Model ThreeMe Tunisia

Macroeconomic impacts of National Low-Carbon Strategy for a little country in development : the case of Tunisia

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1 Introduction

2 Literature review

2.1 Energy and economy framework in Tunisia (Jin)

Tunisia is one of the northernmost countries in Africa, ranked the most competitive economy in Africa by World Economy Forum in 2009 [17]. The local economy is largely oriented towards services, which account for 43% of GDP in 2019 [4], including the booming IT and tourism industries. Agriculture is another key sector of the Tunisian economy, representing 10.4% of the GDP and employing 12.7% of the working population [4]. Thanks to technical progress of agricultural sector, Tunisia is one of the most productive countries in Africa. Tunisia's industry represents 22.7% of GDP and employs 32.5% of the working population in 2020 [5]. The industrial sectors are mainly export oriented especially for manufacturing, Europe is the destination for more than 75% of Tunisia's exports [4].

Since the Jasmine Revolution on 2011, Tunisia economy has been suffered from the extended recession. The sanitary crisis on 2020 has worsened the already precarious situation. Actually, even before COVID-19 Tunisia's capacity for economic resilience had been drained by years of indecisive public policy-making and growing protectionism [3]. In early September 2020, the Tunisian parliament finally reversed a government of Tenchnocrats in an attempt to remedy the country's economic situation [5].

Along with the sluggish economy is the huge energy deficit in Tunisia. IRENA [11] reported that energy deficit (50% in 2019) has existed in Tunisia over the past two decades, mainly because of the increasing consumption but with the stagnated even declined domestic production in recent years. GIZ [9] reported that Tunisia depends for 60% on energy imports, and this number is continuously raising. The energy transition project proclaimed in 2014 aims to reduce energy needs by 34% by 2030, lower subsidies and establish incentive mechanisms favoring profitable and climate friendly investments. However, the challenging is the lack of reliable institutional mechanisms and motivation for enterprises to participate, accompanied with a poorly established service market and weak transmission of knowledge to citizens, especially outside urban area.

2.2 Climate policy

2.2.1 Carbon tax (Jin)

2.2.2 Energetic subsidy (Bee)

Subsidies are defined by Moor and Calamai [15] as *'any measure that keeps prices for consumers below the market level or keeps prices for producers above the market level or that reduces costs for consumers and producers by giving direct or indirect support'*. Energy subsidies are a common policy. Their amount is estimated at $4.7 trillion in 2015 as pointed out Coady et al. [8], which is equivalent to 6.3 percent of Gross Domestic Product . Energy subsidies fluctuate depending on the price of the energy products. From the database of the International Energy Agency, we can notice that the fossil fuel subsidies have fallen by 42 percent between 2019 and 2020 due to the drop of fuel prices.

The energy subsidies are very present in the Middle East, North Africa, Afghanistan and Pakistan region (MENAP). According to Coady et al. [8], MENAP is the fourth region in absolute terms, which subsidized the most energy in 2015. Nevertheless, in relative terms, MENAP is the second, if we take into account the percent of its GDP. The prevalence of energy subsidies in MENAP can be explained by post-par period. Verme [18] explain that theses energy subsidies were introduced in Middle East and North Africa region (MENA) in order to stabilize prices after the decolonization. These stabilization mechanisms became a social protection system.

2.2.3 Recycle of gouvernment income for tax (Lucia)

According to **goulder**, tax redistribution is the mechanism that allows the government to return to the private economy the revenues that are produced by the instrument. There are many ways in which this redistribution can operate. It can be presented as a lump-sum transfer to households and firms, or as a reduction of taxes that introduce a deformation into the economy as is the case of the labor tax.

3 Methodology

3.1 ThreeME model (Bee)

The ThreeME model is a hybrid neo-Keynesian Computable General Equilibrium model (1), which had to be adaptated and calibrated on Tunisian data (2).

3.1.1 A hybrid neo-Keynesian Computable General Equilibrium model

The open source ThreeME model has been developped since 2008 by OFCE (French Economic Observatory), ADEME (French Environment and Energy Management Agency) and NEO (Netherlands Economic Observatory). ThreeME is a Computable General Equilibrium Model (CGEM), with neo-Keynesian features and a hybrid structure.

ThreeME combines several features [6, 7] :

- ThreeME is a Computable General Equilibrium Model (CGEM), which takes into account the interactions and feedbacks between supply and demand (see Fig.X). Demand defines supply and in return, supply determines demand through the production factor incomes.

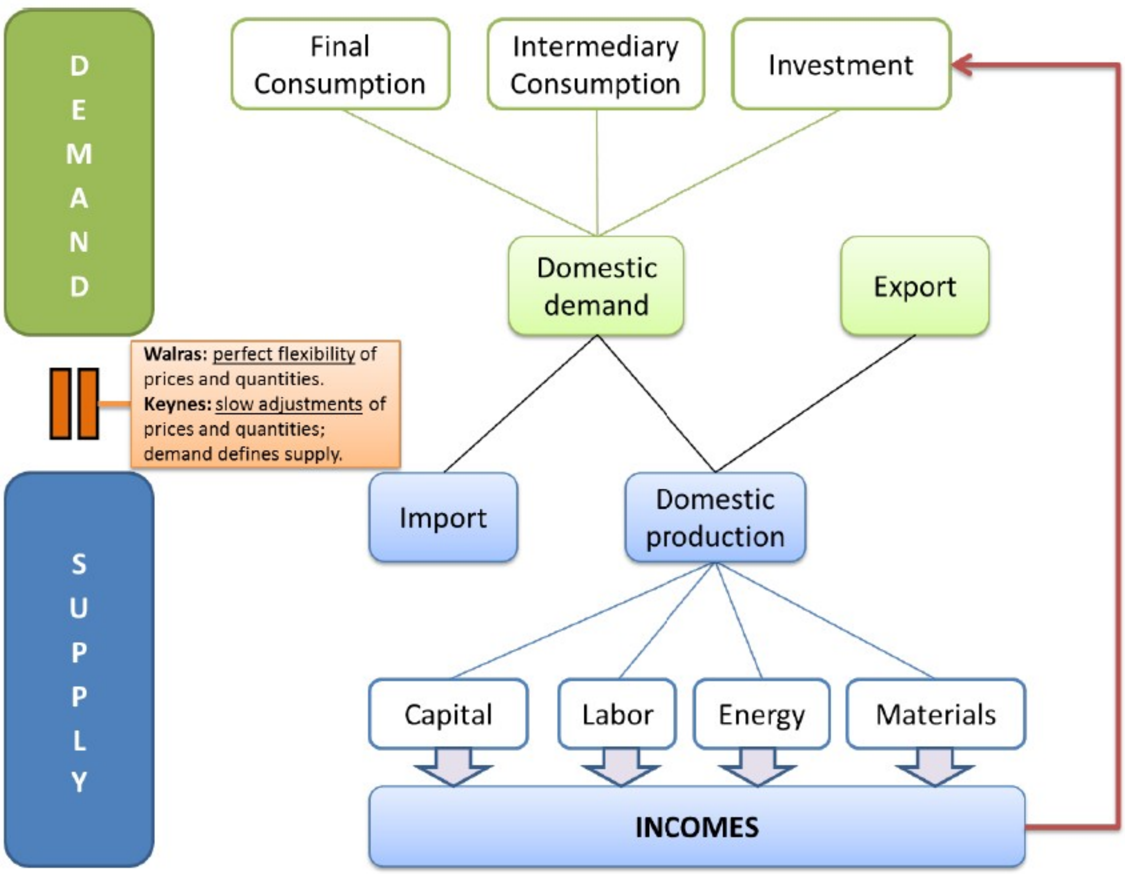


Fig.X : Architecture of CGEM (source : Callonnec et al. [6])

- ThreeME is a CGEM of neo-Keynesian inspiration. ThreeME differs from Walrasian CGEM in its dynamics and its transition to the long run. Instead of perfect flexibility hypothesis, prices and quantities slowly adjust, because of uncertainties, adjustment costs or temporal boundaries. Prices do not clear supply and demands and market imperfections are also included in the model. Consequently, there are disequilibrium between supply and demand. For instance, involuntary unemployment is possible.

- The high sectoral disaggregation is a way to describe the transfers of activity from a sector to another. The ThreeME model allows to track sectoral changes in investment, employment or energy consumption.
- ThreeME is a hybrid model which combines top-down and bottom-up modelling. On one side, the general equilibrium effets are represented. On the other side, the energy disaggregation allows for the analysis of the energy production and consumption. The trade-offs between energy and other production factors and between several energy consumptions are included in the model.

3.1.2 ThreeMe model Tunisia : Adaptation for a little country in development

ThreeME has already been adapted to Mexico by Landa Rivera et al. [14] and to Indonesia by Reynes and Malliet [16]. The adaptation of ThreeME to Tunisia has been founded on consultation with Tunisian experts and other stakeholders. Indeed, the sectoral disaggregation was validated by Tunisian stakeholders. At the end, 21 sectors and 18 products were chosen (see Fig.X). The tax structure is based on the supply and use table (SUT) of the national accounts.

Sectors			Commodities		
Industry	Agriculture and fishing	sagr	**Industry**	Products of agriculture, Hunting, and Fishing	cagr
	Manufacture of food products and beverages	sfoo		Food products and beverages	cfoo
	Manufacture of textile, clothing and leather	stex		Textile, clothing and leather	ctex
	Manufacture of motor vehicles, trailers and electric products	sveh		Motor vehicles, trailers and semi-trailers	cveh
	Manufacture of glass, ceramic and ciment products	sgla		Glass and ceramic products	cgla
	Manufacture of chemicals	sche		Chemicals	cche
	Manufacture of other goods	sogo		others goods	cogo
	Construction of buildings and Civil engineering	scon		Buildings and Civil engineering	ccon
Transport	Rail transport	srai	**Transport**	Rail transport	crai
	Road transport	sroa		Road transport	croa
	Air transport	sair		Air transport	cair
Services	Business services	spri	**Services**	Business services	cpri
	Public services	spub		Public services	cpub
Energy	Oil and natural gas extraction	sext	**Energy**	Crude oil	coil
	Production of refined oil	soil		Transport fuels	cfut
	Distribution of natural gas	sgas		Heating fuel	cfuh
	Transmission and distribution of electricity	setd		Natural gas	cgas
	Gas-fired electricity generation	sega		Electricity	cele
	Wind electricity generation	sewi			
	Solar electricity generation	seso			
	Electricity - Others	seot			

Fig.X : Sectoral disaggregation

The required data are economic data from national accounts, in particular from Input-Output Tables (IOTs), physical data from energy balance and detailed tax data by product. These data were collected from Tunisian institutions, in particular ANME (National Agency for Energy Management), INS (National Institute of statistics), ONE (National Energy Observatory), STEG (Tunisian Company of Electricity and Gas), ITCEQ (Tunisian Institute of Competitiveness and Quantitative Studies), Ministry of Energy, Mines and Energy Transition and the Ministry of Economic Development, Investment and International Cooperation.

3.2 Description of scenario (Lucia)

with/without redistribution? *Voir si peut être on déplace cette partie

We work on six different scenarios that simulate the implementation of six alternative environmental policies.

Scenario 1 : Implementation of a carbon tax from 2021 without redistribution of the revenues of the tax in the economy - they are used to reduce public debt.

Scenario 2 : Carbon tax with recycling of revenues that are redirected to the Energy Transition Fund. In fact, a part is given back to households and a portion is devoted to “non-polluting” businesses.

Scenario 3 : Fossil fuels subsidies removal (without recycling).

Scenario 4 : Fossil fuels subsidies removal (with recycling). A part is given back to households and a portion is given to enterprises in proportion to the employment of each sector in the total salaried labor force.

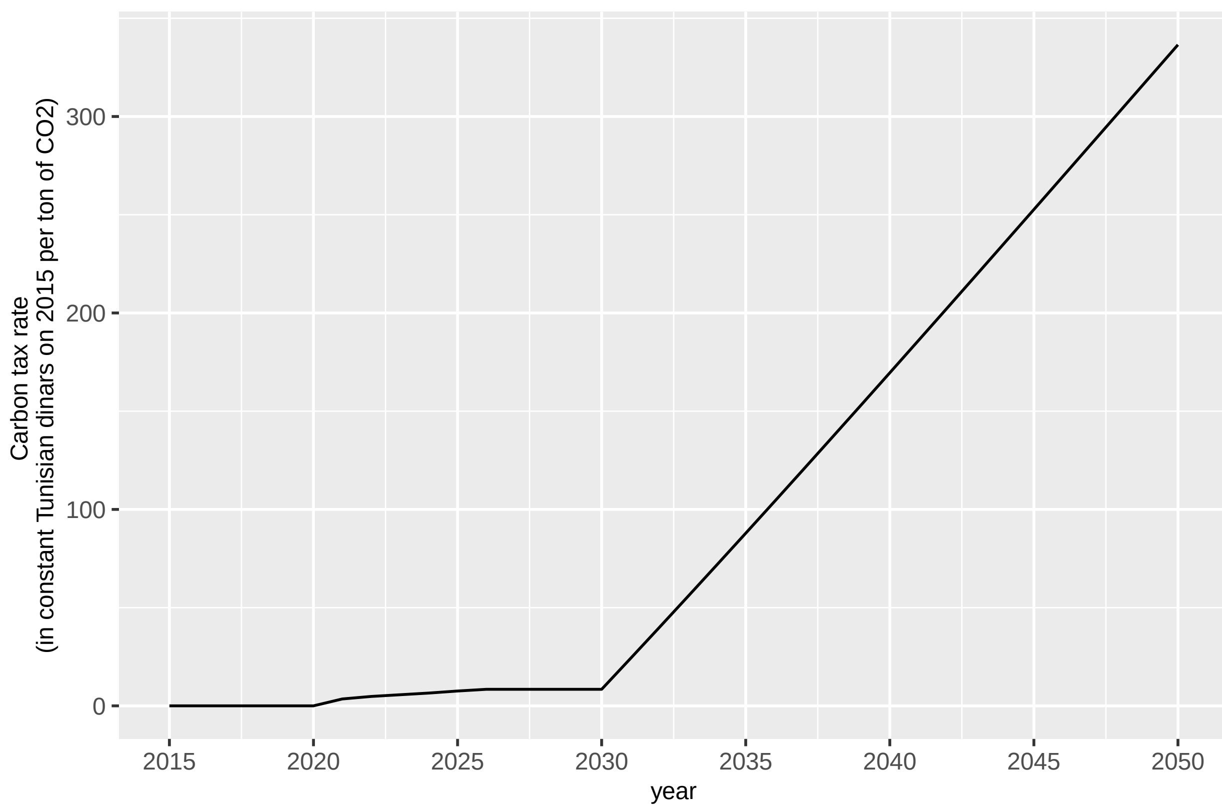
Scenario 5 : Significant penetration of Renewable Energies in the electrical mix (80% by 2050)

Scenario 6 : Combination of scenarios 2, 4 and 5.

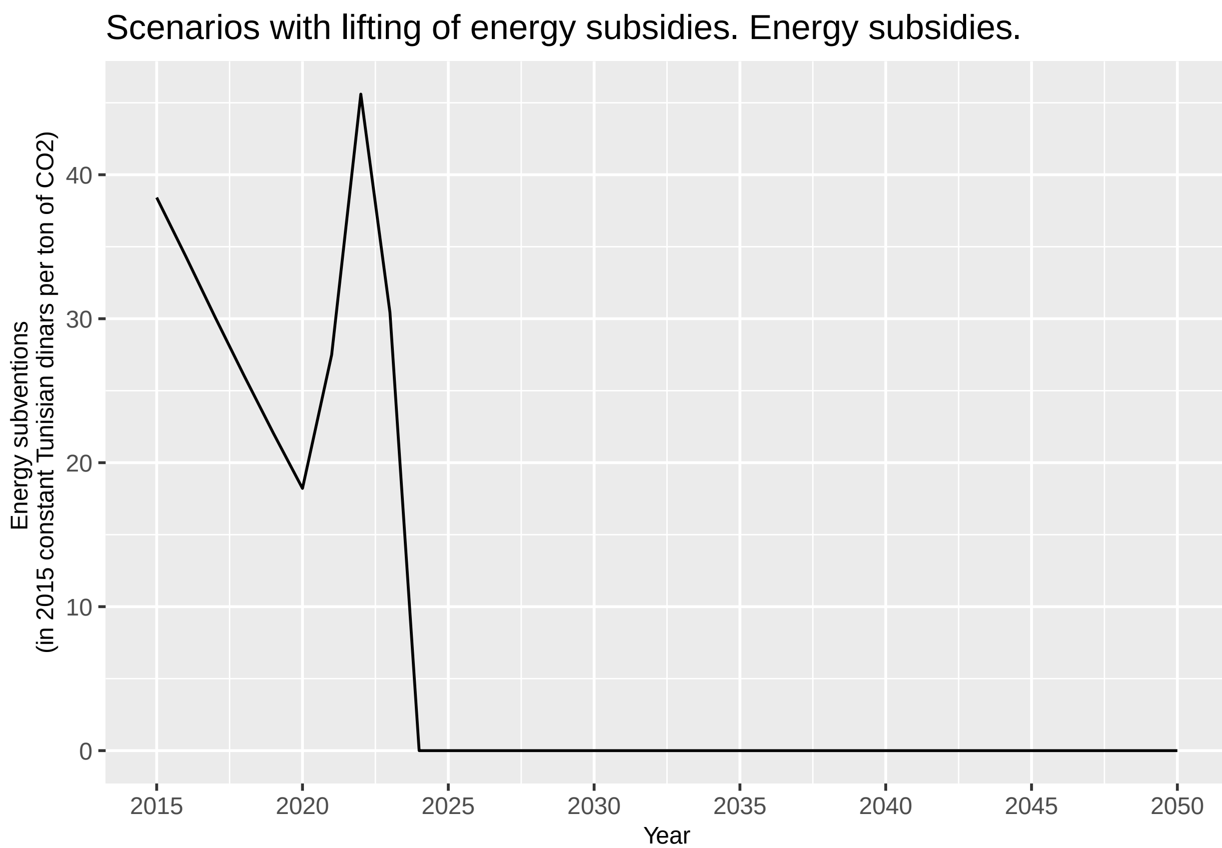
3.2.1 Tax carbone

Avant 2030, le niveau de la TC est calculé de façon a couvrir 100% des besoins du FTE Il passe de 1.1 à 9 DT/tCO2 Après 2030, la trajectoire de la TC est définie de façon à atteindre les objectifs de réduction d’émission à 2050 D’après les hypothèse des substitutions retenues dans ThreeME, l’atteinte d’un factor 5 en 2050 par rapport au niveau de 2020 nécessite une hause régulière de 9 DT/tCO2 à 372 DT/ tCO2. En plus de la TC des signaux prix ont été introduits afin d’atteindre les objectifs de consommations d’énergie par source

Fig.X Evolution of carbon tax in Tunisia



3.2.2 Energy subsidy



3.2.3 ENR

3.2.4 SNBC

3.3 Choice of evaluation indicators

3.3.1 Data structure

All the indicators used in the analysis are in exact hat algebra, meaning the proportional variation to Baseline scenario. time scale of data key indicator: two dimensions economy and environnement

3.3.2 Kaya identity (Jin)

The Kaya identity, firstly proposed by [**kaya1989**], is an identity where the total emission of carbon dioxide can be explained by four product driving forces as population, Gross Domestic Product (GDP) per capita, enerny intensity over GDP and carbon intensity over energy consumption [13]. It is expressed in the form:

$$C = POP \cdot \frac{GDP}{POP} \cdot \frac{TEC}{GDP} \cdot \frac{C}{TEC} \tag{1}$$

where:

- POP is global population;
- GDP is gross domestic product;
- TEC is total energy consumption;
- C is total emission of carbon dioxide;

And:

- GDP/POP is GDP per capita describing the economical activities within a period;
- TEC/GDP is energy intensity;
- C/TEC is carbon intensity;

In this study, we introduced an extension of Kaya identity to explain how different driving forces influenced the total emission for different scenarios. Firstly, a extended Kaya identity is used to analysis CO_2 emission with the aggregated factors, then we couple with Logarithmic Mean Divisia Index (LMDI) method to decomposite CO_2 emission at the sectorial level.

We modified the function of Kaya identity mentioned above to adapt our model assumption, where we integrated a new driving force, named economy structure, to decomposite emissions driving force at sectorial level. The five economic sectors considered in ThreeME Tunisia model are: Industry and Agriculture, Service, Transportation, Energy Transformation and Electricity. However, we did not take population into consideration because its increasing rate remains still over time for all our scenarios and is considered as an exogenous variable in ThreeME model.

Therefore, the CO_2 emission can be written as:

$$C_{tot} = \Sigma C_i = \Sigma(VA \cdot \frac{VA_i}{VA} \cdot \frac{EC_i}{VA_i} \cdot \frac{CE_i}{EC_i}) = \Sigma(V \cdot S_i \cdot E_i \cdot I_i) \quad (2)$$

where $\mathrm{C_{tot}}$ is overall CO_2 emission, $\mathrm{C_i}$ is CO_2 emission of economic sector i, VA is total added value, $\mathrm{VA_i}$ is added value of sector i, $\mathrm{EC_i}$ is total energy consumption by sector i, $\mathrm{CE_i}$ is CO_2 emission arising from sector i. According to equation 8, total CO_2 emission can be explained by four driving forces, including one aggregated indicator, overall economic activities V, and three sectorial indicators, share of total added value of sector i $\mathrm{S_i}$, energy intensity over added value of sector i $\mathrm{E_i}$ and carbon intensity over energy consumption of sector i $\mathrm{I_i}$. Especially, $\mathrm{S_i}$ can be interpreted as economy structure of Tunisia, Grubb et al. [10] and Kanitkar, Banerjee, and Jayaraman [12] found that for a developing country, this term could be a key variable determining the future emissions pathway.

The effects of driving forces can be expressed in two ways: multiplicative and additive form, where multiplicative deviation D_{tot} is the ratio of total CO_2 emission between policy scenario and baseline scenario (equation 3), and additive deviation ΔC_{tot} is the difference of total CO_2 emission (equation 4). The two expressions are shown below:

$$D_{tot} = \frac{C_2}{C_0} = \Pi(\frac{V_2}{V_0} \cdot \frac{S_{2,i}}{S_{0,i}} \cdot \frac{E_{2,i}}{E_{0,i}} \cdot \frac{I_{2,i}}{I_{0,i}}) = D_V \cdot D_S \cdot D_E \cdot D_I = D_V \cdot \Pi(D_{S_i} \cdot D_{E_i} \cdot D_{I_i}) \quad (3)$$

$$\Delta C_{tot} = C_2 - C_0 = \Delta C_V + \Delta C_S + \Delta C_E + \Delta C_I = \Delta C_V + \Sigma(\Delta C_{S_i} + \Delta C_{E_i} + \Delta C_{I_i}) \quad (4)$$

where subscript *tot* represents overall change of emission, subscript 0 and 2 mean baseline scenario and policy scenario respectively. Hence we obtain the index D_V, D_S, D_E and D_I, meaning the deviation of emissions due to change of overall economic activities, economy structure, energy intensity and carbon intensity, while ΔC_V, ΔC_S, ΔC_E and ΔC_I depict the difference of emissions related to change of driving forces.

Now we expect to identify the effect of each driving force at a sectorial level, to do this, we used a LMDI method proposed by Ang and Choi [2] and Ang [1]. For multiplicative form, we have:

$$D_X = exp(\Sigma \frac{(C_{2,i} - C_{0,i})/(lnC_{2,i} - lnC_{0,i})}{(C_2 - C_0)/(lnC_2 - lnC_0)} \cdot ln\frac{X_{2,(i)}}{X_{0,(i)}}) \quad (11)$$

$$\Delta C_X = \Sigma(\frac{C_{2,i} - C_{0,i}}{lnC_{2,i} - lnC_{0,i}} \cdot ln\frac{X_{2,(i)}}{X_{0,(i)}}) \quad (12)$$

where C_2 is total emission of policy scenario, C_0 is total emission of baseline, $C_{2,i}$ is emission of policy scenario arising from sector i, $C_{0,i}$ is emission of baseline arising from sector i, D_X and ΔC_X represent multiplicative and additive index of driving force X, $X_{2,(i)}$ is value of driving force X of policy scenario for sector i, $X_{0,(i)}$ is value of driving force X of baseline for sector i.

4 Results et discussions

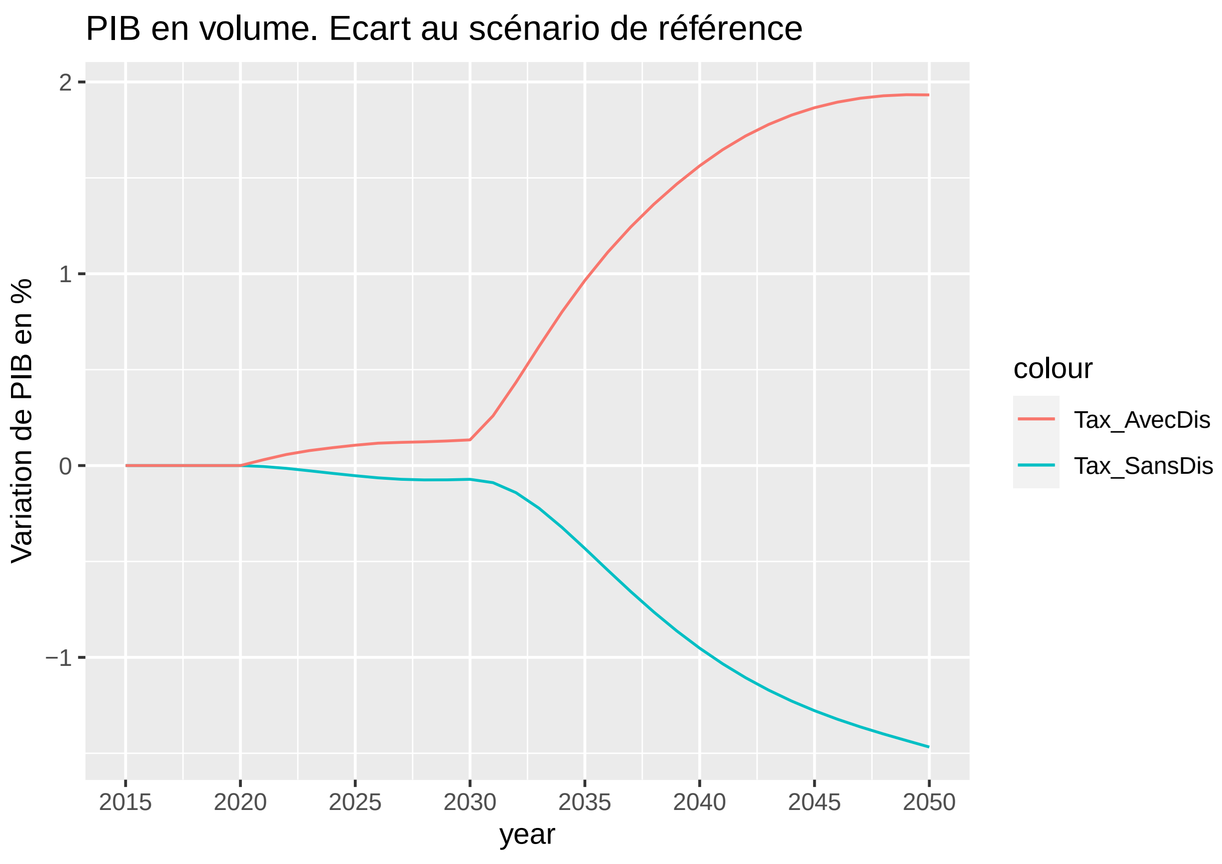
In this section we will analyse the results obtained for the different scenarios for the different variables took into account.

4.1 Importance of redistribution (lucia)

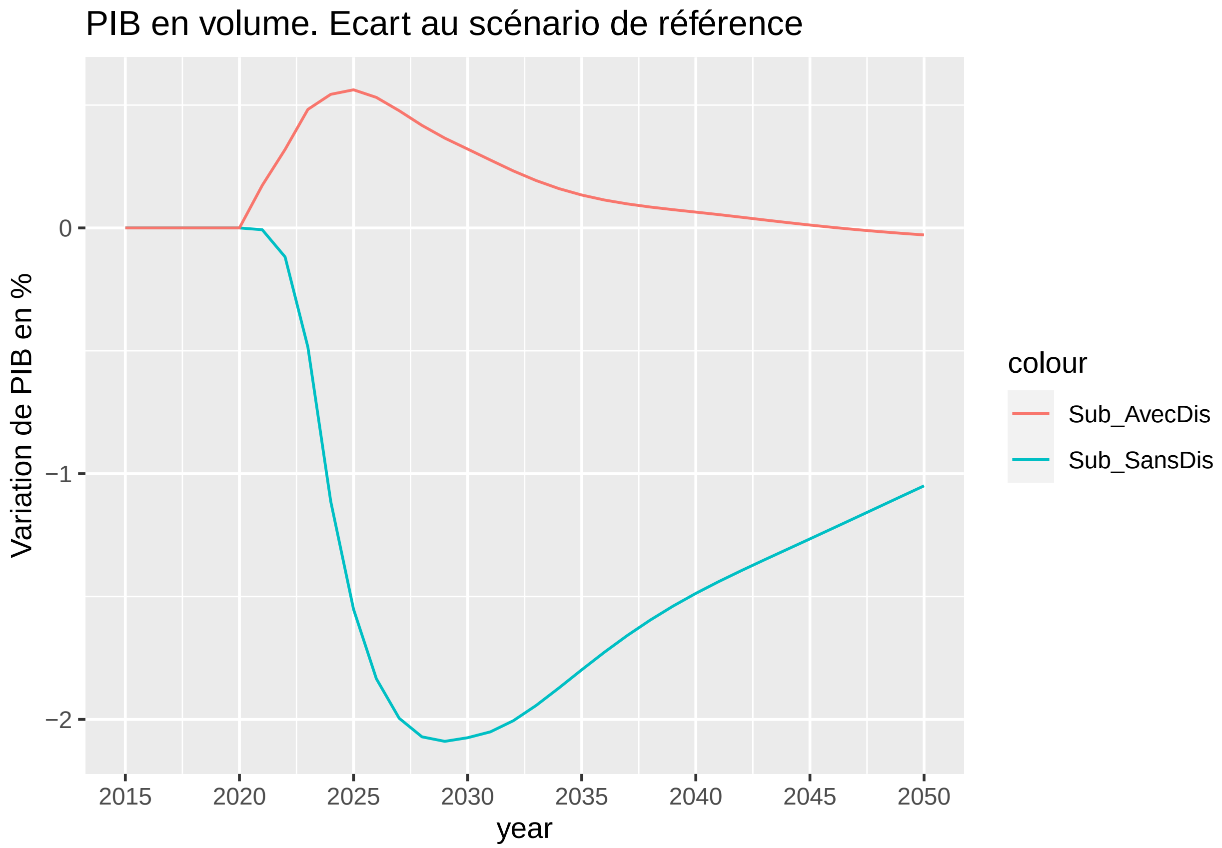
Firstly, we will analyse the influence of the redistribution of both the tax and of the removed energy subsidy. We will observe the impact of the redistribution on the economical and environmental aspects. For the economic aspect, we will take into account the GDP variation and the unemployment. For the environmental, we will analyse the evolution of emissions.

- graphique PIB :

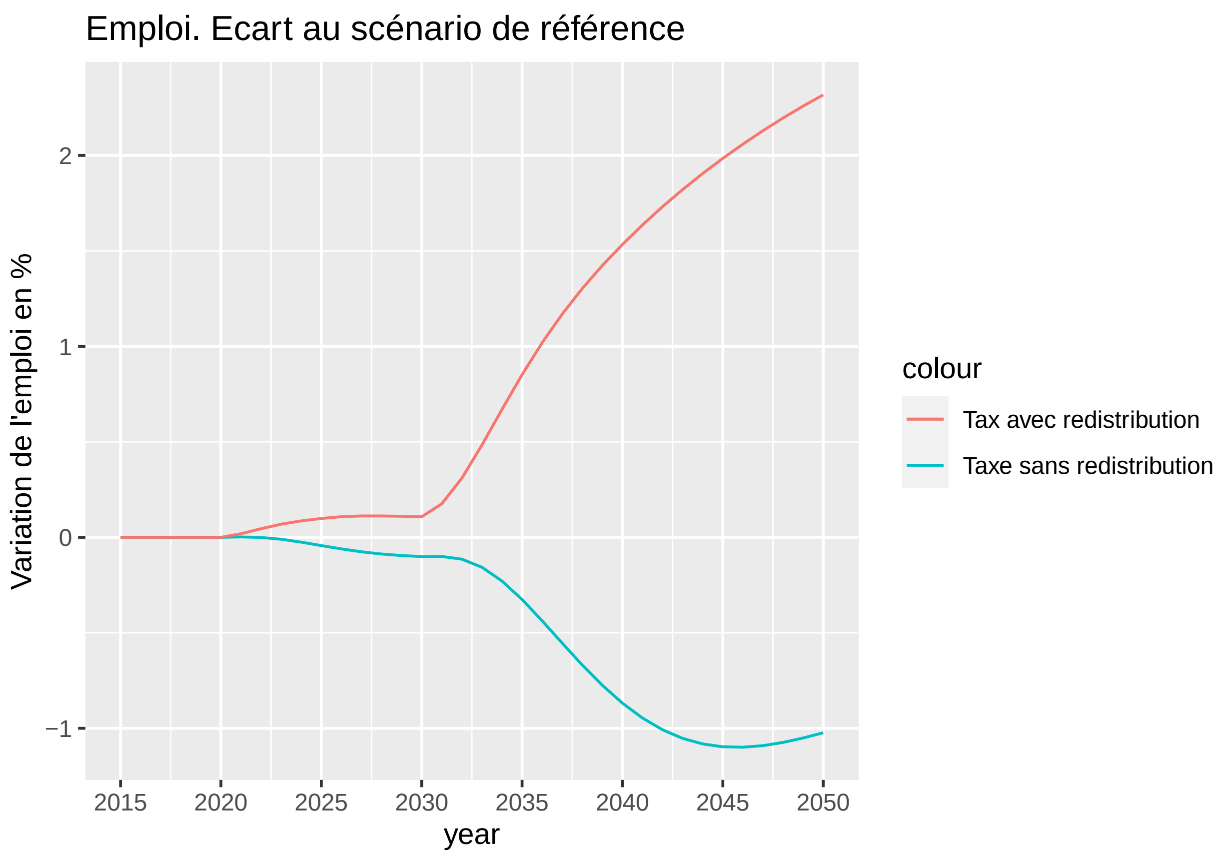
grandes tendances des scénarii Taxe carbone



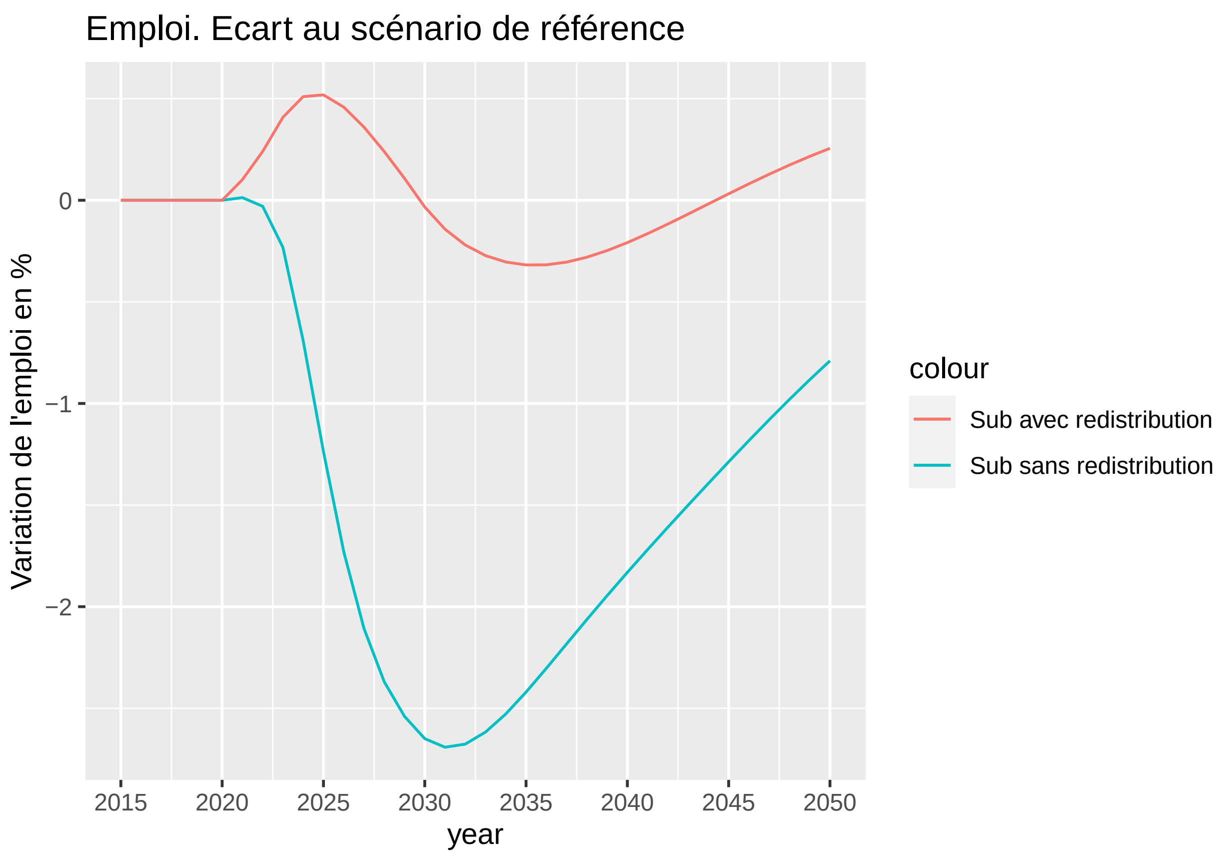
Levée des subventions énergétiques



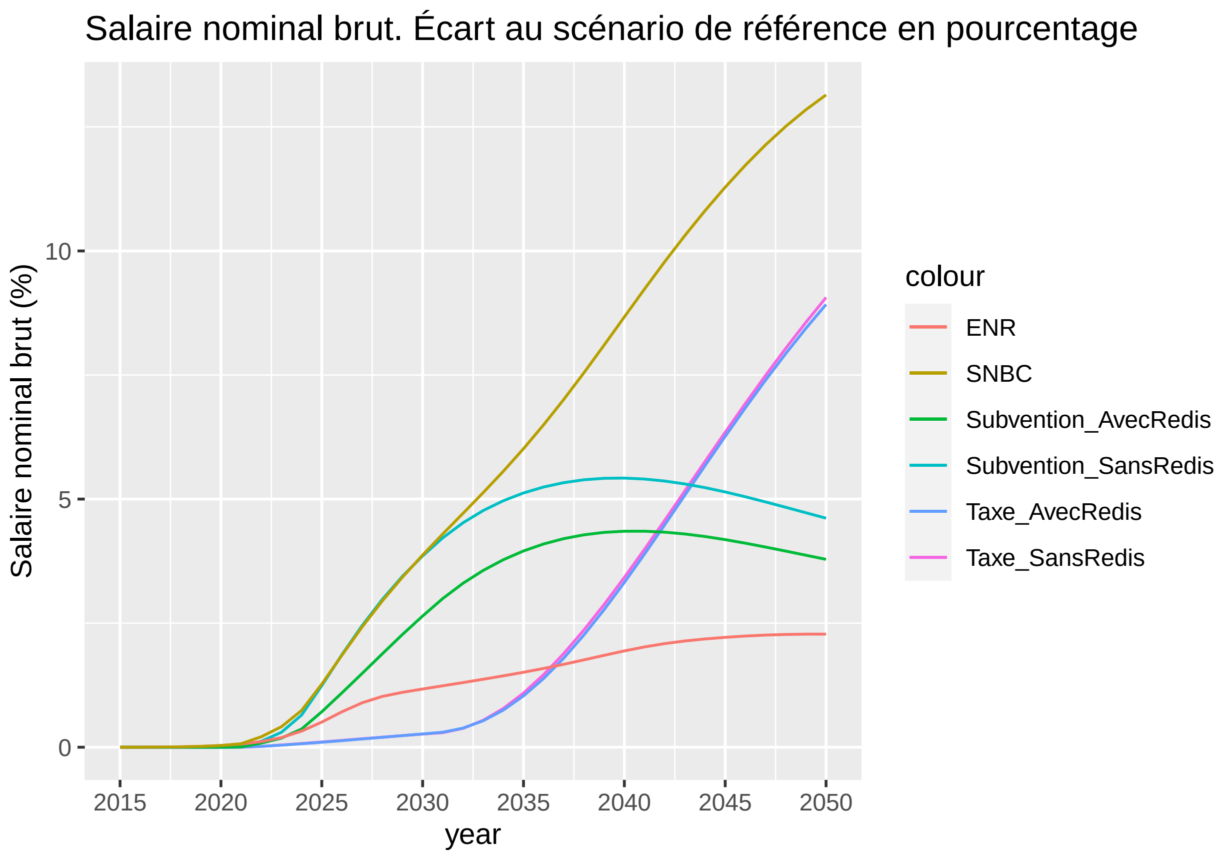
- chomage : grandes tendances des scénarii Taxe carbone



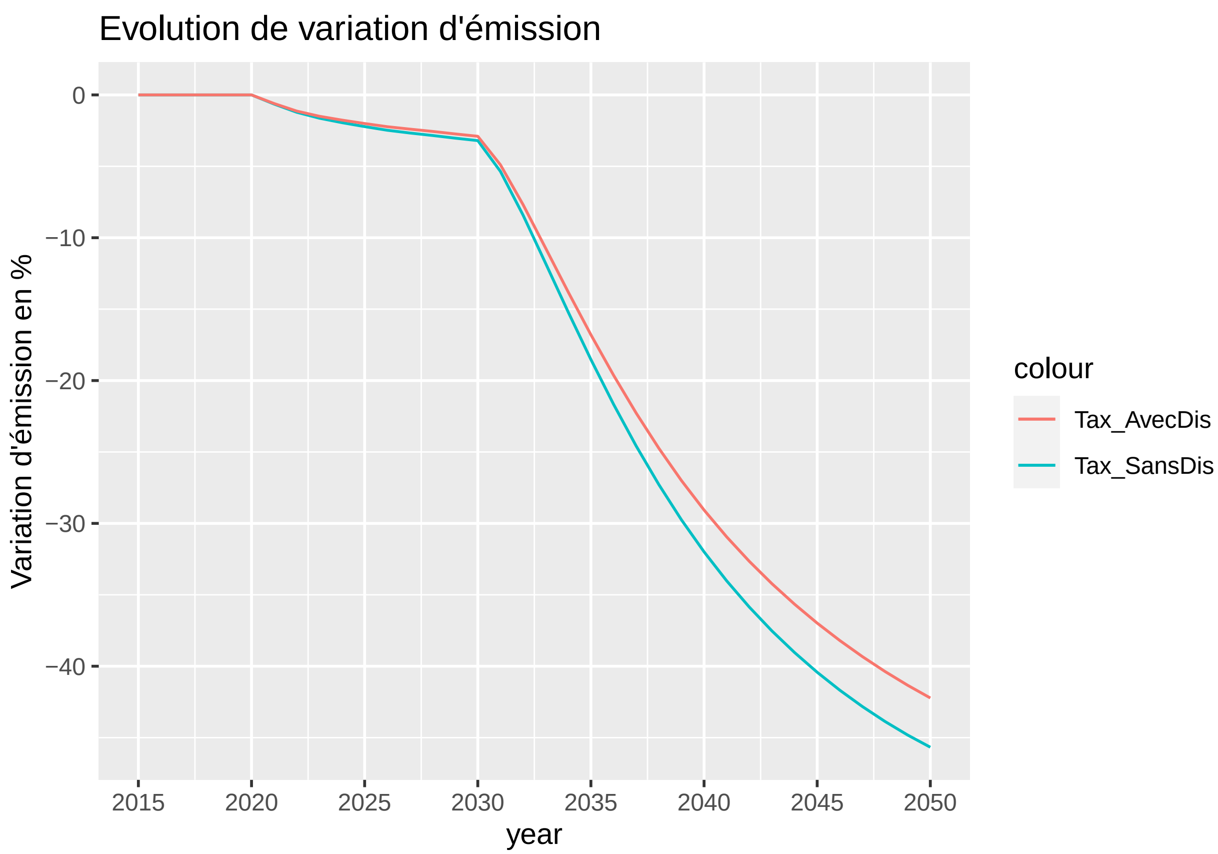
Levée des subventions énergétiques



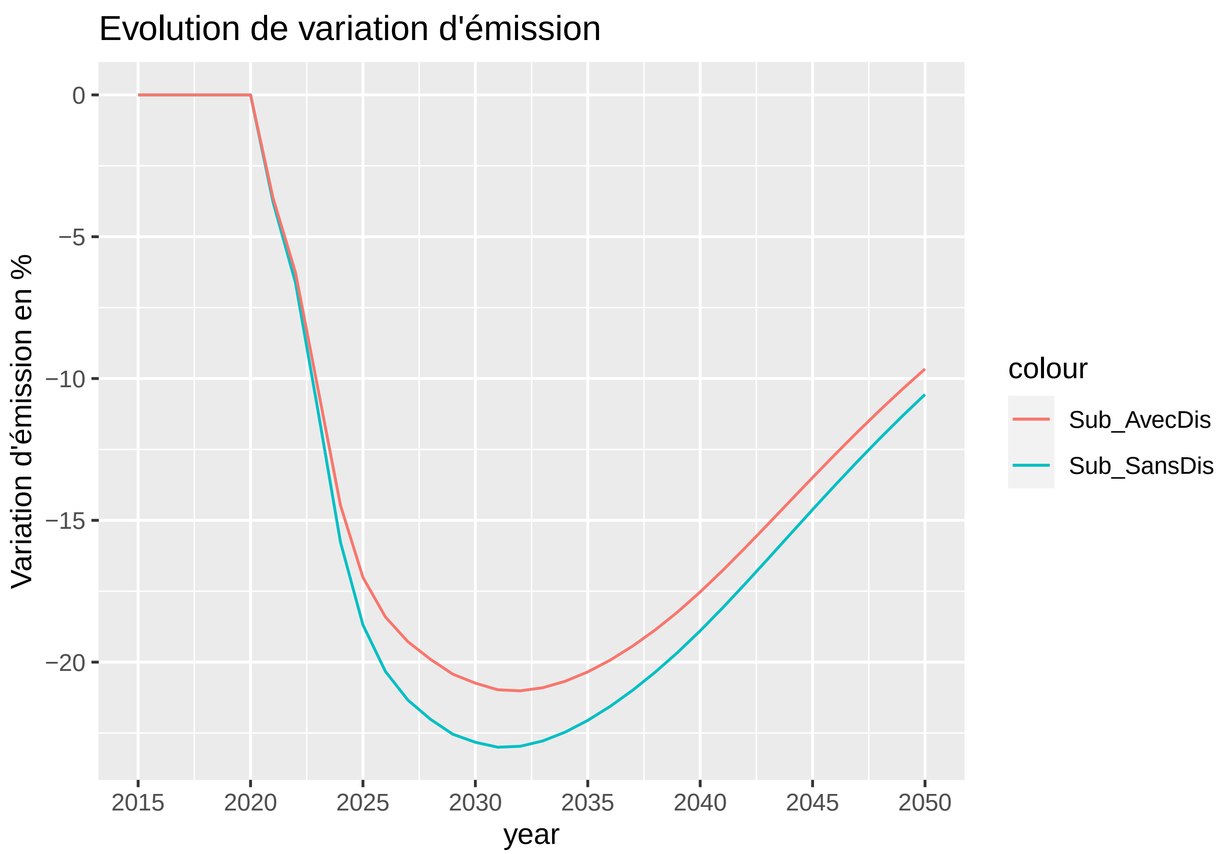
Il peut être intéressant de faire un commentaire sur le salaire brut



- émissions : grandes tendances des scénarii Taxe carbone



Levée des subventions énergétiques



4.2 Carbon tax (jin)

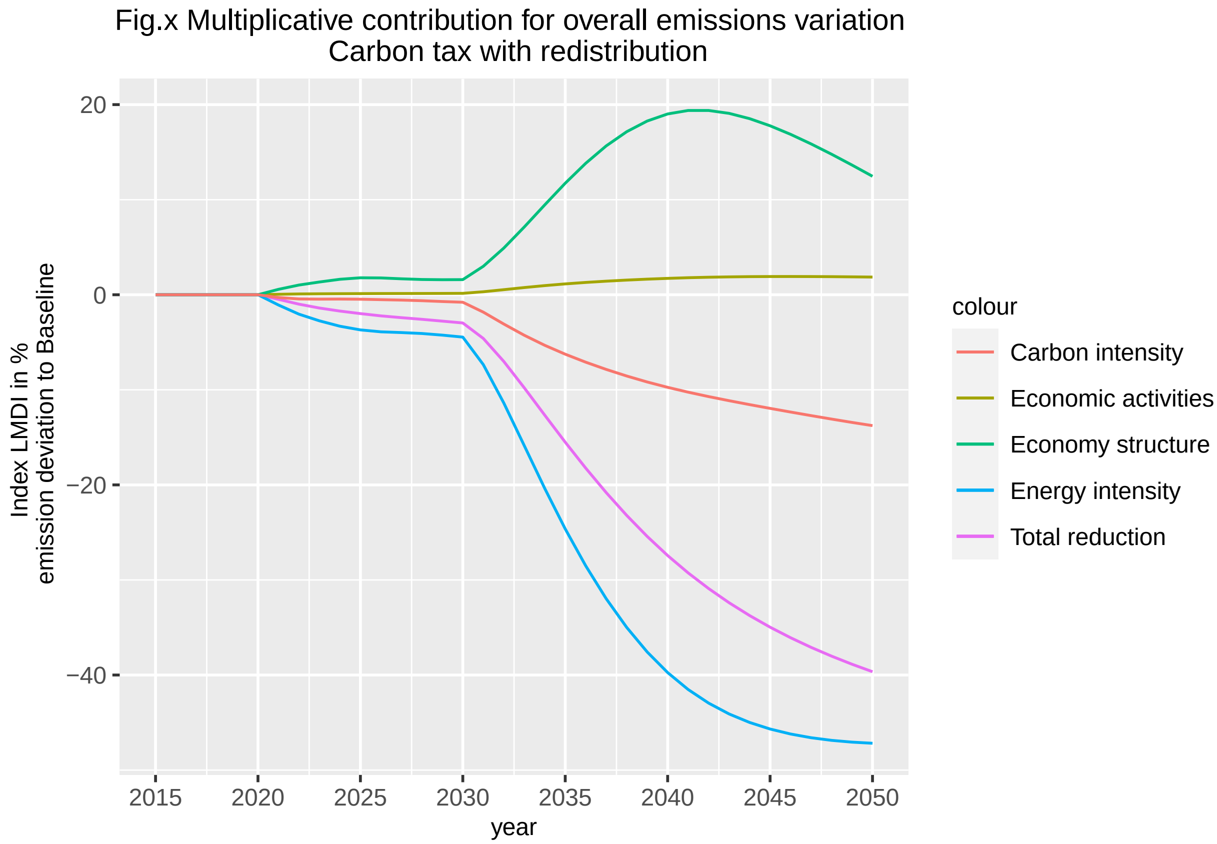
As the carbon tax before 2030 stays at a moderate level, the impacts of this policy are therefore limited, while the significant effects are observed during the later period from 2030 to 2050 when a much stronger tax carbon is implemented. The macroeconomic impacts are summarized in table 1, the results are expressed as percentage deviation from Baseline scenario.

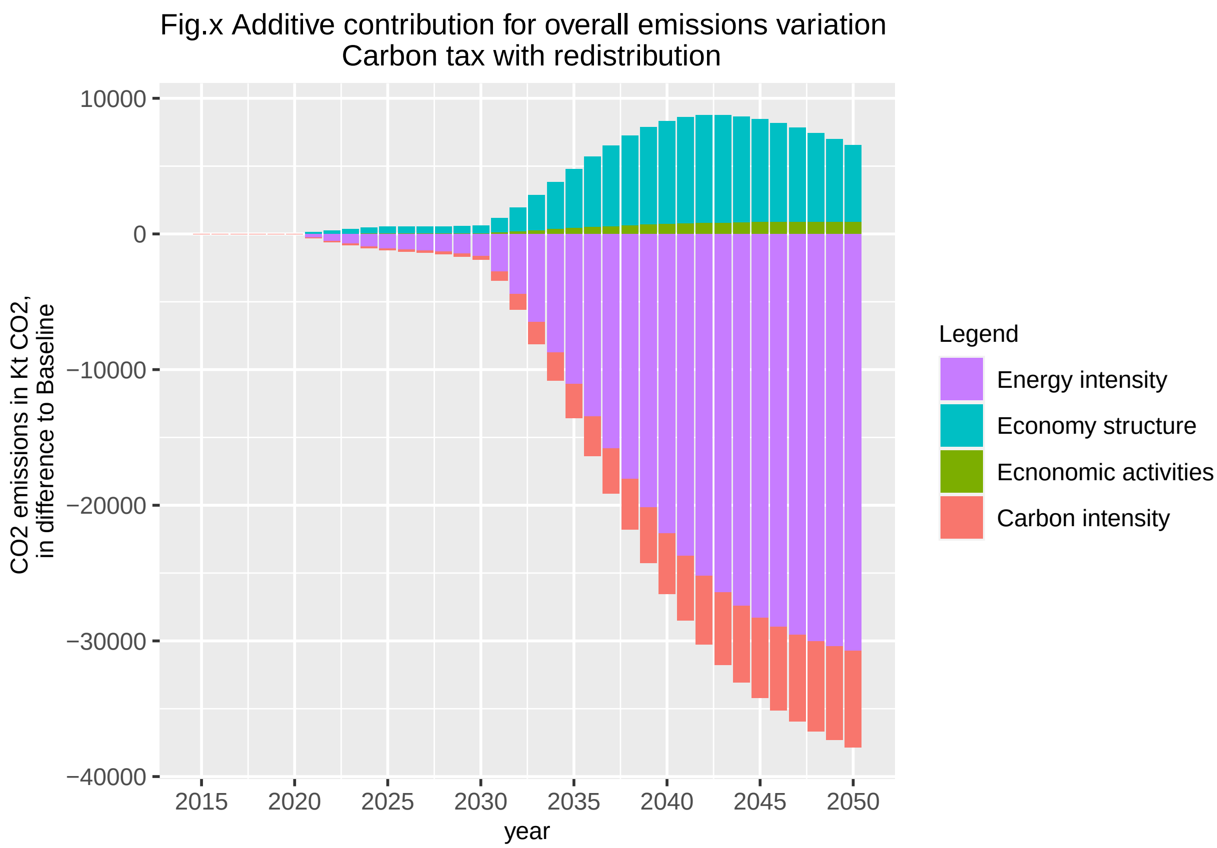
Generally speaking, the policy of carbon tax with redistribution of government revenue has a positive impact on Tunisia's economy. Whereas GDP increases slightly up to 0.13% with respect to baseline on 2030, the relatively rapid augmentation is observed from 2030 to 2050. At the horizon of 2050, it reaches a highest level (+1.93%) thanks to the carbon tax policy. In the meantime, social welfare is improved with the same rhythme as GDP growth, with a higher consumption level (+4.20%) and a higher disposable income (+4.17%) on 2050.

An intuitive influence of carbon tax is that the price of internal market will raise, which is in line with our model output: higher household consumption price of 9.49% with 11.33% and 13.14% for production price and intermediate consumption price, respectively. The increasing cost of household and company will force them to choose the substitution with less CO2 emissions, thus reducing their cost. The variation of internal price also has an impact on the competitiveness of local goods on international market, causing a recession for exportation and a boost for importation.

It is interesting to note that the implemented policy can alleviate social poverty to some extent. We observed, for example, the continuous growth of wage employment. It will reinforce the acceptability of the climate policy.

As the economy grows, we find that the emissions reduction of 42.2% by 2050 is achieved. We are now interested in its pathway, to do this, we firstly employ our extended Kaya identity to clarify the main driving forces, where, a priori, Economic activities are expected to have positive effects on emissions, whilst Energy intensity and Carbon intensity should have negative effects. Figure X. et X. present the results of all the aggregated driving forces. We observe that economy structure has a significantly positive and growing impact until 2043 where it reaches the peak raising 7947.48 Kt CO2 (+19,38%) with regard to baseline, then it begins to decline to 5650,17 Kt CO2 (+12,46%) on 2050. On the other hand, carbon intensity and energy intensity show the negative and monotone trend, the former reducing 7128.35 Kt CO2 (-13.77%) on 2050 and 30715.93 Kt CO2 (-47.18%) for the later. However, the influence of economic activities is negligible (+886,37 Kt CO2 & +1.86%), revealing that even though the total production remains relatively invariable, the revolution of economy structure could still strongly impact the emissions pathway.





Sectorial level analysis, Economy Structure: main sectors are electricity (positive) and energy transformation (negative) what happened in these two sectors? a developpement of electricity production, and a recession of energy transformation

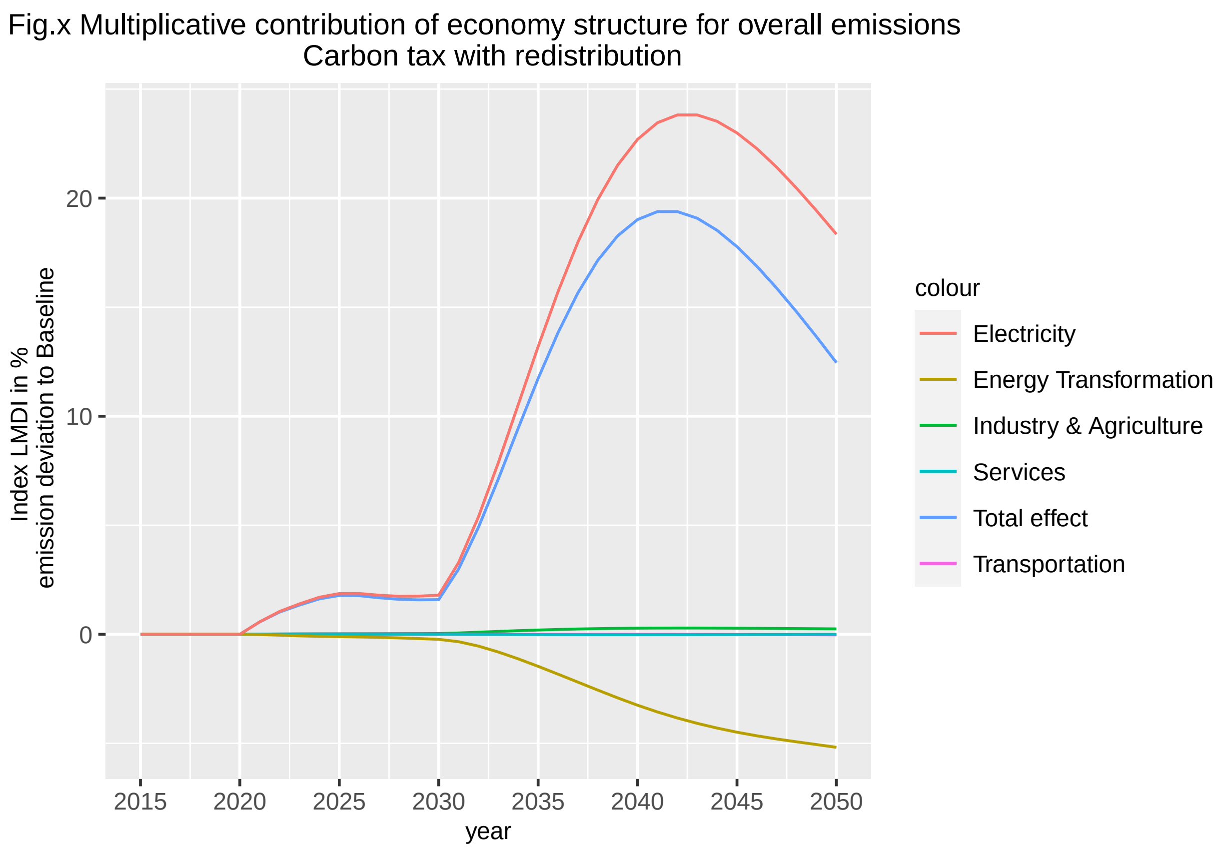
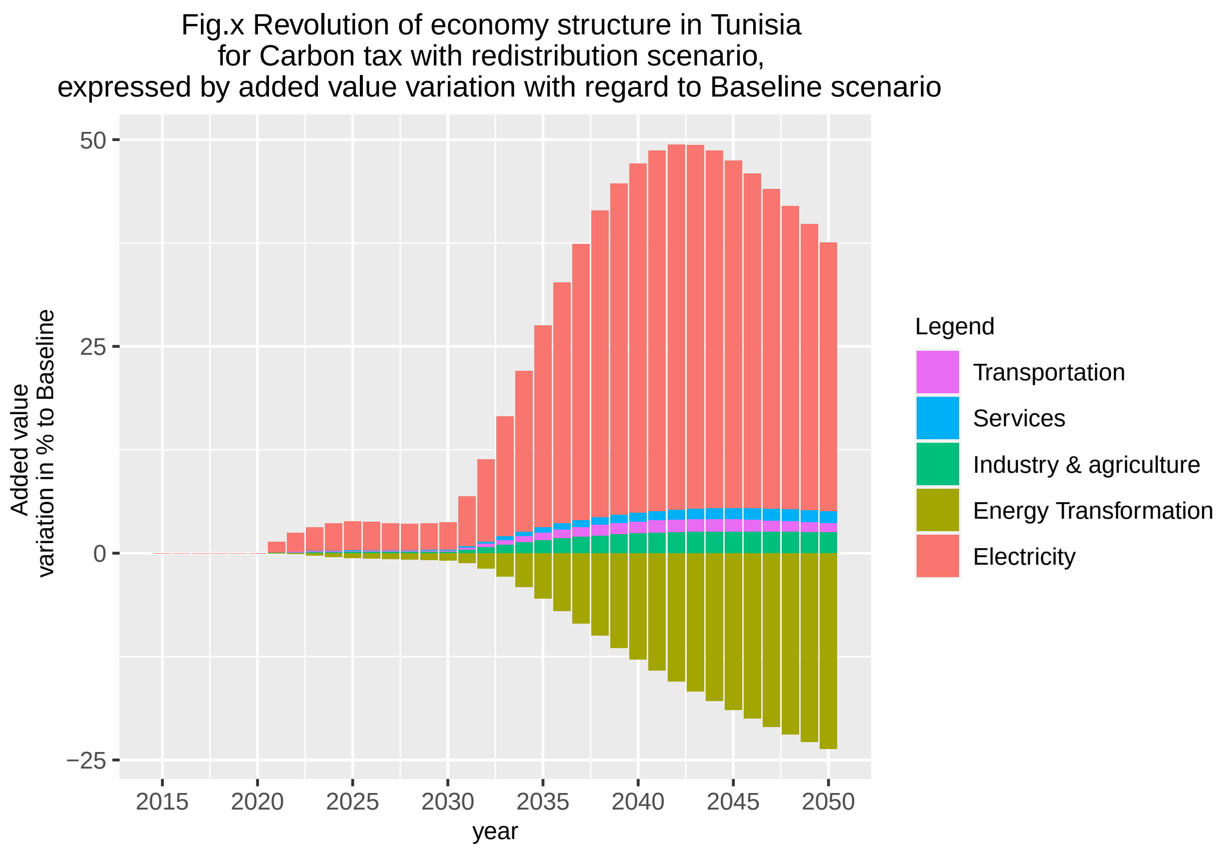


Fig.x Multiplicative contribution of economy structure for overall emissions
Carbon tax with redistribution
Index LMDI in %
emission deviation to Baseline
20
10
0
2015
2020
2025
2030
2035
2040
2045
2050
year
colour
Electricity
Energy Transformation
Industry & Agriculture
Services
Total effect
Transportation



Energy intensity -> we observe the improvement of energy efficiency, in another word the decrement of energy intensity, for all the sectors of Tunisia's economy, especially for electricity and industry & agriculture. explained by the global drop of energy consumption, coupled with the augmentation of added value in certain sectors

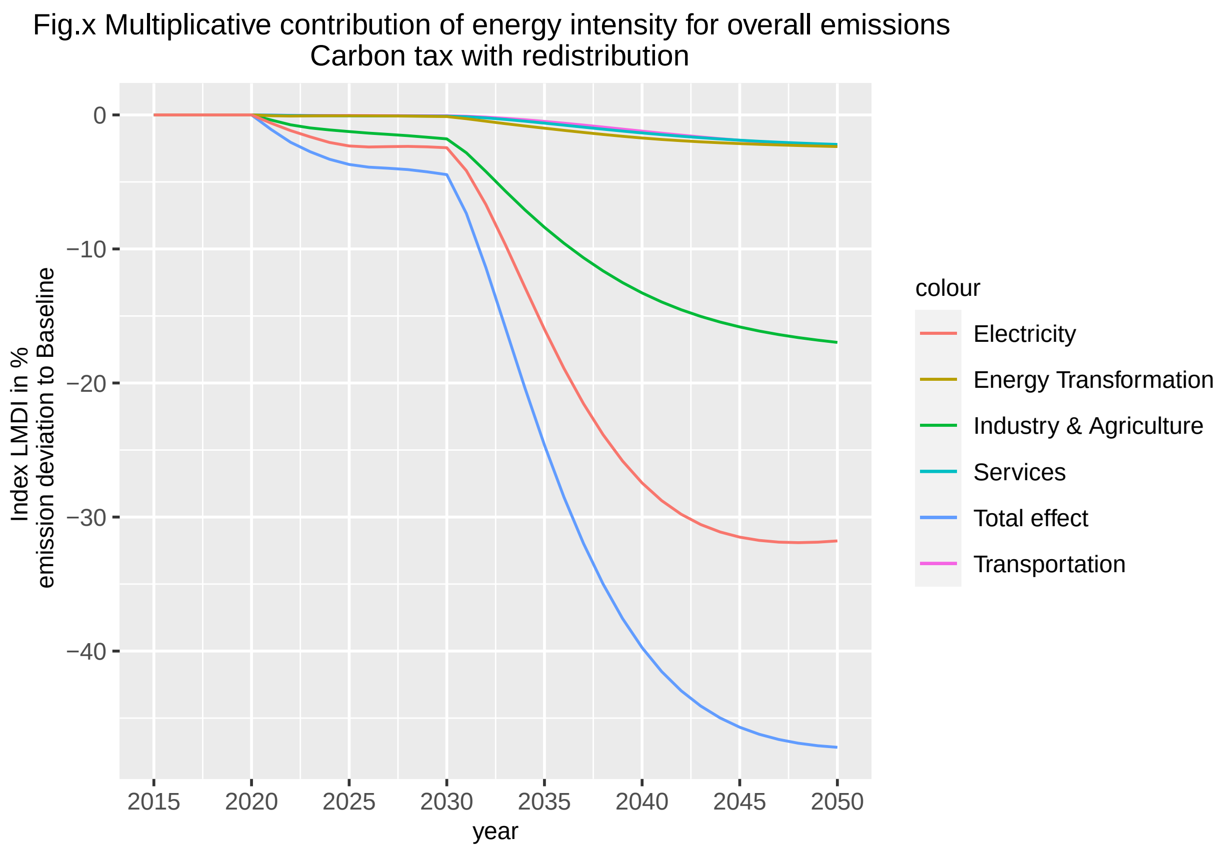
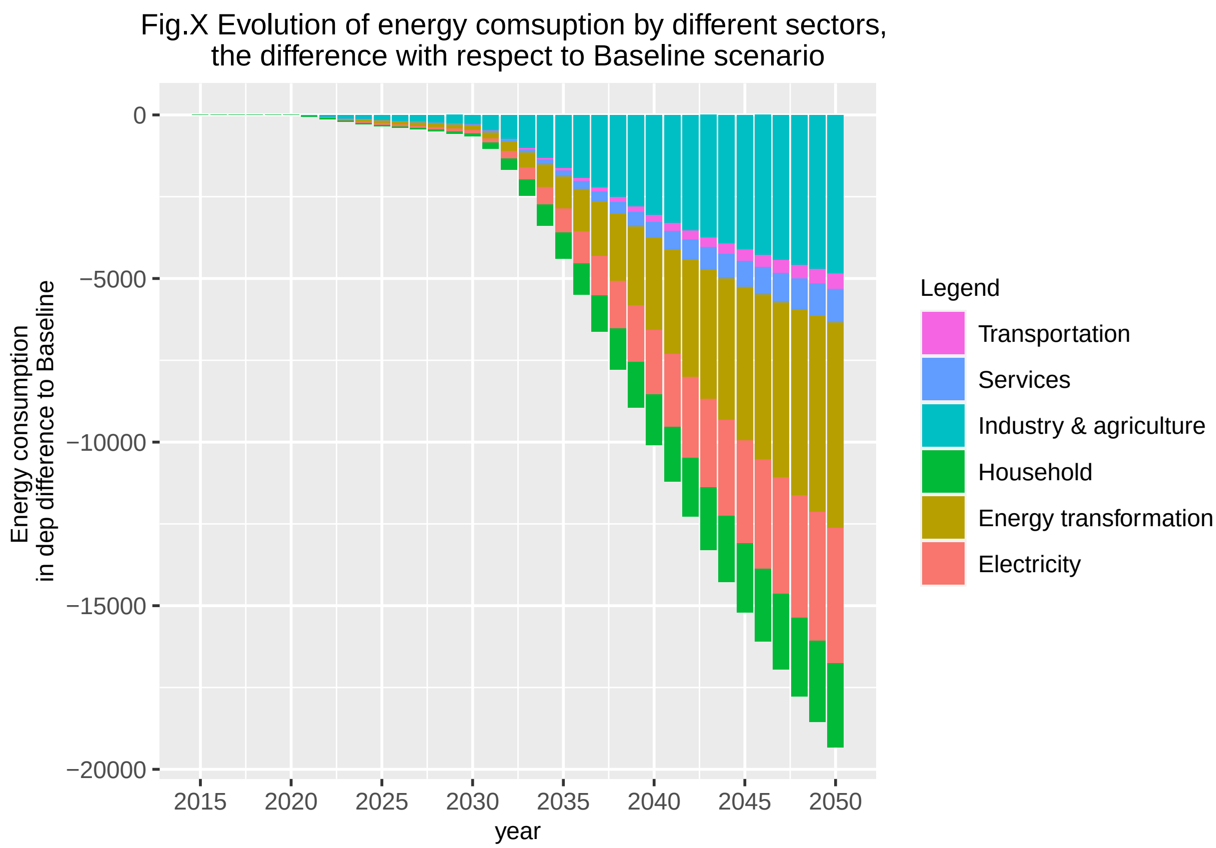


Fig.x Multiplicative contribution of energy intensity for overall emissions
Carbon tax with redistribution
Index LMDI in %
emission deviation to Baseline
0
−10
−20
−30
−40
2015
2020
2025
2030
2035
2040
2045
2050
year
colour
Electricity
Energy Transformation
Industry & Agriculture
Services
Total effect
Transportation



Carbon intensity Dramastically change in energy transformation and industry&agriculture for energy transformation: -> explain the integration of household into this sector -> mainly from less consumption of fuels for transportation, and a increment of electricity -> maybe because the electrical car or hybride car. A slight reduction of natural gas consumption in energy transformation for industry & agriculture: same tendance, less natural gas, less consumption of fuels for transportation, more electricity (for transportation and heating etc)

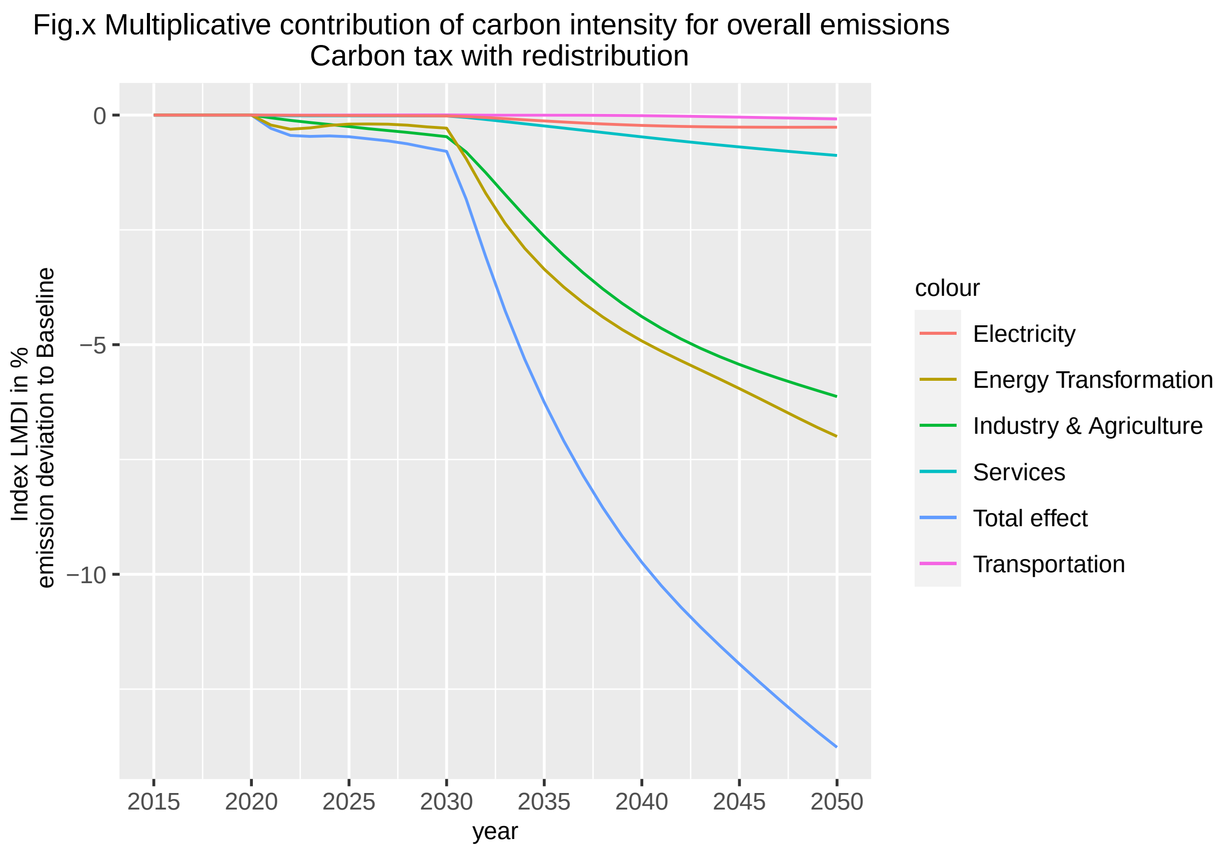
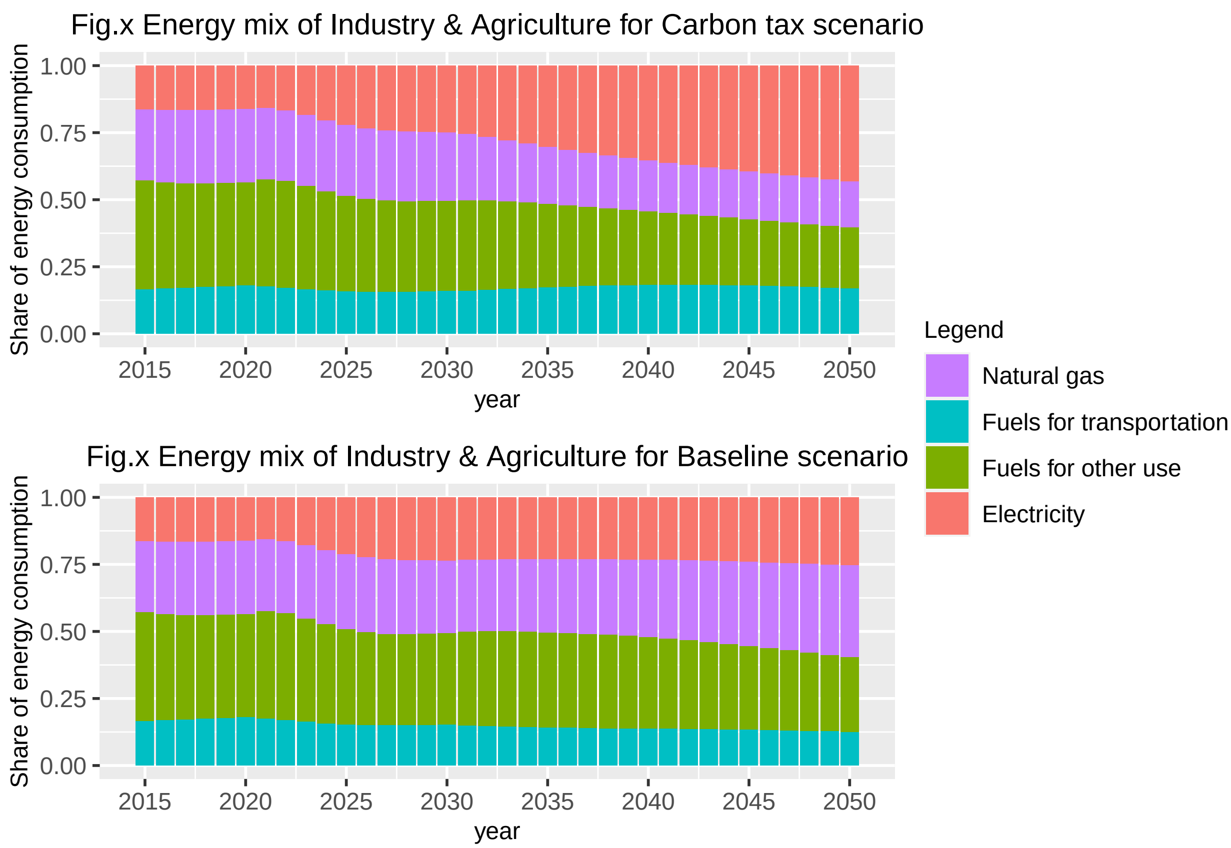
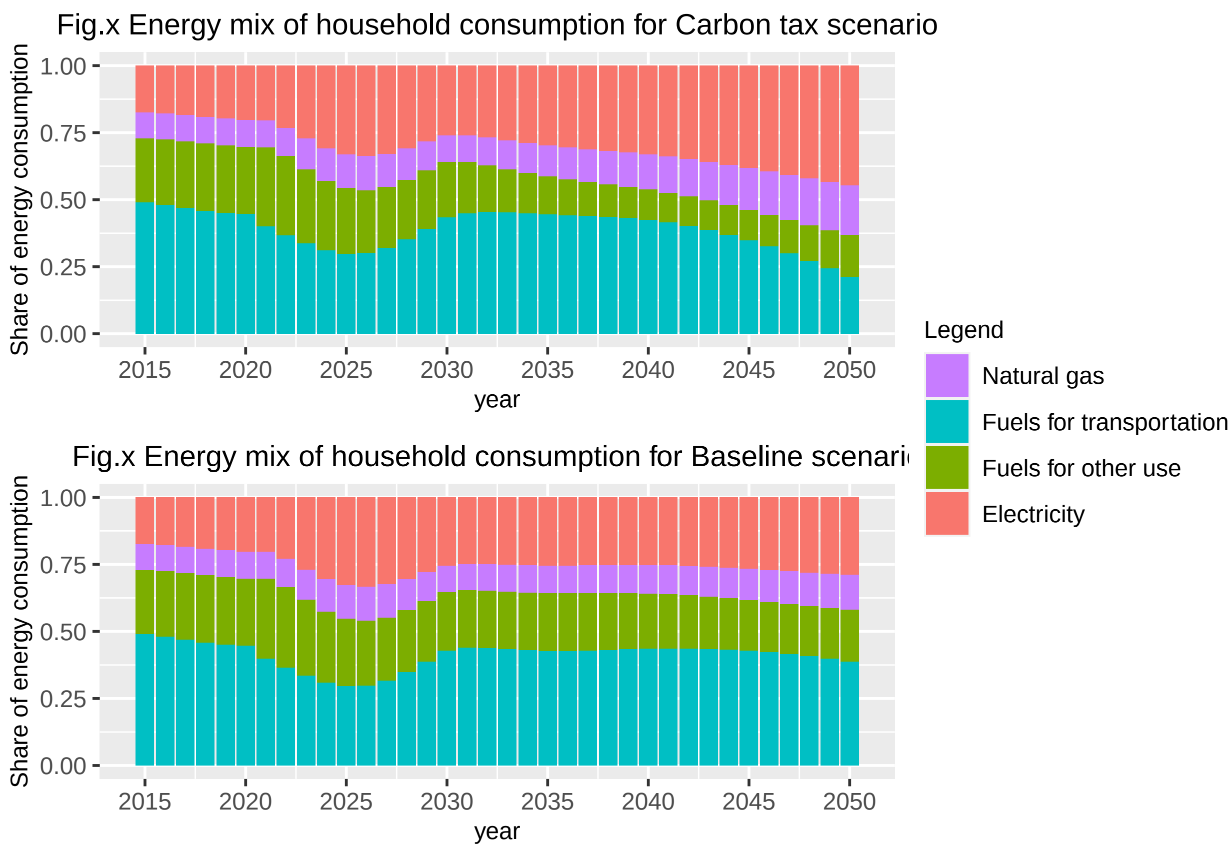


Fig.x Multiplicative contribution of carbon intensity for overall emissions
Carbon tax with redistribution
Index LMDI in %
emission deviation to Baseline
0
−5
−10
2015
2020
2025
2030
2035
2040
2045
2050
year
colour
Electricity
Energy Transformation
Industry & Agriculture
Services
Total effect
Transportation



For energy transformation, we creat a table, which is better than a figure



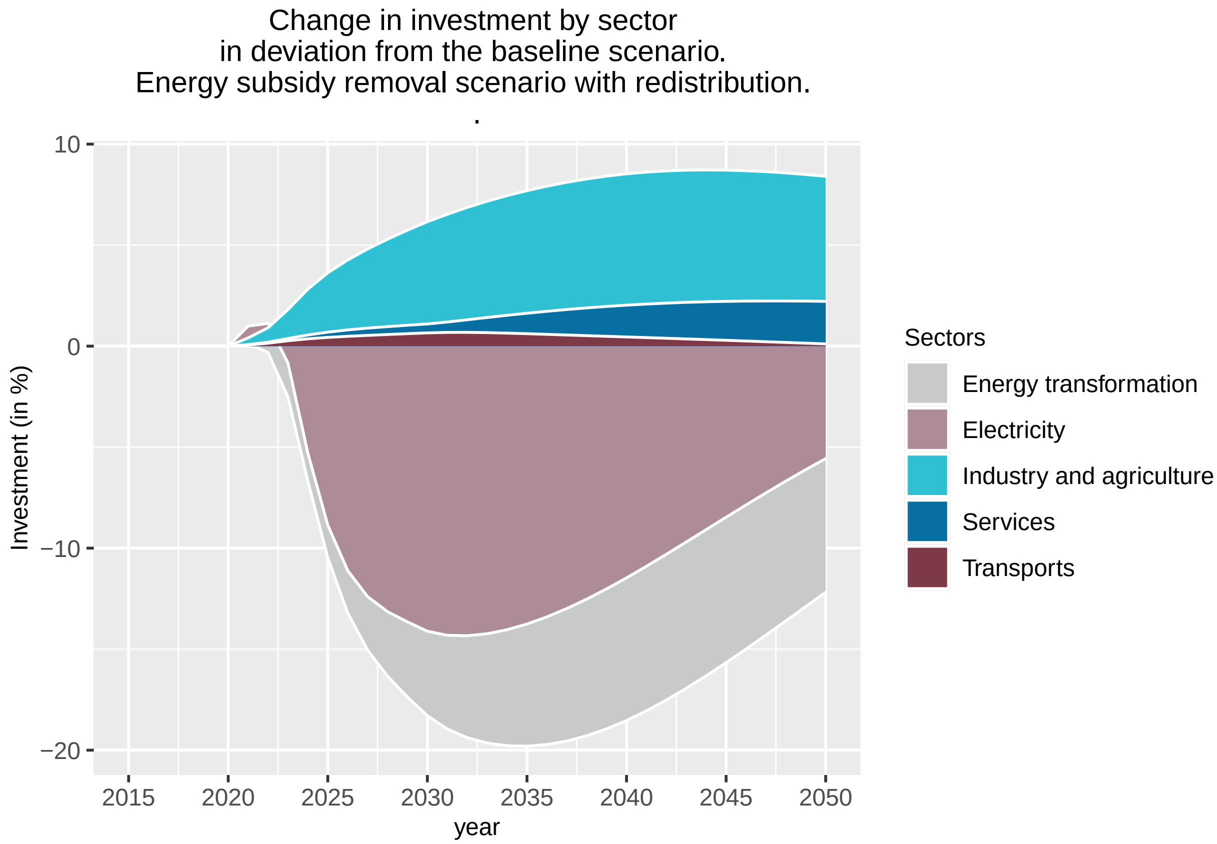
Focus inter-sectoriel energy price will

1 - induce company to invest to reduce energy demande -> une amelioration pour intensite energetique

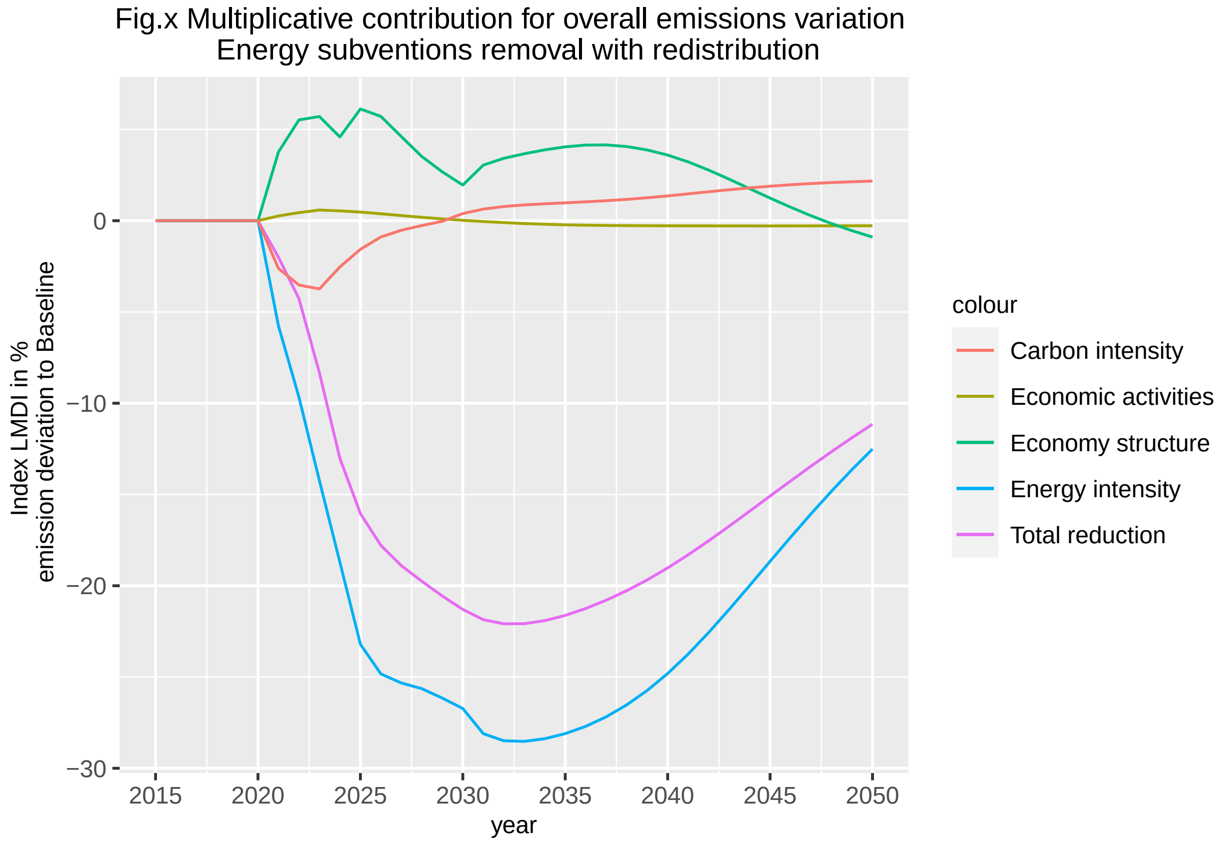
2 - renwable energy -> une amelioration pour intensite carbone, mais dans notre modele ca se voit pas a cause de l'hypothese du modele

4.3 Energy subsidies removal (bee)

4.3.1 Economic impacts



4.3.2 Environmental and energy impacts



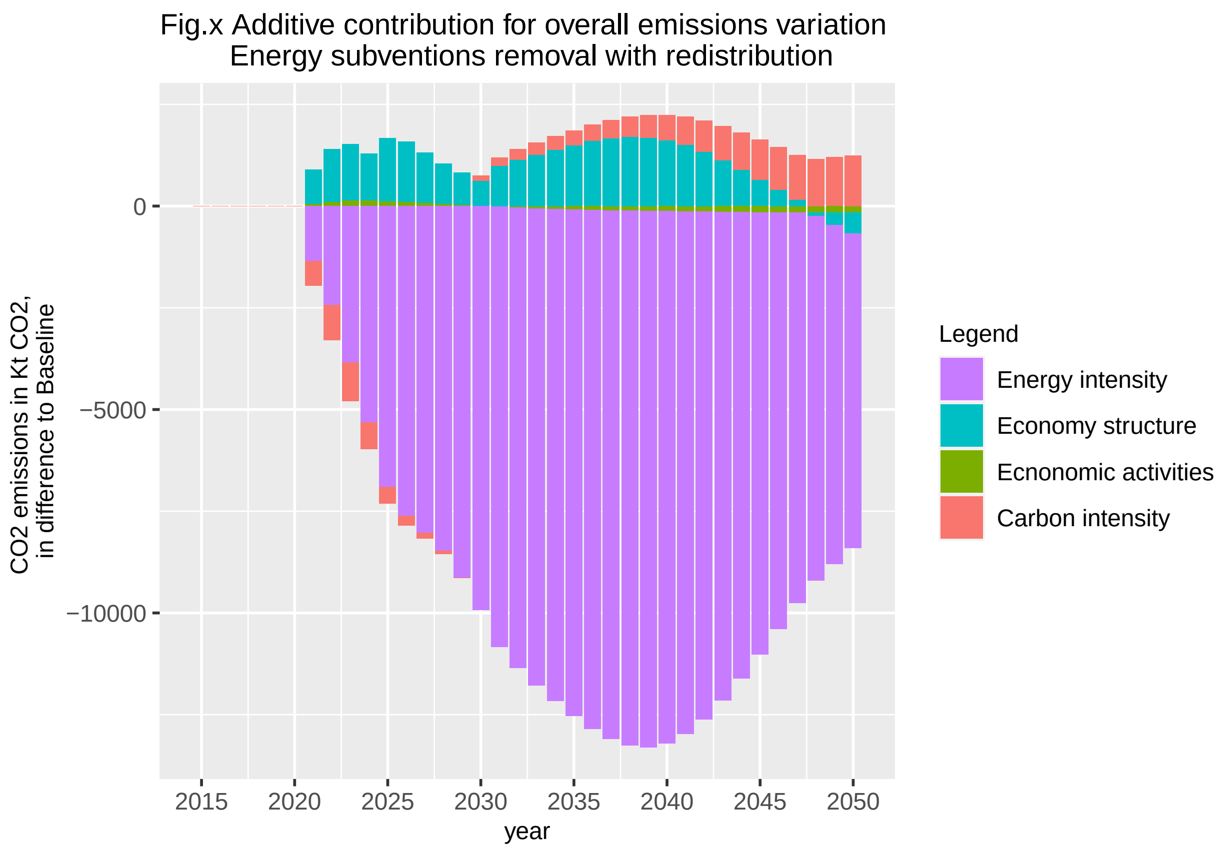


Fig.x Additive contribution for overall emissions variation
Energy subventions removal with redistribution
CO2 emissions in Kt CO2,
in difference to Baseline
0
−5000
−10000
2015
2020
2025
2030
2035
2040
2045
2050
year
Legend
Energy intensity
Economy structure
Ecnonomic activities
Carbon intensity

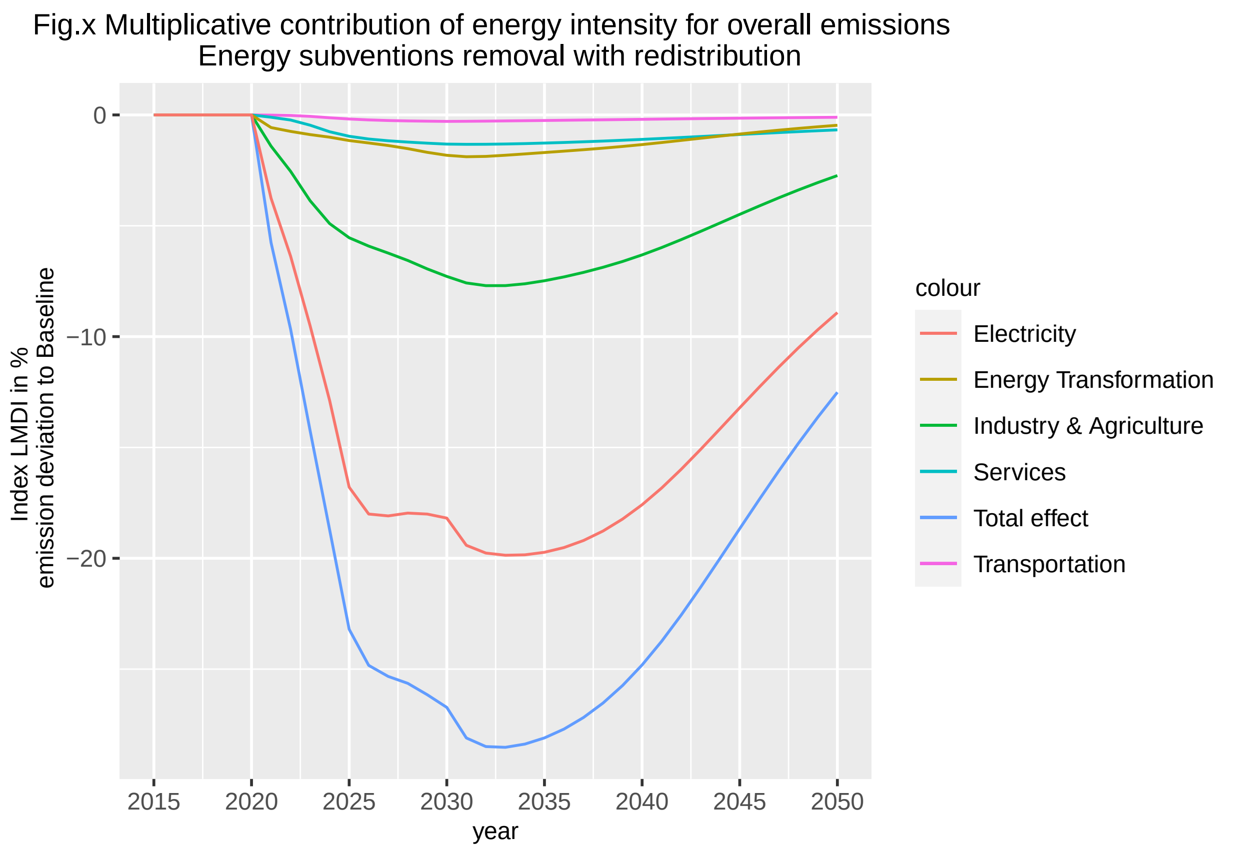


Fig.x Multiplicative contribution of energy intensity for overall emissions
Energy subventions removal with redistribution
Index LMDI in %
emission deviation to Baseline
0
−10
−20
2015
2020
2025
2030
2035
2040
2045
2050
year
colour
Electricity
Energy Transformation
Industry & Agriculture
Services
Total effect
Transportation

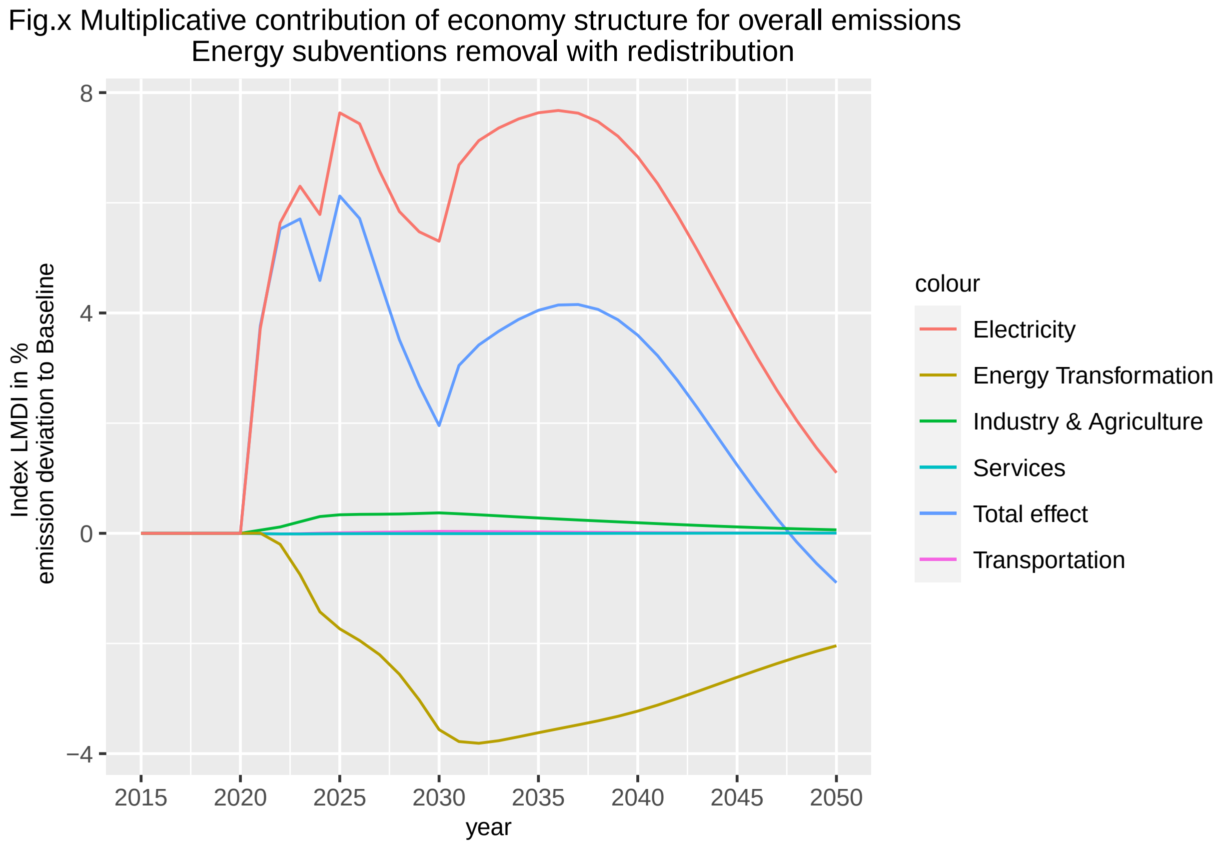


Fig.x Multiplicative contribution of economy structure for overall emissions
Energy subventions removal with redistribution
Index LMDI in %
emission deviation to Baseline
8
4
0
−4
2015
2020
2025
2030
2035
2040
2045
2050
year
colour
Electricity
Energy Transformation
Industry & Agriculture
Services
Total effect
Transportation

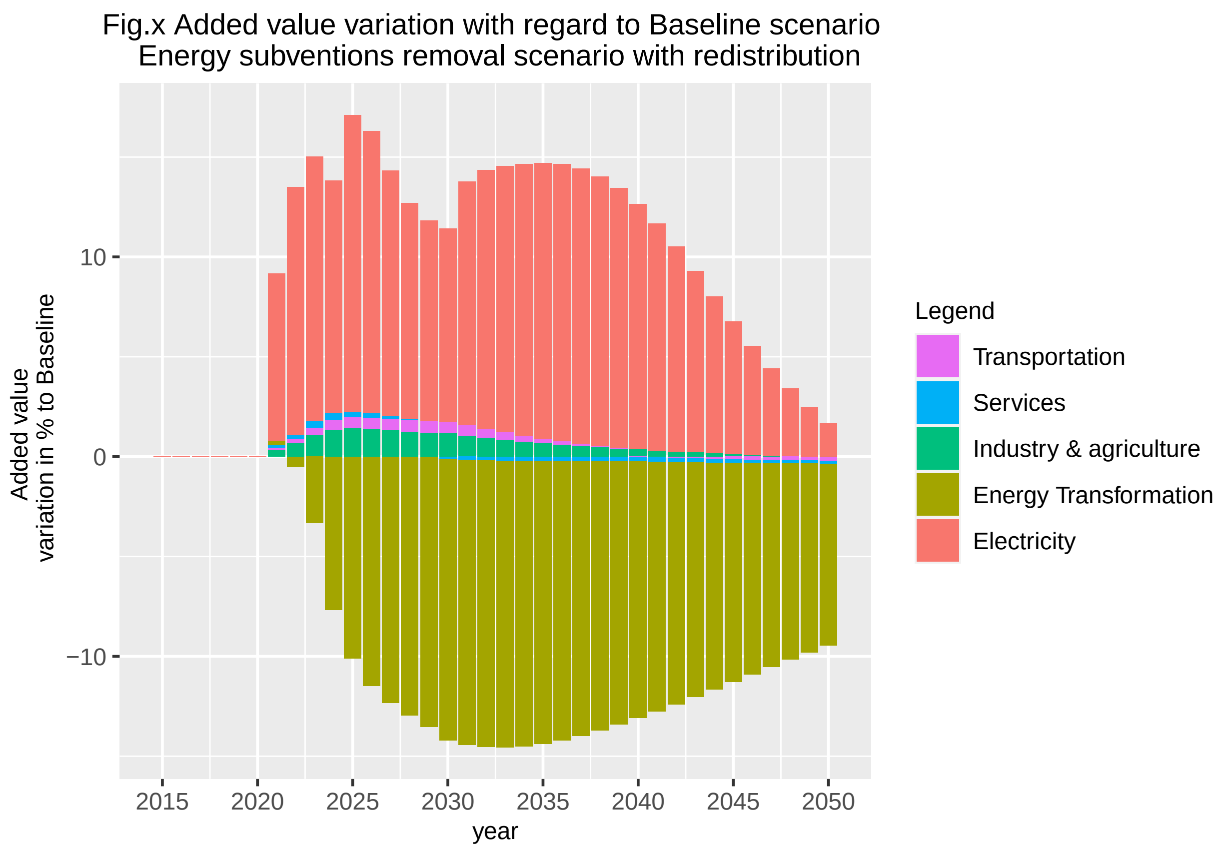


Fig.x Added value variation with regard to Baseline scenario
Energy subventions removal scenario with redistribution
Added value
variation in % to Baseline
10
0
−10
2015
2020
2025
2030
2035
2040
2045
2050
year
Legend
Transportation
Services
Industry & agriculture
Energy Transformation
Electricity

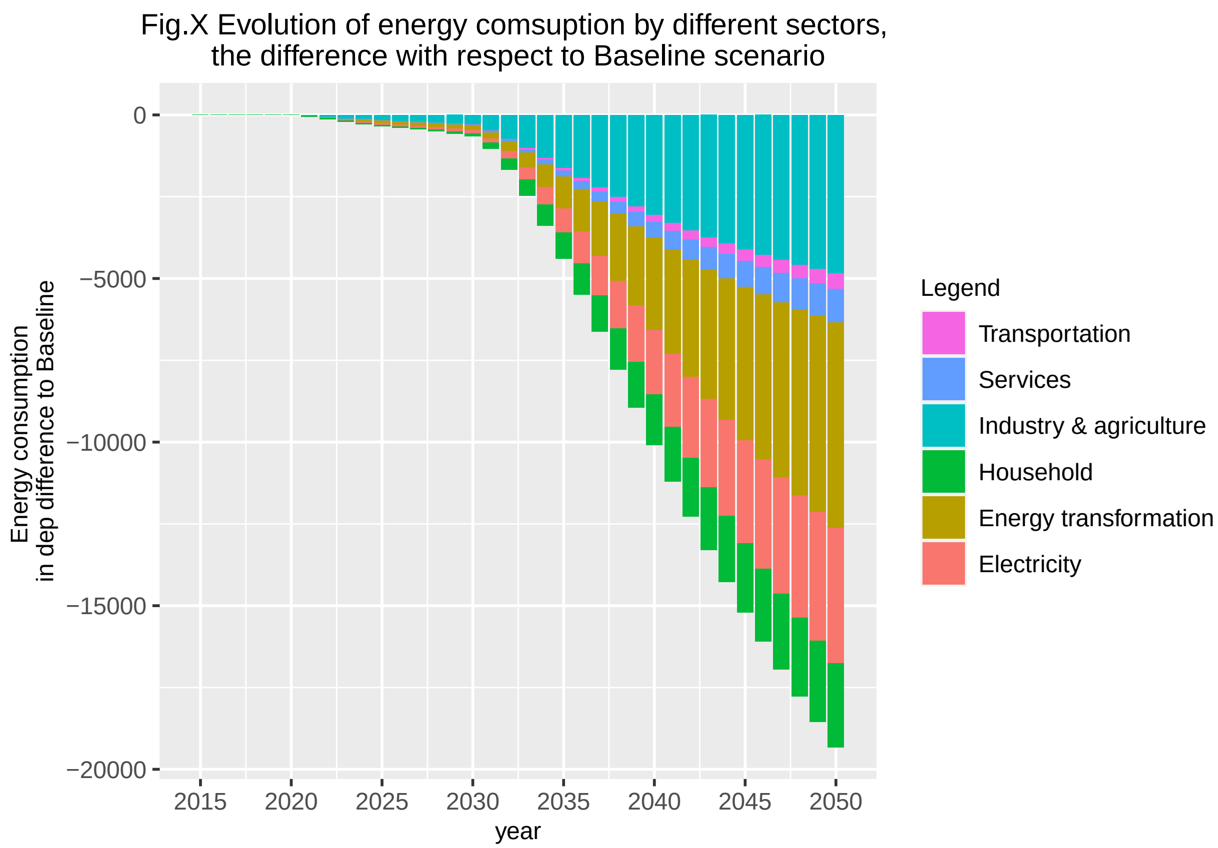


Fig.X Evolution of energy comsuption by different sectors,
the difference with respect to Baseline scenario
Energy consumption
in dep difference to Baseline
0
−5000
−10000
−15000
−20000
2015
2020
2025
2030
2035
2040
2045
2050
year
Legend
Transportation
Services
Industry & agriculture
Household
Energy transformation
Electricity

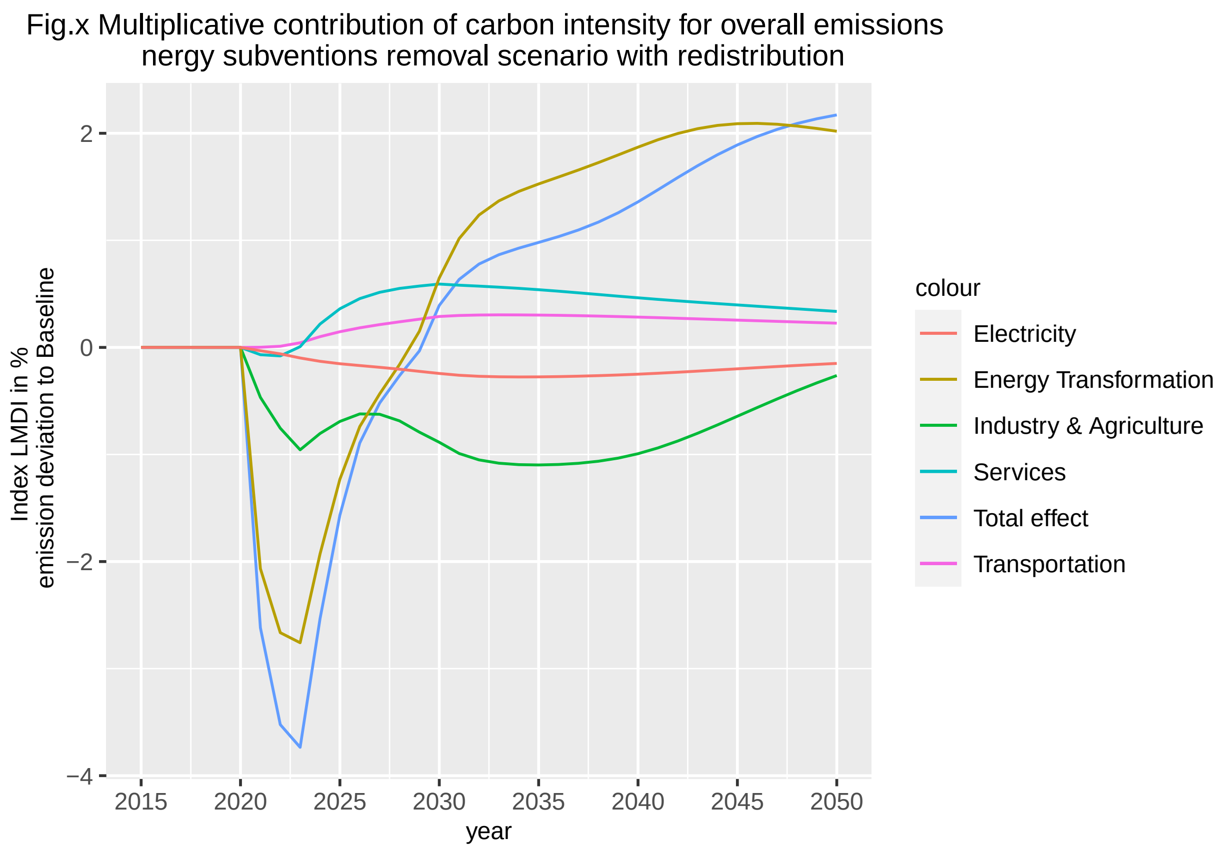


Fig.x Multiplicative contribution of carbon intensity for overall emissions
nergy subventions removal scenario with redistribution
Index LMDI in %
emission deviation to Baseline
2
0
−2
−4
2015
2020
2025
2030
2035
2040
2045
2050
year
colour
Electricity
Energy Transformation
Industry & Agriculture
Services
Total effect
Transportation

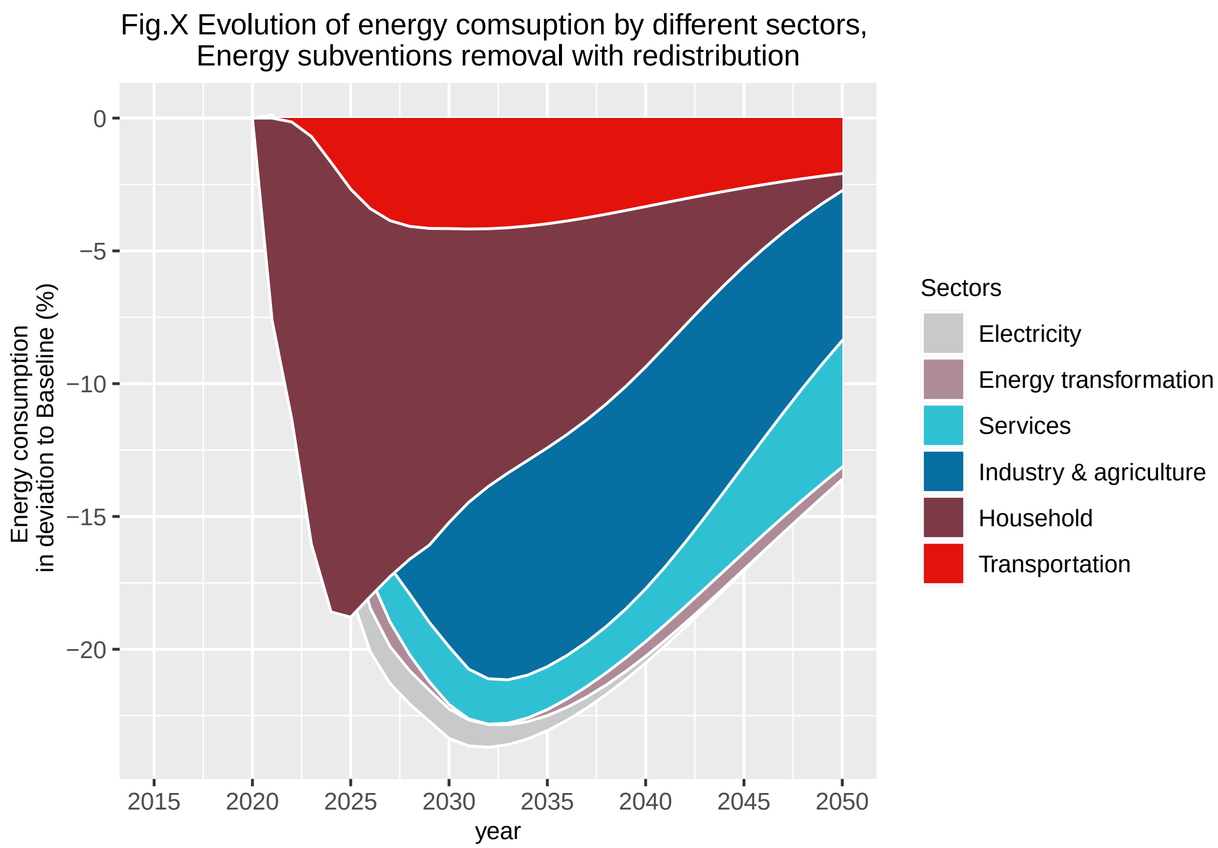


Fig.X Evolution of energy comsuption by different sectors,
Energy subventions removal with redistribution
Energy consumption
in deviation to Baseline (%)
0
−5
−10
−15
−20
2015
2020
2025
2030
2035
2040
2045
2050
year
Sectors
Electricity
Energy transformation
Services
Industry & agriculture
Household
Transportation

4.4 ENR

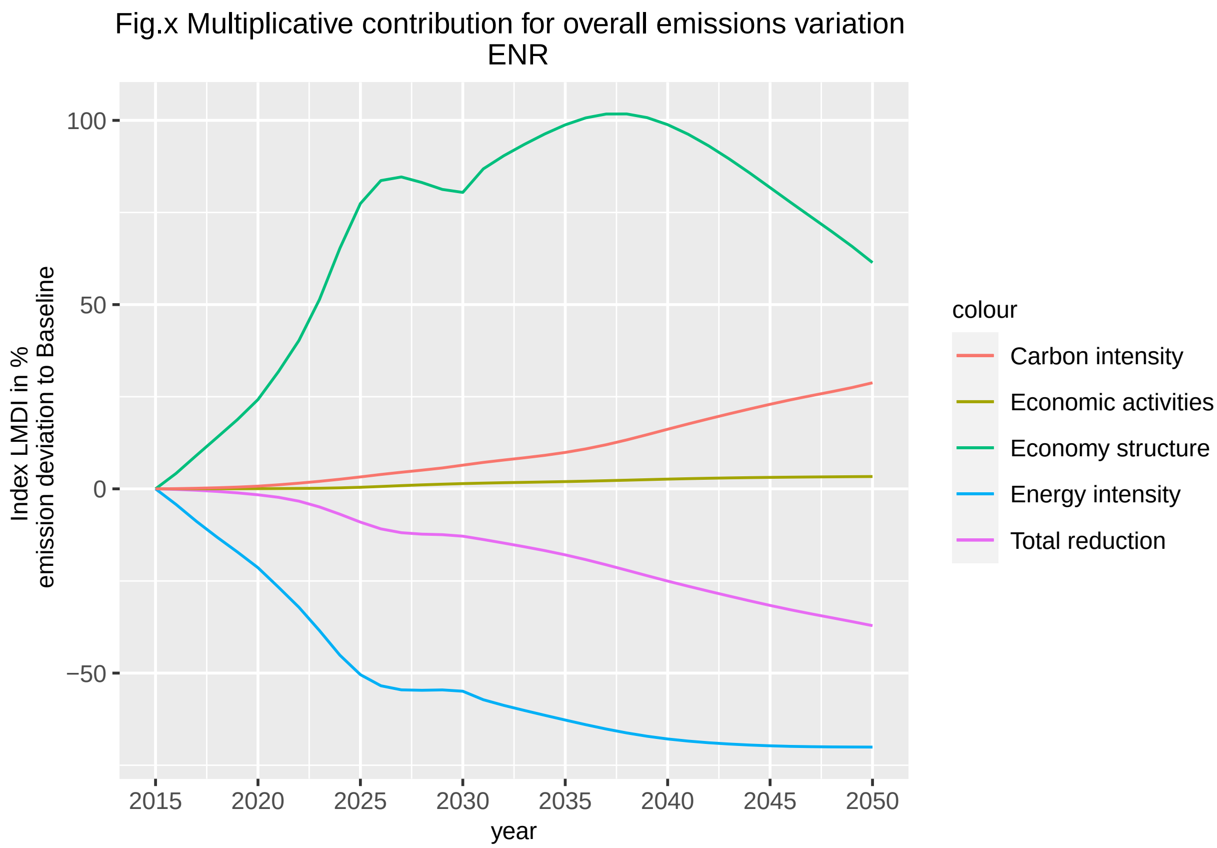
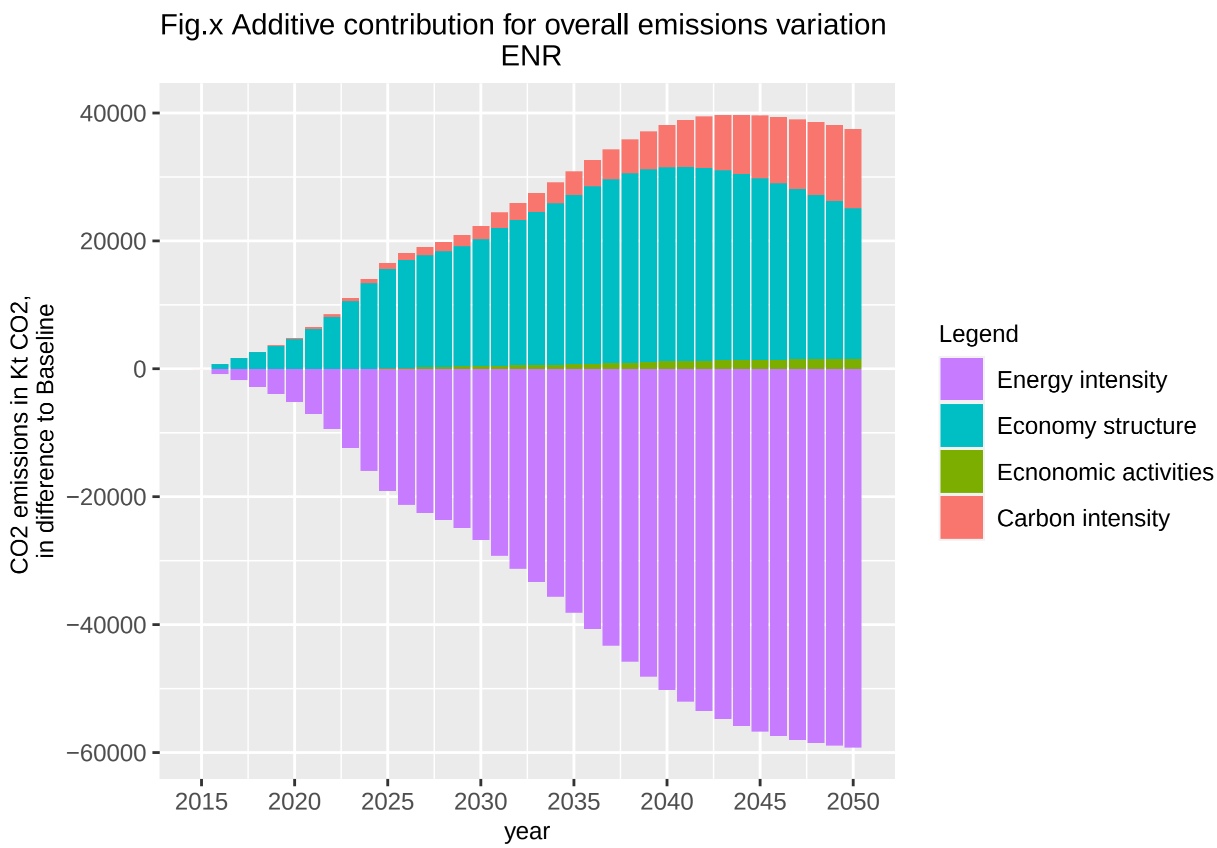


Fig.x Multiplicative contribution for overall emissions variation
ENR
Index LMDI in %
emission deviation to Baseline
100
50
0
−50
2015
2020
2025
2030
2035
2040
2045
2050
year
colour
Carbon intensity
Economic activities
Economy structure
Energy intensity
Total reduction



4.5 SNBC

5 Prolongements

5.1 D'autres leviers pour analyser (ouverture)

5.2 L'amélioration du cadre statistique

OUverture : pb du secteur informel non pris en compte par la comptabilité nationale

6 Conclusion

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