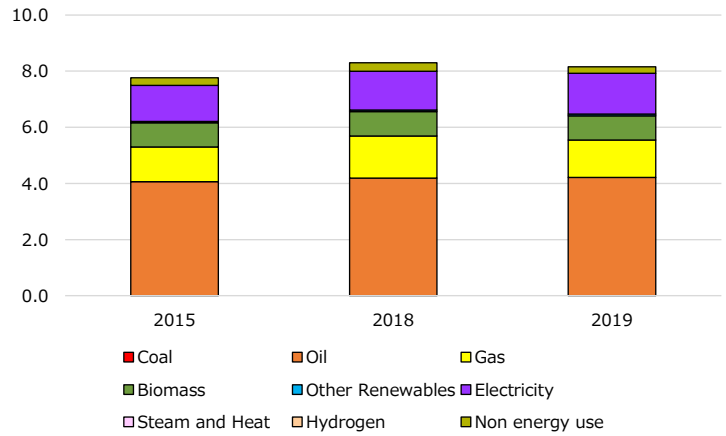
Ministry of Environment, Tunisia (2022) Stratégie de neutralité carbone et de résilience au changement climatique à l'horizon 2050

Overview on Energy Supply and Demand in Tunisia

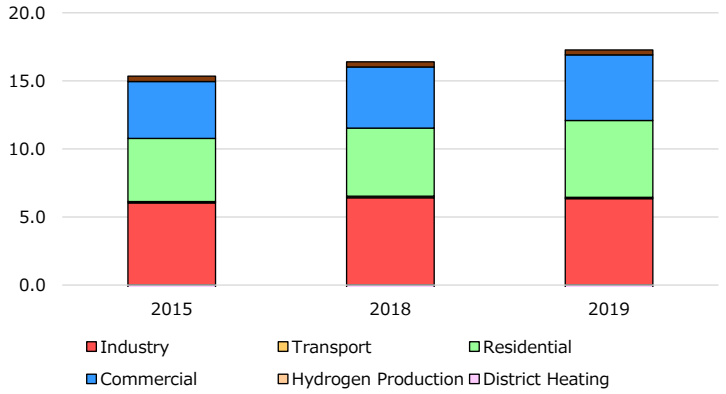
- "Industry and Transport" and "Gas and Oil" are key factor in factors to promote decarbonizations in Tunisia.
- Especially for Power generaion, **over 90% of electricity is generated by gas-fired** power plants.

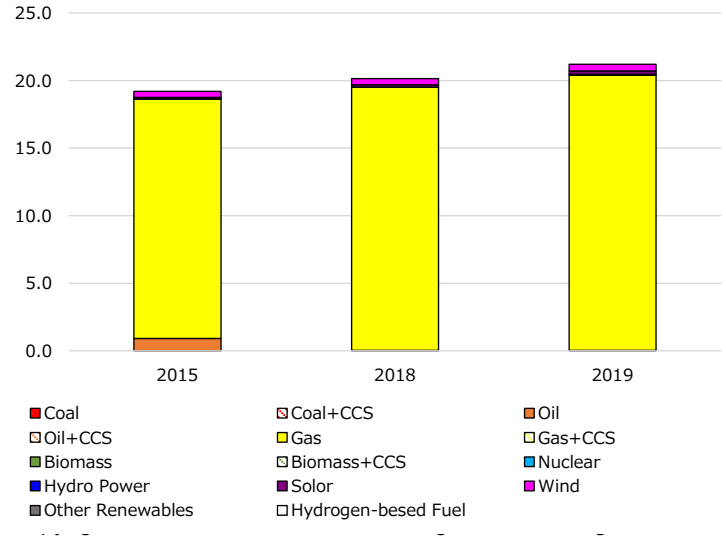
Final Energy Consumption by Sector (top) and by energy type (bottom) [Mtoe]





Electricity Demand(top) and Supply(bottom) [TWh]





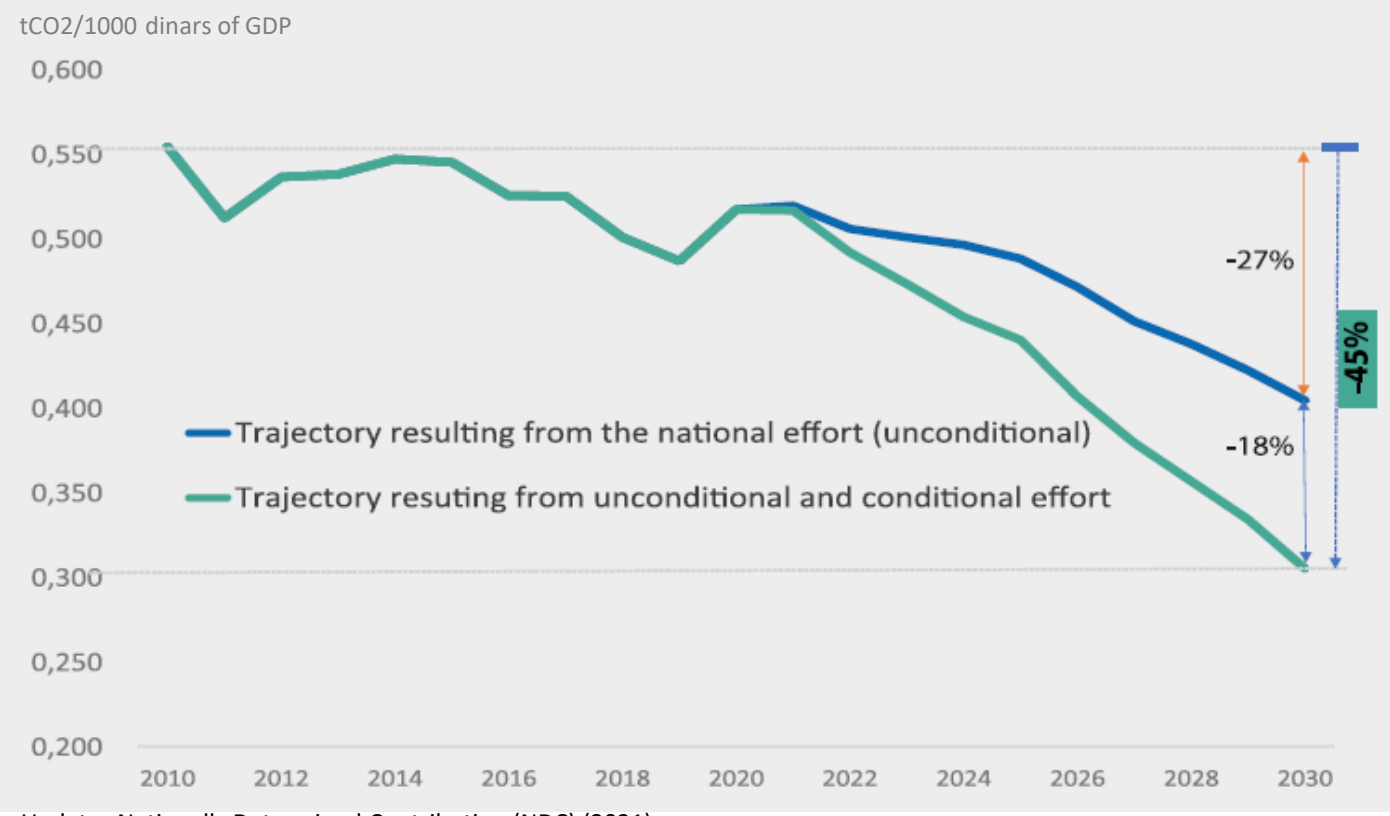
Source: IEA World Energy Balances, IEA Greenhouse Gas Emissions from Energy

Tunisia's Mid-term and Draft Long-term Strategies toward Decarbonization

Updated NDC Target for the year of 2030

- Although Tunisia's global GHG emissions are reratively small (0.07% in 2010), the updated NDC set a 2030 conditional target to **reduce carbon intensity by 45%, relative to 2010 levels** (0.554 tCO2/1000 dinars of GDP).
- **Emissions per capita are expected to be 2.4 t-CO2e/capita in 2030**. (The global average was 7tCO2e/capita in 2010)

Carbon Intensity Trajectories of Tunisia

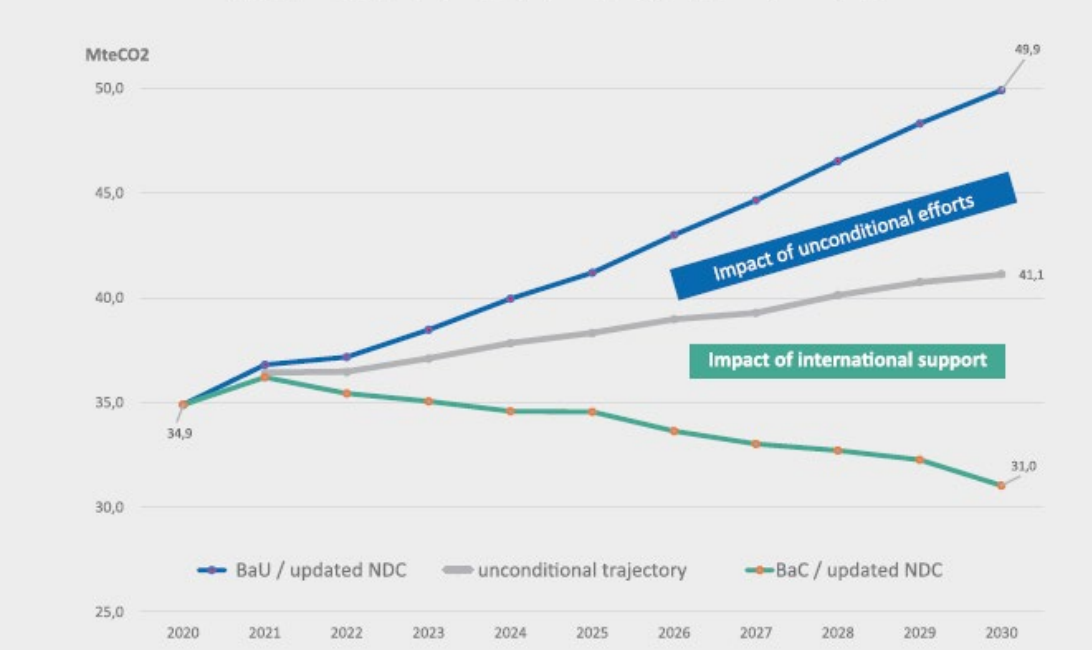


Source:Republic of Tunisia, Updates Nationally Determined Contribution (NDC) (2021)

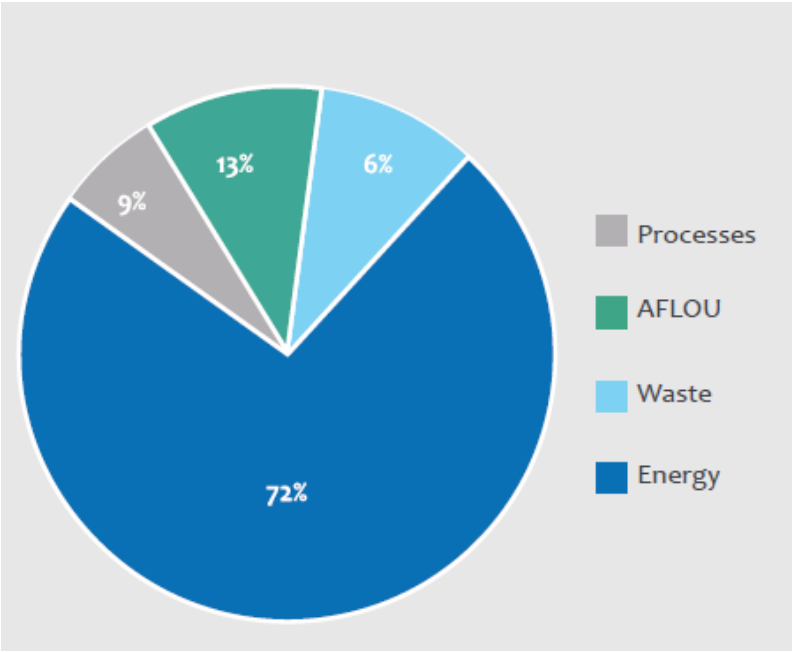
Scenario Analysis toward 2030 in Updated NDC

- The revised NDC provides calculations of GHG emissions for three scenario: the BaU scenario, the no-condition-action scenario, and the conditional scenario (BaC). Under the BaC scenario, emission in 2030 will be 31.0 MtCO2, which is 11% lower than 2020 (34.9 MtCO2 e),.

Net BaU and BaC Emissions Trajectory of Tunisia



Distribution of Cumulative GHG Reduction (2021-2030)



Source:Republic of Tunisia, Updates Nationally Determined Contribution (NDC) (2021)

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About Draft Low Carbon National Strategy

- SNBC & RCC stands for a compilation of two strategies: the National Low Carbon Strategy (SNBC) and the Climate Resilient National Development Strategy (SNRCC).
- The Tunisian the Ministry of the Environment, German consulting firm HEAT, French consulting firm ACTERRA and German International Postal Service GIZ began the research in November 2021, and a pre-final version was published in March 2022.

Composition of SNBC&RCC

Chapter 1	The Geography and Climate of Tunisia
Chapter 2	Vulnerability to climate change
Chapter 3	Current and past mitigation policies
Chapter 4	Vision towards Low-Carbon transition
Chapter 5	Low Carbon Strategy aiming for 2050 CN
Chapter 6	National Resilience Strategy
Chapter 7	Synergy of Interdependence and Synergy between 2 different strategies
Chapter 8	Implementation and follow up for the 2 different strategies

Source:Ministère de l'Environnement, Stratégie de neutralité carbone et de résilience au changement climatique à l'horizon 2050 (2022)

The following two future projection scenarios was analized in Charpter 5.

① **BaU Scenario**
: Baseline scenarios considering growing sectoral trends to affect GHG emissions

② **BaC Scenario**
: Low-carbon scenarios that regulate global warming to lower than 2 Celsius degrees, or 1.5 Celsius degrees under certain circumstances, by taking an ambitious path to the Carbon Neutrality by 2050

Assumptions by Sector in Draft Low Carbon National Strategy

Discussion Purpose Only

Examples of measures in each sector under BaC scenario

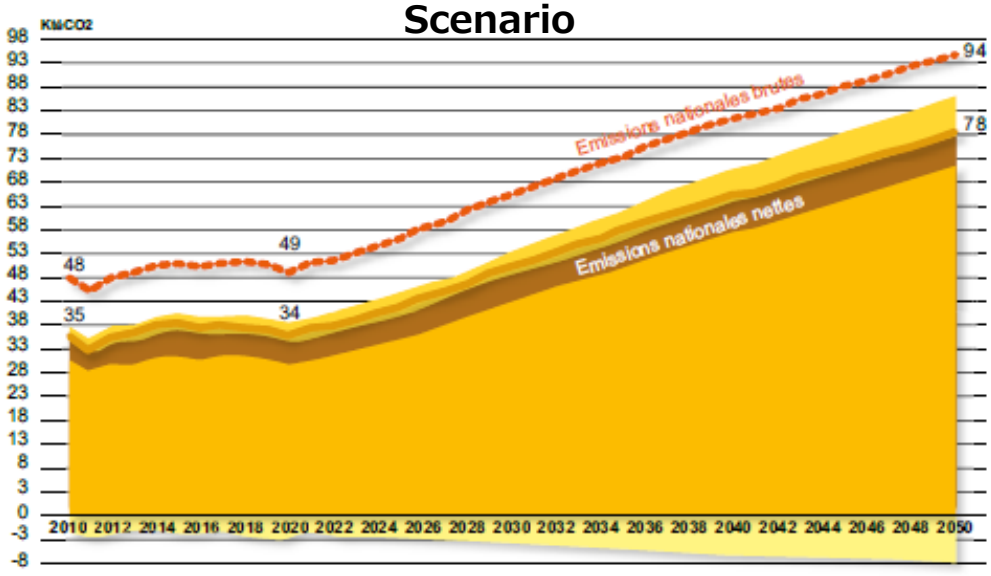
Energy Sector	Industrial Process Sector	AFAT Sector	Waste Sector
• **80% of electricity generated in 2050 will be replaced to renewable energy** • 40% of primary energy balance becomes renewable ones • The primary energy consumption in 2050 halves compared to that of BaU • The primary energy intensity in 2050 accounts for one third in a comparison with those in 2020 • **End-use electrification accounts for 43% in 2050**	• Reduction of Nitric Acid Emissions • **Employment of CCS in the Cement Sector will start in 2040, as well as neutralizing the process emissions by 2050** • To comply with Kigali Amendment on HFC, emissions will be reduced by 6 times in a comparison with the BaU in 2050	• 43% (4.3 million ha) of agricultural lands including rangelands will be covered by the actions for restoration and conservation of land and ecosystems, and for the optimal use by 2050 • For the sake of the livestock optimization, 100% of cattle and sheep will be covered in 2050 • 342,000 ha of grain fields will be covered by BPA and conservation agriculture by 2050 • Implementing organic farming over 660,000 ha by 2050	• Residential waste generation will be reduced by 20% in urban areas and 10% in rural areas in 2050 compared to those in 2020 • Raising the recycling rate of residential waste produced to 36% in 2050 • Implements Organic collection (compost) or Energy collection (RDF and electricity) for 70% of waste in 2050 • By conducting a 100%-systematic electric collection at landfill with a degassing/flaring system, it enables to generate 1 million tons of alternative fuels (such as RDF) to supply 60% of thermal energy demand in the Cement Sector

Source:Ministère de l'Environnement, Stratégie de neutralité carbone et de résilience au changement climatique à l'horizon 2050 (2022)

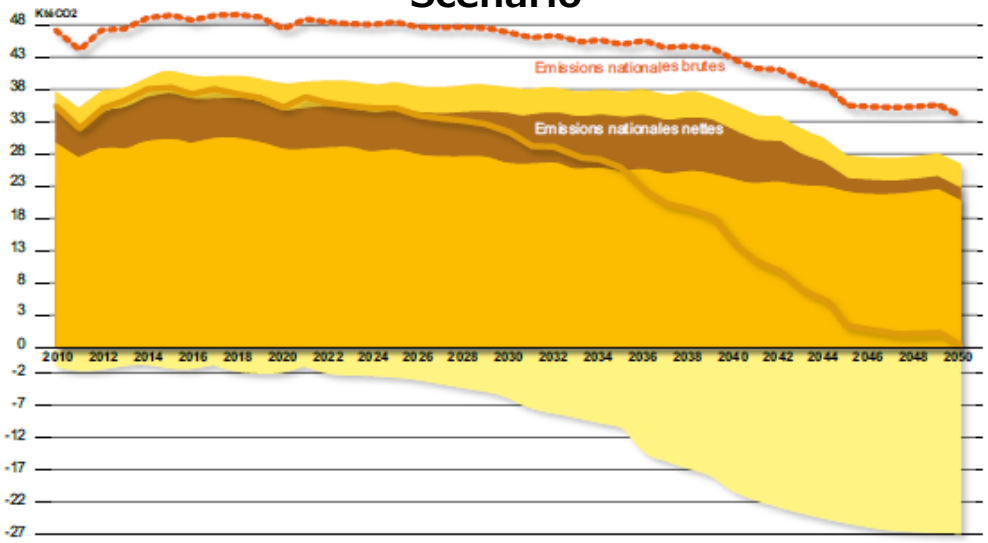
Scenario Analysis in Draft Low Carbon National Strategy

- Under the **BaU scenario, total GHG emissions will nearly double in 2050** from 49 MtCO2e to 94 MtCO2e .
- **In the energy sector**, **total GHG emissions in 2050 are projected to be more than double from those in 2020**. On the other hand, **a decoupling of net emissions and economic growth** can be seen in the fact that GDP growth is projected to be about 4.4 times from 2020 to 2050.
- Under the BaC scenario, **Significant increases in absorption, particularly in the AFOLU sector, will contribute to carbon neutrality.**

GHG Emissions of all Sectors under the BaU Scenario



GHG Emissions of all Sectors under the BaC Scenario



Total emission
Net emission
Waste
Industrial Process
Energy
AFOLU

Source:Ministère de l'Environnement, Stratégie de neutralité carbone et de résilience au changement climatique à l'horizon 2050 (2022)

Key Topics of “Investment” and “Hydrogen”

Funding to achieve Decarbonization in NDC

- According to the NDC, US $19.3 billion funding will be required between 2021 and 2030. Detailed estimates include US $14.3 billion for mitigation, US $4.3 billion for adaptation and US $700 million for supports in capacity building.
- For access to the Article 6 mechanism, Tunisia is actively preparing to demonstrate and apply a carbon tax on energy products and a credit scheme in the power generation and cement manufacturing sectors as a pilot carbon pricing instrument.

Investment Financing required for supporting the NDC low-carbon scenario over the period of 2021 through 2030 (million US$ 2020)

SECTORS/AREAS	Total	Sahre※
ENERGY	11,785	82.6%
Energy efficiency	5,755	-
Renewable energy	4,377	-
Infrastructures (enhancing the electrical system)	1,653	-
PROCESSES	675	4.7%
AFOLU	753	5.3%
WASTE	1,182	6.1%
Solid waste	313	-
Sanitation	869	-
TOTAL	**14,273**	**100%**

Source:Republic of Tunisia, Updates Nationally Determined Contribution (NDC) (2021)

* The total sum may not match all the time due to rounding differences.

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Tunisia's Hydrogen Strategy

- According to SNBCRCC, Tunisia is proposing to establish an international partnership to position itself for major research on hydrogen. The nation is interested in expanding the use of hydrogen for the industrial area and producing and exploiting green hydrogen with renewable energy.

- In June 2022, the Ministry of Industry, Mines and Energy of Tunisia officially announced the launch of the "Green Hydrogen Project for Sustainable Growth and Low Carbon Economy in Tunisia (**H2 Vert.TUN**) during the workshop that took place at the German GIZ in the capital Tunis." The duration of the project, which aims at improving the framework for building a renewable energy value chain for green hydrogen and its products, has been set from 2022 to 2025.

Areas of Concern for Tunisia presented at SNBCRCC

- Production, storage and distribution of hydrogen
- Final consumption of hydrogen, including private and commercial vehicles, and manufacturing industry
- Other utilities including a direct combustion fueled by hydrogen and fuel cell applications

3 strategic pillars of "H2Vert.TUN"

1. Developing a national green hydrogen strategy
2. Optimizing conditions for private sector investment
3. Expanding the professional capacities of those with political and scientific responsibility

Source:Ministère de l'Environnement, Stratégie de neutralité carbone et de résilience au changement climatique à l'horizon 2050 (2022)
GIZ, Promoting a green hydrogen economy in Tunisia (2022)

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Preliminary Emission Scenario Analysis

-One case study for Tunisia-

Preliminary Emission Scenario Analysis: Summary

Discussion Purpose Only

- In the draft proposal on long-term strategy, two BaU (Expectant) and BaC (Measures) scenarios have been analyzed; however, the breakdown by industry type and by energy type is unclear.

- Additionally, draft long-term strategy adopts significant increases in absorption, particularly in the AFOLU sector, to achieve carbon neutrality.

- **Using the AIM/ESS model,** which is an accounting-type model of energy supply and demand, **a detailed estimation analysis of emissions was conducted** for the following 2 cases up to 2050: **"Technology-fixed scenario (fixed in 2019)"** and **"Countermeasure scenario"**.

- **For the preliminary analysis for drastic emission reduction in Energy sector**, we try to set **"Countermeasure Scenario"** as a scenario under assumption in which **CO2 emissions from fuel combustion would be significantly reduced** compared to the draft proposal for long-term strategy, and which **reduction reach as much as 90% minus in a comparison with the level in 2019 by 2050**.

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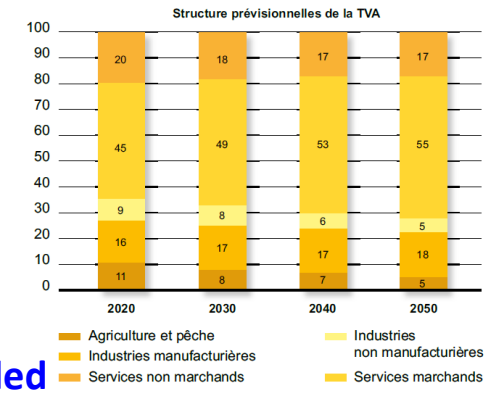
Scenario Analysis Assumptions on Service Demand

- With GDP and its breakdown (secondary industry/tertiary industry/others) and population as activity indicators, the quantificational demand for services in industry, transport, residential and business sectors was estimated respectively to apply it in common for 2 cases: the Technology-fixed scenario (fixed in 2019) and the Countermeasure Scenario.

Activity indicators (2019=100)	2019	2030	2040	2050
GDP Source: Draft proposal for long-term strategy (with 5% of annual growth)	100	171	356	454
Population Source: Draft proposal for long-term strategy	100	108	112	114

Forecast for Added Value by Sector by 2050



Industrial, Commercial and Freight transport: Proportional to GDP and decoupled by 50% (Source: draft long-term strategy)

Residential and Passenger transport: proportional to population

Assumed service demand (2019=100)	2019	2030	2040	2050
Manufacture	100	105	118	136
Construction/Mining and quarrying	100	105	108	114
Agriculture/forestry/Fishing	100	105	99	93
Passenger Transport	100	100	104	108
Freight transport	100	105	115	128
Residential	100	100	104	108
Commercial	100	105	115	128

Preliminary Scenario Analysis: Assumptions on Measures

Discussion Purpose Only

- **This scenario contains variable countermeasures to explore the possibilities of Tunisia's decarbonized society.**
- For the volume of renewable energy installed in 2030 and the maximum potential installation in the measure case, refer to the Tunisian Report in 2021 from the African Development Bank.
- Specially for the year of 2050, "the 80% renewable energy sources" in the long-term strategy was adopted. Also, citing from the draft long-term strategy, it is assumed that 100% CCS will be installed in the Cement Manufacturing Sector by 2050.
- Under the above conditions, for the other categories such as Energy saving , Electrification, Hydrogen utilization, and CCUS, a single path was drawn in which CO2 originating from combustion would be reduced as much as 90% in 2050 .

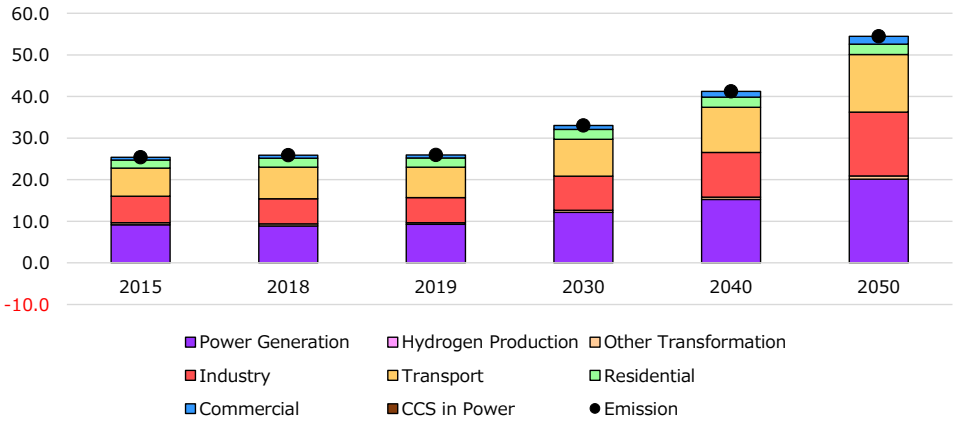
	2030	Main Measurements2050
Energy Sector	Assumed 5-year lag behind of the linear complements between 2019 and 2050	80% Renewable energy in the power supply composition (Solar: 50%, Wind: 20%, Bio-thermal: 10%, Natural Gas-fired: 20%), Installing CCS in Natural Gas-fired Power Plants (100% coverage), Installing BECCS in biomass-fired power plants (100% coverage), Production of carbon-free hydrogen with electrolysis equipment (100% coverage)
Industrial Sector		Improvements in the efficiency of industrial machinery (20 to 30% improvement): Adoption of heat pumps for boilers (app. 50% coverage): Electrification of industrial furnaces (app. 20% coverage): Introduction of Hydrogen Burners (app. 20% coverage): Installation of CCS in Cement Manufacturing (100% coverage): Extended usage of biomass in Paper Manufacturing and installation of CCS and BECCS (100% coverage)
Transportation Sector		Improvements in Automobile efficiency (app. 50% improvements): Progress in penetration of EVs passenger cars (app. 90%): Progress in FCV/EVs trucks penetration (app. 50% and 25% respectively): Biodiesel in trucks (50% mix ratio): Electrification of railroads (app. 80% penetration): Improving fuel efficiency of Airplanes and Ships (app. 20%)
Residential & Commercial Sectors		Proceeding electrification and improvements in the efficiency of air conditioning (100% penetration, 20 to 40% improvements): Penetrating the use of heat pumps for water heaters (app. 50% coverage): Penetrating the use of Induction kitchens (app. 25% coverage): Introducing more efficient home appliances (app. 50% improvement)

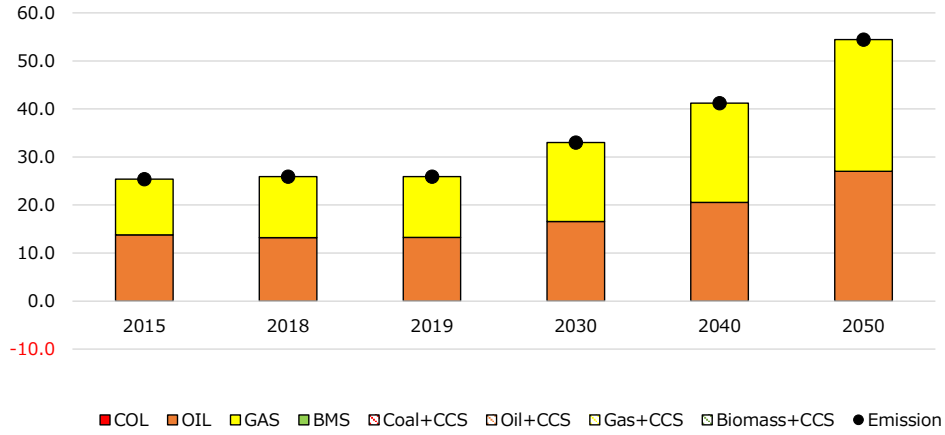
Preliminary Results in CO2 Emission from Fuel Combustion

Discussion Purpose Only

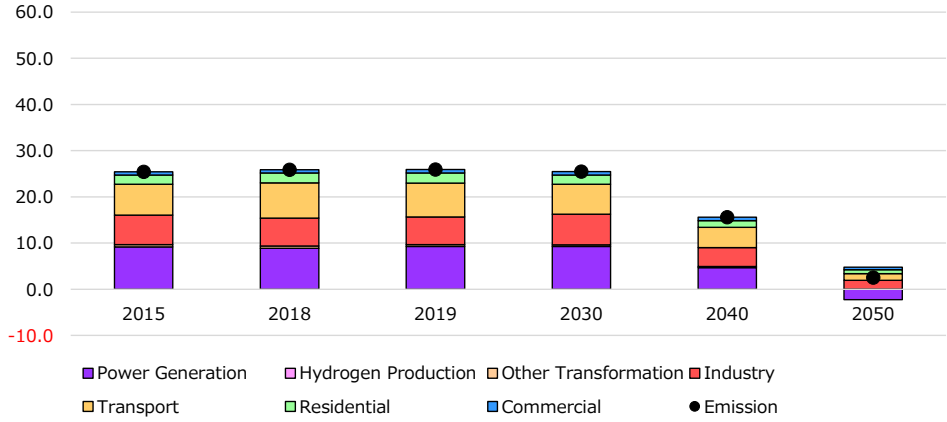
- In 2050, the Technology-fixed scenario emitted 55 Mt CO2 from combustion. The measure case will address 2.5 MtCO2, which includes significant reductions in natural gas and oil consumption, energy conservation and electrification, as well as reductions through CCS and BECCS.

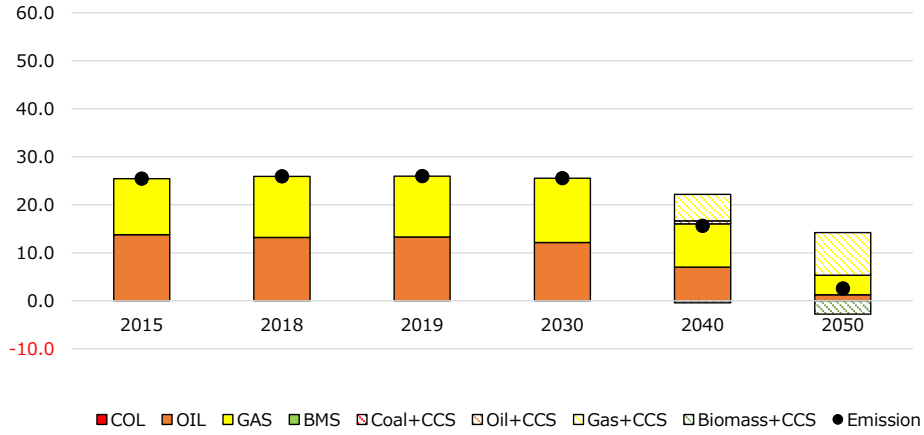
CO2 Emissions in Technology Fixed [MtCO2]





Emissions in Countermusure -90% [MtCO2]

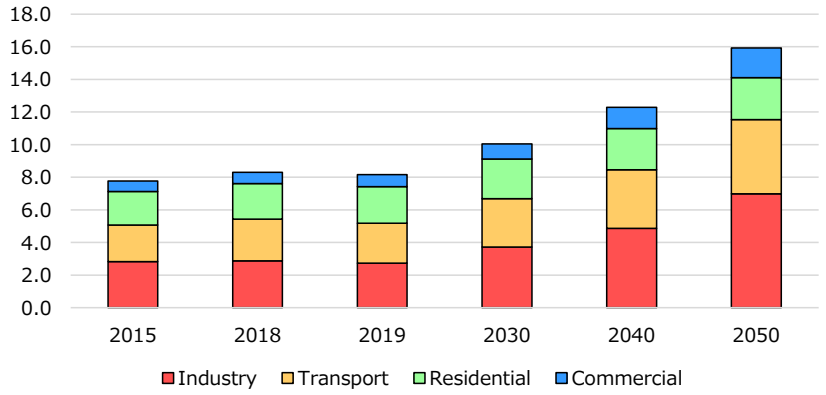


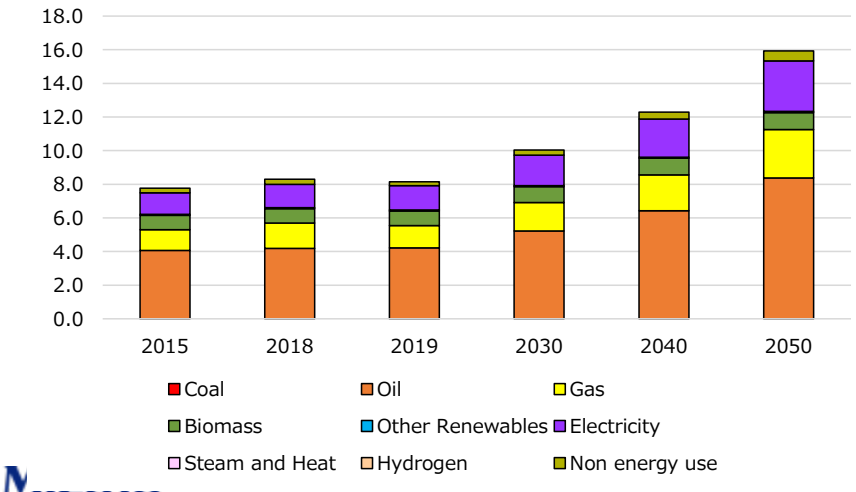


Preliminary Results in Energy Consumption

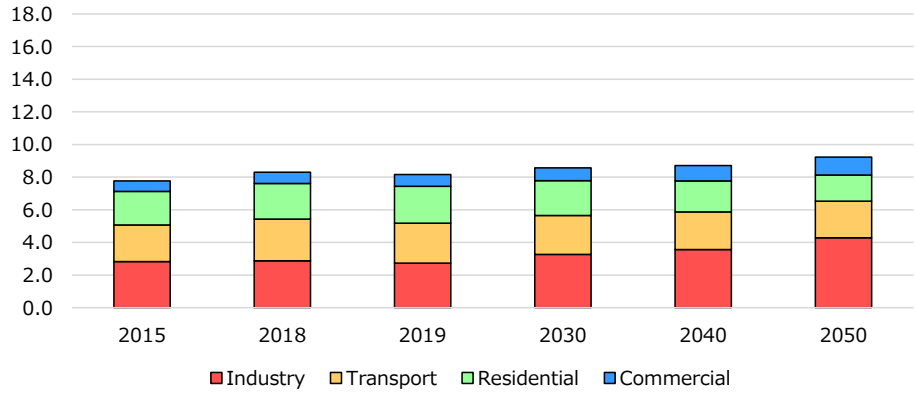
- The estimated emission of TFC in the technology fixed case shows 16 Mtoe in 2050 while the countermeasure cases are down 42% to 9.2 Mtoe compared to that of the technology fixation. As the countermeasure case, electrification (36% share) and hydrogenation (16% share) is likely to advance significantly.

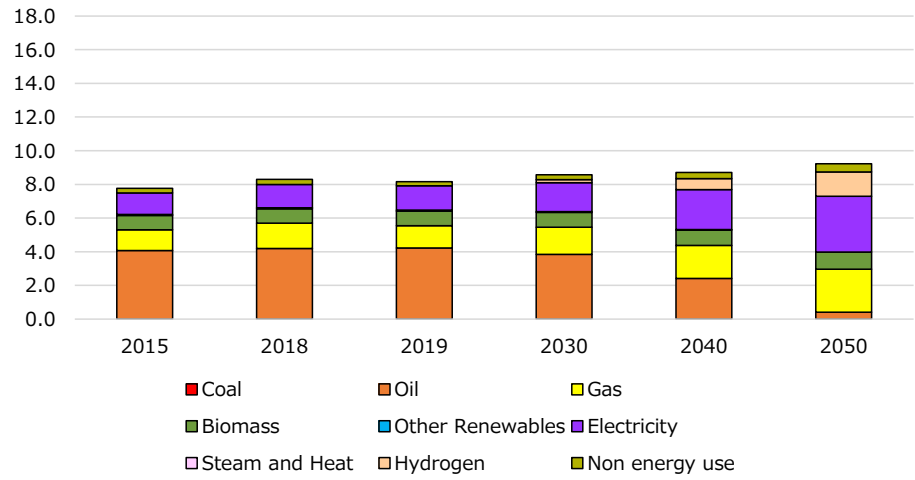
Final Energy Consumption in Technology Fixed [Mtoe]





Final Energy Consumption in Countermusure -90% [Mtoe]

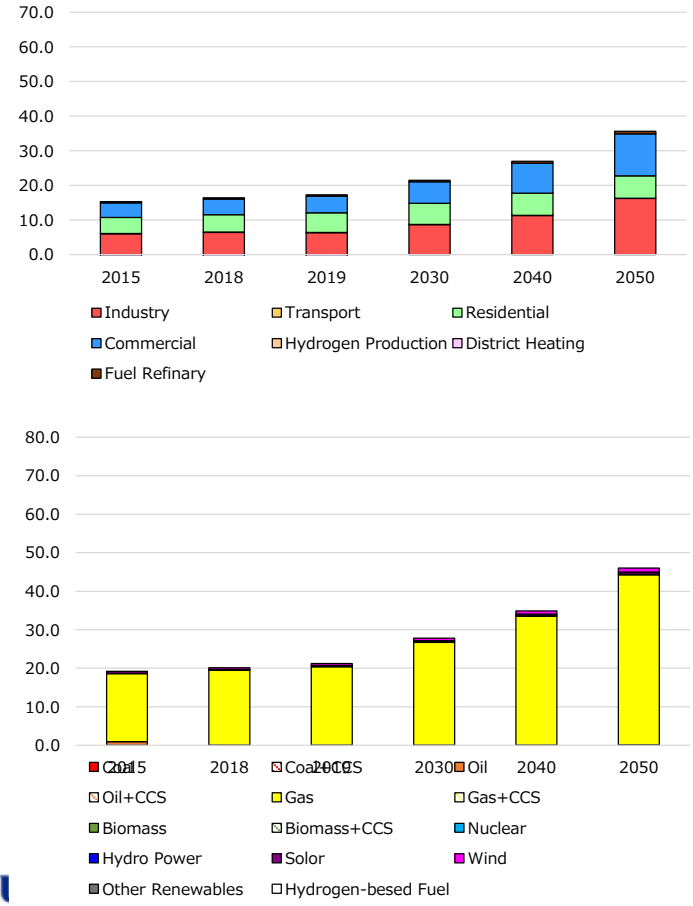




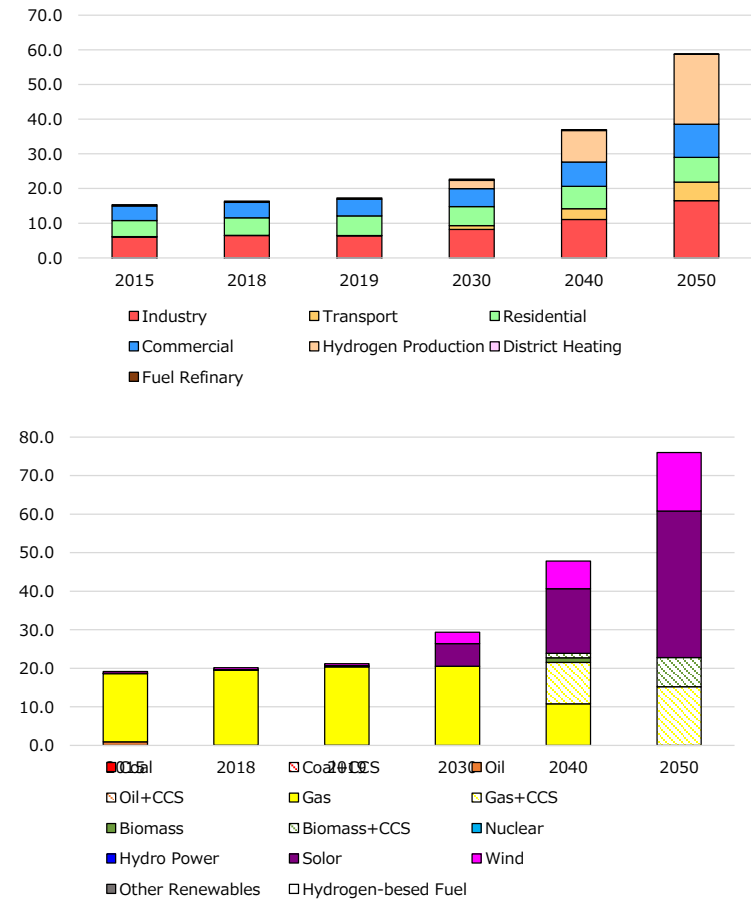
Preliminary Results in Electricity Demand and Generation

- While the Technology-fixed scenario will generate 46 TWh of electricity in 2050, the countermeasure case will increase to 76 TWh through electrification plus decarbonization of electricity (solar + wind + thermal power with CCS).
- Among the electricity demand, both for Transportation Sector and for Hydrogen Production will increase in the countermeasure case.

Power Demand (top) and Electricity Power Generation (bottom) in Technology Fixed [TWh]



Power Demand (top) and Electricity Power Generation (bottom) in Countermusure -90% [TWh]

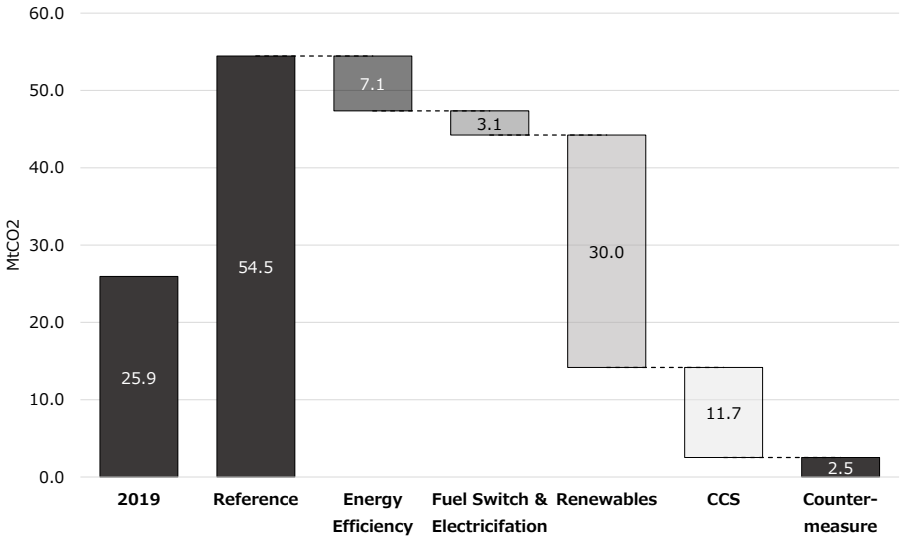


Preliminary Result in Reduction Contribution Analysis

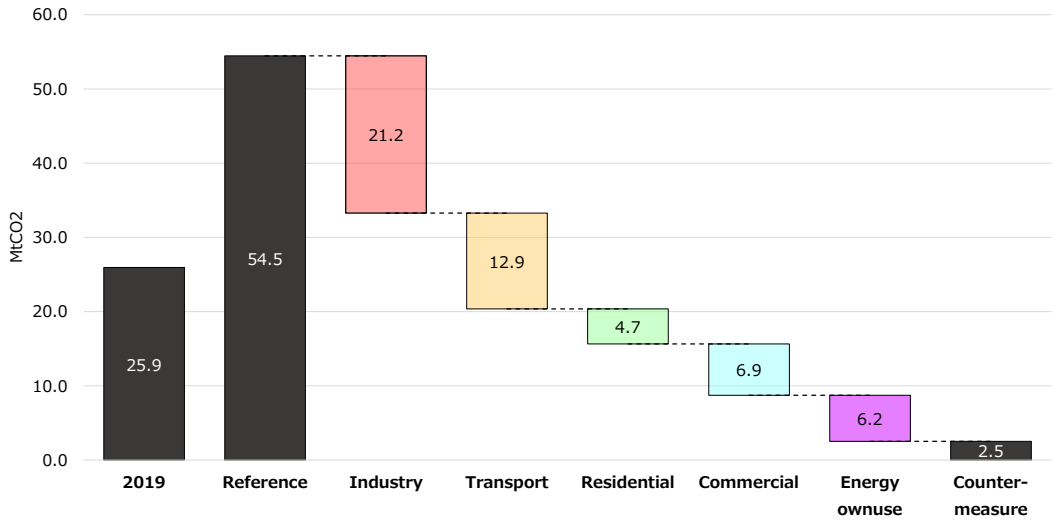
Discussion Purpose Only

- The amount of emission reduction in the countermeasure case is 52.2MtCO2. Of this amount, 30.4MtCO2 will be contributed by the introduction of renewable energy for electricity and hydrogen production using it.
- Looking at each sector, the industrial sector and the transportation sector will contribute greatly to the reduction, and these two sectors will contribute to about two-thirds of the total reduction.
- **<u>These reduction contribution analysis by each country can identify which kind of sector or technologies could have the large market potentials in the country.</u>**

Reduction Contributions by mesure



Reduction Contributions by sector

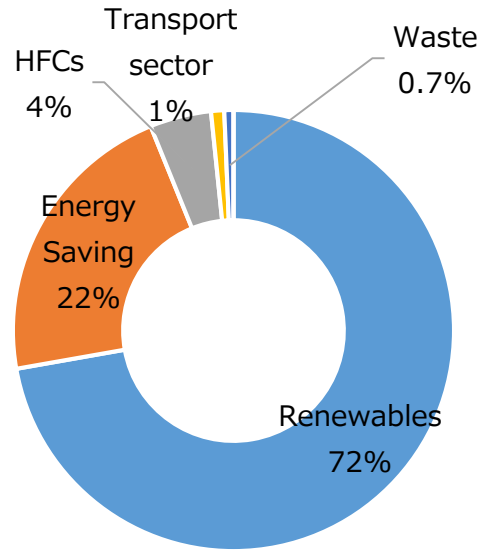


Conclusion and Indication for Promoting JCM Activity

- These reduction contribution analysis by each country can identify which kind of sector or technologies could have the large market potentials in the country.
- Quantitative analysis using energy model is useful to conduct those kind of analysis. Model analyisis can show a variety of set of “Condition” and its “Result”.

- According to the data of achivement of Japan’s JCM, the large share of reduced CO2 is occupied by installing renewables.
- From the view point of promoting JCM activity, this preliminary model analysis shows the variable reduction potentials not only by renewables, but also by fuel switch, electrification, shift to hydrogen ,CCUS and so on. It is effective to expand the scope of JCM Toward 2050.
- We are continuously on this model research and expanding the taget African countries.

Achievement JCM of Japan (2020)
Share of Reduced CO2 emissions by measure



Source: Data from Ministry of Environment, Japan (2021)

Supplemental Materials

Industrial Process, AFOLU and Waste Sectors in NDC

Industrial Process Sector

- Mitigation measures in the Industrial Process Sector mainly targets N_2O from Cement Production, HFCs and Nitrate Plants. These three sectors account for 87% of the total industrial process sector.
- Such the actions as the launch of an emissions mitigation initiative for the cement sector, the start of carbon pricing, catalytic N_2O degradation projects, and HFCs reuse projects are anticipated.
- For the sake of these measures, the emission of the Industrial Process Sector will be 7.2 Mt-CO2 e in 2030, which is 13% minus in a comparison with that of BaU.

AFOLU Sector

- The main mitigation measures in the AFOLU Sector target biomass and soil carbon sequestration.
- It is also anticipated to include actions more enhanced fire response plans, composting poultry manure and reducing intestinal fermentation in livestock.
- The net additional absorption from the BaU scenario under the BaC scenario as of 2030 showed to be 2.5 MtCO2 e. The whole reduction over the sectors amounted to 9 Mt-CO2e, of which 35% resulted in the mitigation measures and 65% in the absorption measures.

Waste Sector

- Measures for the Waste Sector assumes to manage upstream waste and enhance more proper sorting waste materials.
- The reduction under the BaC scenario between 2021 and 2030 will be 5.5 Mt-CO2 e, 92% of which the Solid Waste Measures derive.

Source:Republic of Tunisia, Updates Nationally Determined Contribution (NDC) (2021)

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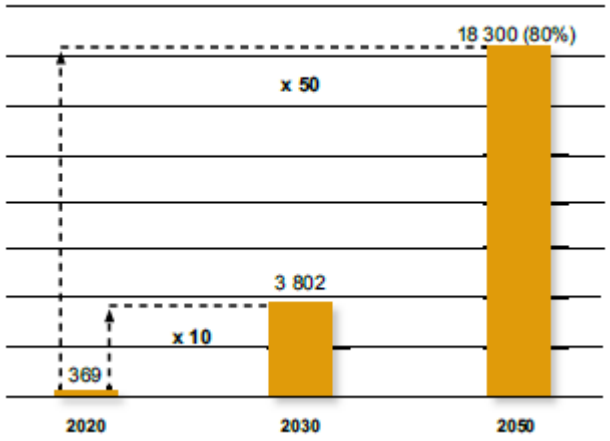
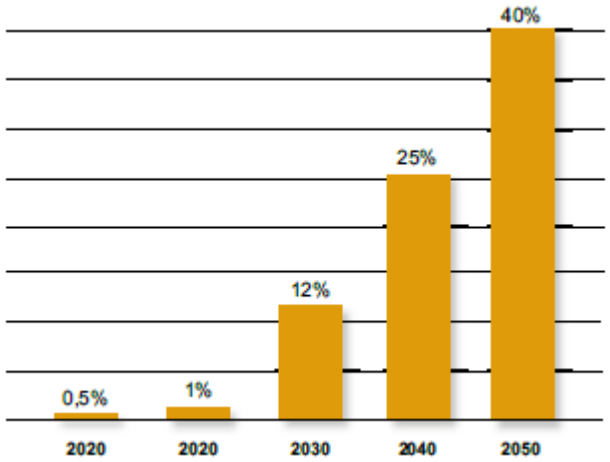
Low-carbon National Strategies: Energy Sector

- By increasing the facility capacity with renewable energy from as little as 370 MW in 2020 to 18 GW in 2050, it is expected to account for 80% of electricity generation.
- With significant adoption of renewable energy, itwill lead to increase in use of end-use solar water heaters and conversion to alternative fuels in the cement sector, increasing the renewable contribution of the primary energy mix from 1% at a present time to 11% in 2030 and 40% in 2050.
- Electrification in End-use: Increase from 20% of the final energy mix in 2020 to 25% in 2030 and 43% in 2050.

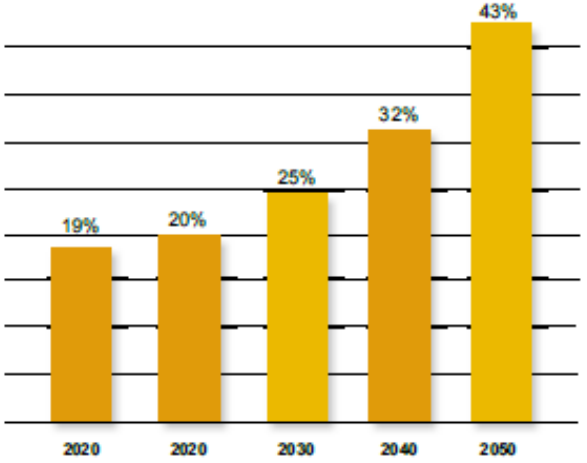
Renewables Facility Capacity (MW)



Share of Renewables in Primary Energy Mix



Share of Electricity in Final Consumption

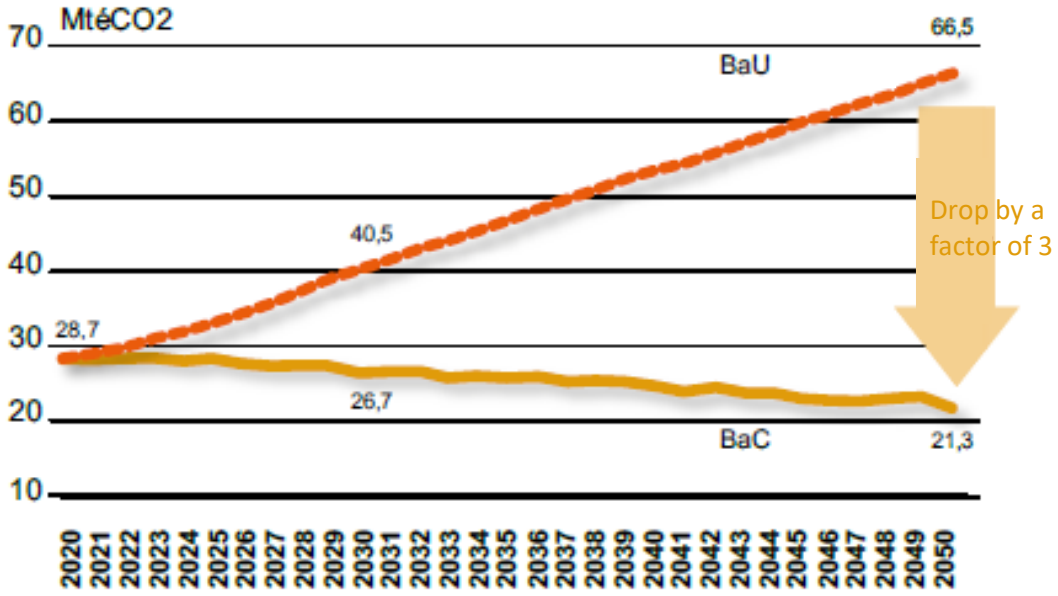


Source:Ministère de l'Environnement, Stratégie de neutralité carbone et de résilience au changement climatique à l'horizon 2050 (2022)

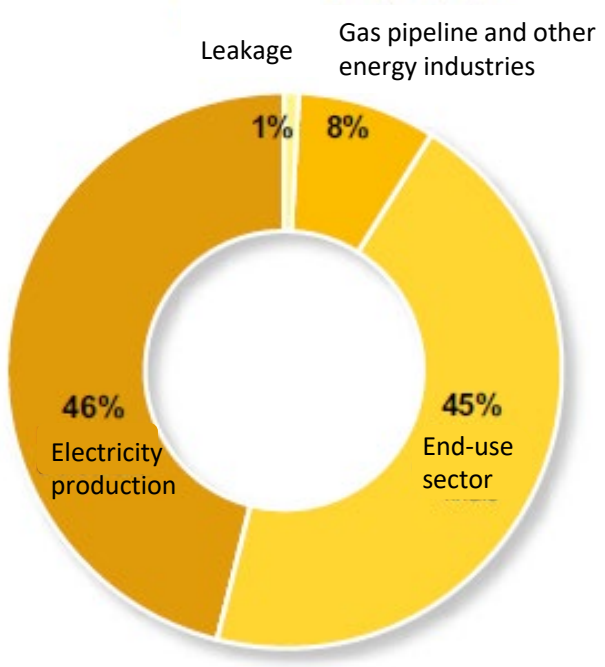
Low-carbon National Strategies: Emissions reductions in Energy Sector

- Emissions as of 2050 in the Energy Sector demonstrate to be 66 Mt-CO2 e under the BaU scenario while 21 Mt-CO2 e under the BaC scenario.
- Emission reductions in the Energy Sector will take place mainly in the power generation sector (46%), followed by the Final Consumption Sector (45%). Leakage and other emissions account for the majority of the remaining 9%.

Emission Path in the Energy Sector



Source breakdown in cumulative reductions from 2021 to 2050



Source:Ministère de l'Environnement, Stratégie de neutralité carbone et de résilience au changement climatique à l'horizon 2050 (2022)

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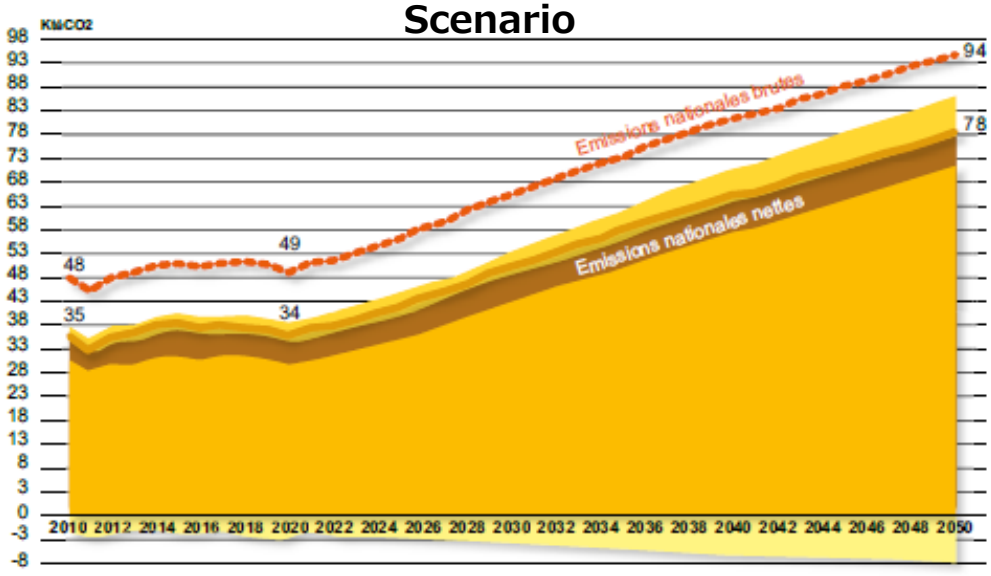
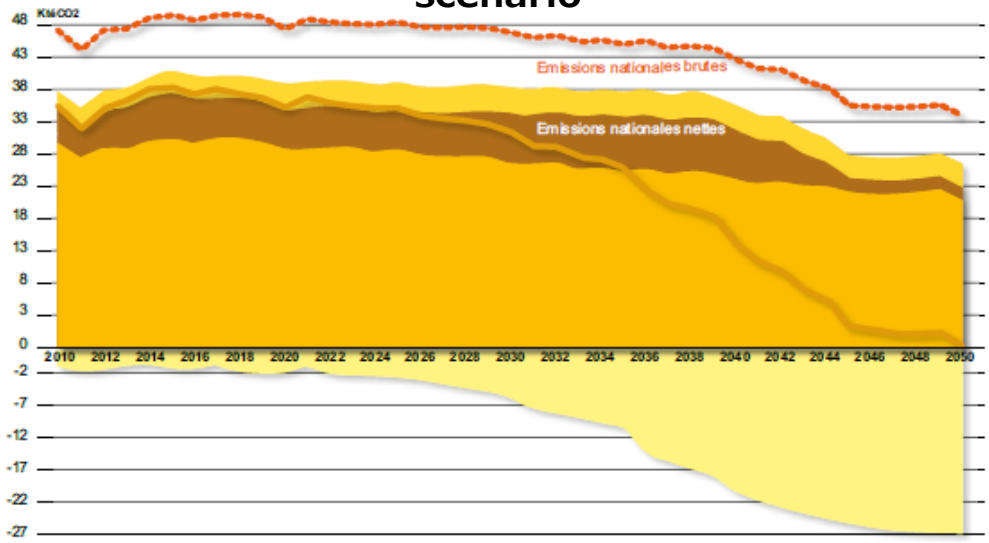
Scenario Analysis: Summary

- In the draft proposal on long-term strategy, two BaU (Expectant) and BaC (Measures) scenarios have been analyzed; however, the breakdown by industry type and by energy type is unclear.
- Therefore, using the AIM/ESS model, which is an accounting-type model of energy supply and demand, a detailed estimation analysis of emissions was conducted for the following 2 cases up to 2050: the Technology-fixed scenario (fixed in 2019) and the Countermeasure scenario.
- "The Countermeasure Scenario" was set as a scenario under assumption in which emissions of combustion-derived CO2 would be significantly reduced compared to the draft proposal for long-term strategy, and which reduction reach as much as 90% minus in a comparison with the level in 2019 by 2050.

GHG Emissions of All sectors under the BaU Scenario



GHG Emissions of All sectors under the BaC scenario



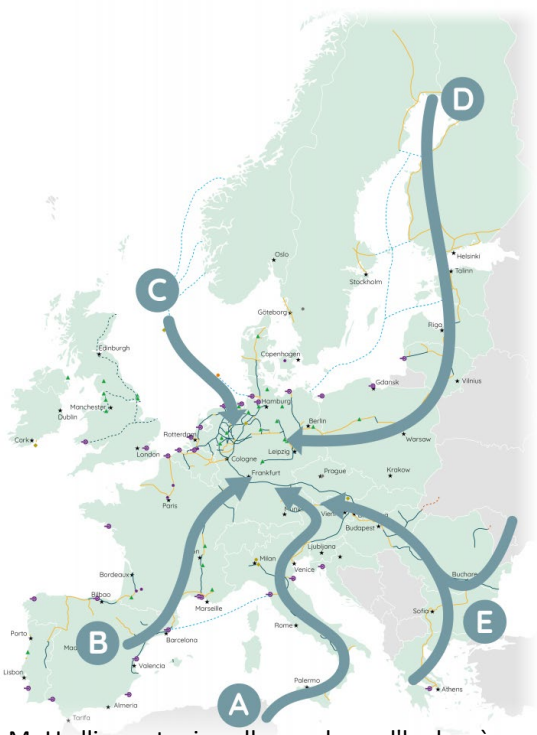
Total emission
Net emission
Waste
Industrial Process
Energy
AFOLU

Source:Ministère de l'Environnement, Stratégie de neutralité carbone et de résilience au changement climatique à l'horizon 2050 (2022)

Tunisia's Hydrogen Strategy: In the Alliance with European Countries

- In December 2020, Tunisia signed the Tunisia-German Alliance for Green Hydrogen, based on long-term cooperation with Germany in the energy sector. The alliance includes focusing on areas such as establishing test units for hydrogen production and building research as well as capacity. Germany will provide a 31 million euro subsidy to Tunisia.

- The European Hydrogen Backbone initiative plans to secure 5 European hydrogen procurement routes as of 2030. One of these projects, Corridor A, seeking the procurement of low-cost green hydrogen throught the existing pipeline, "Trans-Mediterranean Pipeline“, which connects Algeria, Tunisia and Italy.



Five hydrogen procurement routes in Europe

- **Corridor A**
  : North Africa & Southern Europe
- Corridor B
  : Southwest Europe & North Africa
- Corridor C
  : North Sea
- Corridor D
  : Nordic and Baltic regions
- Corridor E
  : East and South-East Europe

Source:Tunisia government, Signature MoU alliance tuniso-allemande sur l'hydrogène
European Hydrogen Backbone,Five hydrogen supply corridors for Europe in 2030 (2022)