

How can Climate be taken into account in National Accounts ? An Insee Proposal to « augment » National Accounts

Escoe conference May 23rd 2025
S. Roux



23/05/2025

PROGRESS SINCE 2009

- **Stiglitz-Sen-Fitoussi report, Septembre 2009 : a number of recommandations**
 - Use more qualitative indicators to measure well-being
 - Distinguish between the measurement of current well-being and its sustainability
 - Wherever possible, supplement with indicators of dispersion
- **Consequences :**
 - At global level : Sustainable Development Goals (SDGs)
 - In France,
 - After a consultation of public statistics stakeholders: dashboard of 10 « new wealth indicators » put into law in 2015
 - Several Insee publications on well-being: domestic work, gender equality, subjective wellbeing, extended redistribution, ...
 - Introduction of the Augmented National Accounts (ANA) programme in 2022

THE ANA PROJECT

- **Building an information system supporting the regular (yearly) production of statistics on environment and income distribution consistent with the national accounts**
 - Carbon accounts: emissions and footprint
 - Distributed national accounts (including household sector, but not only)
- **Integrating the analysis of environment or inequality and of the economic activity : Propositions of synthetic indicators**
 - Adaptation of economic performance indicators to greenhouse gas emission
 - Alternative measure of growth of net income accounting for differences accross households
- **Publishing and disseminating each year these statistics and analyses**
 - First publication on November 5th 2024
- **Investing in other topics (nowcasting, human capital, ...)**

QUESTIONS TO BE ADRESSED :

- About what should a synthetic indicator inform us on ?
 - Tradeoff between economic activity and other dimensions
 - Indicator incorporating all dimensions (Inclusive Wealth indicator)
 - Separately focused on specific dimensions
 - Adapting the standard indicators of the SNA based on familiar concepts
 - Possible adaptation of the accounts (and their concepts):
 - Production boundary
 - New agents : introducing specific operations
- How would we estimate such indicators ?
 - Estimation method
 - Linear combination of other indicators
 - Specific computation using more disaggregated information
 - Information required
 - Should rely on SNA at least !
 - Need to get information on the other dimensions and make it compatible, which ANA try to do !

GDP : A MEASURE OF THE ECONOMIC ACTIVITY, BUT ...

- Boundary restricted to production generating monetary flows (with some exceptions)
- Does not take into account inter-temporal effects (vs. NDP-type indicator which subtracts CCF)
- Valuation at market prices: externalities not incorporated

SYSTEM OF NATIONAL ACCOUNTS (SNA)

- Detailed description of the economy: activity by industry and asset description
- Overall consistency :
 - accounting transactions associated with clearly identified agents,
 - accounting established so that all transactions between agents are balanced
- Based on observation of monetary flows between these agents, and a whole system of statistical information.

QUESTION: HOW CAN THE SNA BE MARGINALLY ADAPTED TO DESCRIBE THE CONSEQUENCES OF CLIMATIC DAMAGE?

- Provide information on the ‘real’ state of the economy: sustainability issues (cf. SNA 2025)
 - Highlighting the costs of GHG emissions
- Does not provide information on economic optimality: the SNA is not intended to be prescriptive

LIST OF PROJECTS AIMED AT ADAPTING THE NATIONAL ACCOUNTING FRAMEWORK TO THE ENVIRONMENT

- **Revision of the SNA 2025**
 - Thinking about a better approach to well-being and sustainability
 - Favours NDP-type indicators, taking into account (in part) natural resources
- **Beyond GDP literature (cf. Dasgupta, 2021)**
 - Taking into account other dimensions (human capital, domestic work, etc.): extending the accounting framework
 - Aim for a global indicator of inclusive wealth (cf. ESCOE work)
- **Approach focusing on damage**
 - Muller, Mendelsohn and Nordhaus (AER, 2011) and Labroue and Bureau (2024)
 - Taking externalities into account: attributing damage to emitting sectors
- **Approach focusing on environmental constraints**
 - Unpaid ecological costs or restoration costs (Vanoli, 2017, Kervinio et al., 2023)
 - Introduction of a ‘Nature’ agent to whom an ecological debt is contracted
 - Modelling approaches in this context:
 - Germain-Lellouch (2020), Abbas et al. (2024), Blanchet and Fleurbaey (2024) (among others...), assess the properties of national accounting indicators

RELATIONS BETWEEN EMISSIONS AND ACTIVITY

- **Cost of emitting GHG :**
 - Increases in temperature, sea level, ...
 - Affects activities that depend on climate : **damage costs**
 - Long term effects that may last for centuries
- **Cost of not emitting GHG :**
 - Many economic activities cause GHG emissions
 - Mitigation policies should restrict such activities : **mitigation costs**
 - More short-term effects
- **Effects beyond GDP :**
 - Effects on health or mortality of climate damages
 - Such considerations will induce mitigation policies

Assessing the sustainability and the performance of an emitting economy

(VERY) SIMPLIFIED MODEL OF THE ECONOMY

- Practical experience of a national accountant
- Extension of the accounting framework to 2 new agents
- Definition of the different agents and operations to be applied:
 - Supply-use tables and assets accounts

IMPLEMENTATION:

- Generalisation to an intertemporal economy
- Valuation
 - Crucial role of the discount rate

DERIVATION OF SYNTHETIC INDICATORS

- Adjusted Net Domestic Product
- Adjusted Net Saving
- Value of environmental assets

APPLICATION TO FRANCE

- *Insee-Analyses n°98*, November 2024, « Can the climate be taken into account in the national accounts », Larrieu S., Roux S.

NEW SECTORS :

– « Climate » Sector :

- Produces a « **climate service** » that is used as an intermediate input by other sectors and households
- This service is **deteriorated** due to the rising stock of CO2 in the atmosphere : **degradation of the climate asset**
- The loss in value of this service can be assessed by estimating the future damages caused by current emissions : **social cost of carbon**

– « Carbon regulator » Sector :

- Produces « **GHG emissions rights** » used as intermediate inputs by emitting sectors
- **Mitigation policies** cap the total allowable carbon emissions : « **carbon budget** »
- Valuation of emissions is based on the **shadow price of carbon**, which reflects the cost of abatement

VALUE TRANSFERED FROM THE EXISTING SECTORS TO THE NEW ONES

– Make the degradation of assets induced by GHG emissions appear :

- Consumption of the **climate asset**
- Consumption of the **carbon budget**

– Possible extension beyond GDP to capture the effects of environmental damages on households' well-being

SYNTHETIC INDICATORS

- **NDP : Net Domestic Product (GDP – Consumption of fixed capital)**
 - **ANDP: NDP + attribution** : degradation of climate services induced by our production + mitigation costs
 - **AENDP: NDP + attribution + extension** : global degradation of climate services provided to households
- **NS : Net savings (Gross Disposable Income - Final consumption - CFC)**
 - **ANS: NS + ajustement** : degradation of climate services affecting our production capacity + mitigation costs
 - **AENS : NS + extension to households**: deterioration in climate services provided to households in France
- **Climate Debt ?**
 - **Climate liability (retrospective)**: valuation of the carbon stock emitted by a country in the past in terms of future damage
 - **Cumulative deviations from the target emissions trajectory, operational vision**: measurement of deviations from commitments.
 - **Prospective debt**: valuation of the carbon budget. Future cost of decarbonisation, but also present value of production enabled by emissions.

VALUING EMISSIONS

- **Cost of damage: social cost of carbon**
 - Breakdown between effects on the productive sector and on households (health, mortality), at different dates and in different countries
 - Estimates in the literature: Rennert et al (2022)
- **Cost of mitigation policies :**
 - Abatement cost, French value of climate action (Quinet, 2019)= Shadow price associated with Budget carbon constraint
 - Sufficient for the cost-effectiveness approach
- **Articulation between the two costs, and with National Accounts**
 - Mitigation policies set according to damage prospects : Optimal policy should equalise them (cf. Nordhaus), cost-benefit approach
 - In the accounts, no such optimality assumption: both valuations are introduced.
 - Consistency with the valuation of other assets in the NA (by the market)?
Question of the discount rate

GENERAL DESCRIPTION OF THE MODEL

- 2 periods only, closed economy
- 2 new sectors :
 - Climate
 - Carbon regulator
- Households :
 - Receive income generated by other agents
 - Emit E_M tonnes of GHG
- 2 existing sectors :
 - Manufacturing :
 - Not affected by climate change, but emits E tonnes of GHG in year 1
 - Can no longer emit in year 2 (mitigation): drop in production mE
 - Agricultural:
 - Non-emitting,
 - drop in production $cE_T = c(E+E_M)$ in year 2, linked to emissions in year 1

Agricultural sector: uses a flow of climate services for its production, and therefore suffers the damage associated with climate change when this flow is reduced.

Standard Account				Extended Account			
	Year 1	Year 2	variation		Year 1	Year 2	variation
P1	100	85	-15	P1	100	85	-15
				Climate Services	15	0	-15
				GHG emission rights	0	0	0
Added Value	100	85	-15	Adjusted Added Value	85	85	0
Asset Value	185	85		Adjusted Asset Value	170	85	

- Loss induced by climate degradation in the agricultural sector : -15

Manufacturing sector: produces greenhouse gas emissions, but suffers no damage from climate change

Standard Account				Extended Account			
	Year 1	Year 2	variation		Year 1	Year 2	variation
P1	200	200	0	P1	200	200	0
				Climate Services	0	0	0
				GHG emission rights	0	0	0
VA	200	200	0	Adjusted Added Value	200	200	0
Asset Value	400	200		Adjusted Asset Value	400	200	
Emissions (in teq CO2)				Emissions (in teq CO2)			
GHG Emissions	2	0	-2	GHG Emissions	2	0	-2

Use Table			
	Year 1	Year 2	variation
Agriculture	15	0	-15
Manufacturing	0	0	0
Households (beyond GDP)	0	0	0
Production Account			
	Year 1	Year 2	variation
Production	15	0	-15
No input			
Adjusted Added Value (within GDP)	15	0	-15
Extended Added Value	15	0	-15

Emissions Account			
	Year 1	Year 2	
Opening stock	100	103	
Emissions	3	0	
Closing stock	103	103	
Asset valuation			
	Year 1	Year 2	
Opening value	15	0	
Depletion	-15	0	
Closing value	0	0	

- The climate services produced are used as an input by the user sector.
- The deterioration of the climate, i.e. the increase in the stock of CO₂, reduces production.
- Accounted for from year 1, via the deterioration in the quality of the climate: consumption of climate capital

GDP:

- Adjusted Value Added differs from classical Value Added by sector
- Total Adjusted value added is equal to the classical one: Transfer of value from the agricultural sector to the climate sector

ADJUSTED NDP:

- Consumption of natural capital recorded in the previous year
- Decline in value well recorded at the date of emissions

WEALTH:

- Transfer of part of the value of the agricultural sector to the climate
- Decline in asset value due to consumption of natural capital: highlighted

Standard Account				Extended Account			
Production Approach				Production Approach			
	Year 1	Year 2	variation		Year 1	Year 2	variation
Agriculture	100	85	-15	Agriculture	85	85	0
Manufacturing	200	200	0	Manufacturing	200	200	0
				Climate	15	0	-15
				Carbon Regulator	0	0	0
GDP	300	285	-15	GDP adjusted-extended	300	285	-15
				Cons. Climate Capital	-15	0	
				Cons. Carbon Budget	0	0	
NDP	300	285	-15	NDP adjusted-extended	285	285	0
Asset Accounts				Asset Accounts			
	Year 1	Year 2			Year 1	Year 2	
Opening Value				Opening Value			
Agriculture	185	85		Agriculture	170	85	
Manufacturing	400	200		Manufacturing	400	200	
Climate				Climate	15	0	
Carbon Regulator				Carbon Regulator	0	0	
Total Assets	585	285		Total Assets	585	285	
Flows				Flows			
Reev. Agriculture	-100	-85		Reev. Agriculture	-85	-85	
Reev. Manuf	-200	-200		Reev. Manuf	-200	-200	
Cons. Climate Capital	0	0		Cons. Climate Capital	-15	0	
Cons. Carbon Budget	0	0		Cons. Carbon Budget	0	0	
Total flows	-300	-285		Total flows	-300	-285	

- Loss induced by restriction on the emission rights in the manufacturing sector : -10.

Agricultural sector: uses a flow of climate services for its production, and therefore suffers the damage associated with climate change when this flow is reduced.

Standard Account				Extended Account			
	Year 1	Year 2	variation		Year 1	Year 2	variation
P1	100	85	-15	P1	100	85	-15
				Climate Services	15	0	-15
				GHG emission rights	0	0	0
Added Value	100	85	-15	Adjusted Added Value	85	85	0
Asset Value	185	85		Adjusted Asset Value	170	85	

Manufacturing sector: produces greenhouse gas emissions, but suffers no damage from climate change

Standard Account				Extended Account			
	Year 1	Year 2	variation		Year 1	Year 2	variation
P1	200	190	-10	P1	200	190	-10
				Climate Services	0	0	0
				GHG emission rights	10	0	-10
VA	200	190	-10	Adjusted Added Value	190	190	0
Asset Value	390	190		Adjusted Asset Value	380	190	
Emissions (in teq CO2)				Emissions (in teq CO2)			
GHG Emissions	2	0	-2	GHG Emissions	2	0	-2

Use Table			
	Year 1	Year 2	variation
Agriculture	0	0	0
Manufacturing	10	0	-10
Households (beyond GDP)	0	0	0
Production Account			
	Year 1	Year 2	variation
Production	10	0	-10
No input			
Adjusted Added Value (within GDP)	10	0	-10
Extended Added Value	10	0	-10

Carbon Budget (in teq CO2)			
	Year 1	Year 2	
Opening stock	3	0	
Emissions	3	0	
Closing stock	0	0	
Asset Valuation			
	Year 1	Year 2	
Opening Value	10	0	
Depletion	-10	0	
Closing value	0	0	

- Emission rights are used as inputs when the sector emits
- Stopping emissions interrupts the service (production at 0 in year 2)
- Emissions consume the carbon budget : diminution in the value of the regulator
- The following year, no more emissions, the stock is completely consumed.

GDP :

- Adjusted Value Added differs from classical Value Added by sector
- Total Adjusted value added is equal to the classical one: Transfer of value from manufacturing to the regulator

ADJUSTED NDP :

- Consumption of budget carbon counted at the date of the emission
- The drop of value added at year 2 in standard accounts appears at year 1 in ANDP, through the consumption of carbon budget

WEALTH :

- Transfer of part of the value of the manufacturing sector to the regulator
- Decline in asset value due to consumption of carbon budget: highlighted

Standard Account				Extended Account			
Production Approach				Production Approach			
	Year 1	Year 2	variation		Year 1	Year 2	variation
Agriculture	100	85	-15	Agriculture	85	85	0
Manufacturing	200	190	-10	Manufacturing	190	190	0
				Climate	15	0	-15
				Carbon Regulator	10	0	-10
GDP	300	275	-25	GDP adjusted-extended	300	275	-25
				Cons. Climate Capital	-15	0	
				Cons. Carbon Budget	-10	0	
NDP	300	275	-25	NDP adjusted-extended	275	275	0
Asset Accounts				Asset Accounts			
	Year 1	Year 2			Year 1	Year 2	
Opening Value				Opening Value			
Agriculture	185	85		Agriculture	170	85	
Manufacturing	390	190		Manufacturing	380	190	
Climate				Climate	15	0	
Carbon Regulator				Carbon Regulator	10	0	
Total Assets	575	275		Total Assets	575	275	
Flows				Flows			
Reev. Agriculture	-100	-85		Reev. Agriculture	-85	-85	
Reev. Manuf	-200	-190		Reev. Manuf	-190	-190	
Cons. Climate Capital	0	0		Cons. Climate Capital	-15	0	
Cons. Carbon Budget	0	0		Cons. Carbon Budget	-10	0	
Total flows	-300	-275		Total flows	-300	-275	

Beyond GDP extension

- Loss induced by climate degradation for households : -9

Households: consume a flow of climate services, and therefore suffer the damage associated with climate change when this flow is reduced.

Standard Account				Extended Account			
	Year 1	Year 2	variation		Year 1	Year 2	variation
Income	300	275	-25	Income	300	275	-25
				Climate Services	9	0	-9
				GHG emission rights	0	0	0
Consumption	300	275	-25	Monetary Consumption	300	275	-25
				Extended Consumption	309	275	-34
Emissions				Emissions			
GHG Emissions	1	0	-1	GHG Emissions	1	0	-1

Use Table			
	Year 1	Year 2	variation
Agriculture	15	0	-15
Manufacturing	0	0	0
Households (beyond GDP)	9	0	-9
Production Account			
	Year 1	Year 2	variation
Production	24	0	-24
No input			
Adjusted Added Value (within GDP)	15	0	-15
Extended Added Value	24	0	-24

Emissions Account			
	Year 1	Year 2	
Opening stock	100	103	
Emissions	3	0	
Closing stock	103	103	
Asset valuation			
	Year 1	Year 2	
Opening value	24	0	
Depletion	-24	0	
Closing value	0	0	

- Taking into account the deterioration in household services increases the decline in Extended Value Added
- Recorded from year 1, via the deterioration in the quality of the climate: the consumption of natural capital further reduces the value of the climate

GDP:

- Extended GDP is higher than GDP: climate services to households taken into account.

ADJUSTED NDP:

- Consumption of climate capital accounted for in the previous year
- Decline in value well recorded at the date of emissions
- Same emissions, but greater decline in value because damage to households accounted for

WEALTH:

- Extended wealth different (higher) than conventional wealth

Standard Account				Extended Account			
Production Approach				Production Approach			
	Year 1	Year 2	variation		Year 1	Year 2	variation
Agriculture	100	85	-15	Agriculture	85	85	0
Manufacturing	200	190	-10	Manufacturing	190	190	0
				Climate	24	0	-24
				Carbon Regulator	10	0	-10
GDP	300	275	-25	GDP adjusted-extended	309	275	-34
				Cons. Climate Capital	-24	0	
				Cons. Carbon Budget	-10	0	
NDP	300	275	-25	NDP adjusted-extended	275	275	0
Asset Accounts				Asset Accounts			
	Year 1	Year 2			Year 1	Year 2	
Opening Value				Opening Value			
Agriculture	185	85		Agriculture	170	85	
Manufacturing	390	190		Manufacturing	380	190	
Climate				Climate	24	0	
Carbon Regulator				Carbon Regulator	10	0	
Total Assets	575	275		Total Assets	584	275	
Flows				Flows			
Reev. Agriculture	-100	-85		Reev. Agriculture	-85	-85	
Reev. Manuf	-200	-190		Reev. Manuf	-190	-190	
Cons. Climate Capital	0	0		Cons. Climate Capital	-24	0	
Cons. Carbon Budget	0	0		Cons. Carbon Budget	-10	0	
Total flows	-300	-275		Total flows	-309	-275	

The SNA balance sheet already incorporates some future damages through the market valuation of assets

- The adaptation only makes these damage costs more visible
 - Value is transferred between old agents and new agents : externalities may affect prices, but not the value added or the wealth of the whole economy
 - Costs are seen as consumption of assets (climate and carbon budget) : adjusting net indicators, i-e net domestic product (NDP) or net savings (NS)
- **Both damage and mitigation costs should be considered**
- There are GHG emissions that increase future damages : climate asset
 - There are mitigation policies that limit GHG emissions : carbon budget
 - Accounting rules differ with respect to sectors that emit or are victims of GHG emissions (some sectors can be both)
 - This is not a marginalist interpretation (effect of a supplementary ton wrt a reference situation)
- **Accounting for damages made to household (« beyond ») modifies the standard indicators**
- Beyond the production boundary of SNA
 - Extended consumption : closer to « well-being »

ELEMENTARY COMPONENTS :

- **Value of Climate Services :** $A_{s,p,\tau}(S_t^{C02}) \approx \bar{A}_{s,p} - c_{s,p,\tau}(S_t^{C02}, I_t)(S_\tau^{C02} - S_{t_0}^{C02})$

$c_{s,p,\tau}$ is the marginal cost of carbon stock of sector **s** at date τ ,
 $\bar{A}_{s,p}$ normalised to 0 at date t_0

- **Value of emission rights :** $m_{s,p,t}E_{s,p,t}$

m_{spt} is the marginal abatement cost and E_{spt} the GHG emissions
 Both can be extended to Households

- **Adjusted added value of sector s at date t**

$$VAA_{s,p,t} = VA_{s,p,t} + c_{s,p,t}(S_t^{C02}, I_t)(S_t^{C02} - S_{t_0}^{C02}) - m_{s,p,t}E_{s,p,t}$$

- **Extended and added value of**

- « Climate » sector: $VAE_{Clim,p,t} = -(S_t^{C02} - S_{t_0}^{C02}) \sum_{s,M} c_{s,p,t}(S_t^{C02}, I_t)$

- Carbon Regulator: $VAE_{Reg,p,t} = \sum_{s,M} m_{s,p,t}E_{s,p,t}$

– Total Extended Adjusted Added Value (including households):

$$VAE_{Tot,p,t} = VAE_{Atm,p,t} + VAE_{Reg,p,t} + \sum VAA_{s,p,t}$$

$$VAE_{Tot,p,t} = \sum_{s,M} -(S_t^{CO2} - S_{t_0}^{CO2})c_{s,p,t}(S_t^{CO2}, I_t) + \sum_{s,M} m_{s,p,t}E_{s,p,t} \\ + \sum_s VA_{s,p,t} + c_{s,p,t}(S_t^{CO2}, I_t)(S_t^{CO2} - S_{t_0}^{CO2}) - m_{s,p,t}E_{s,p,t}$$

$$VAE_{Tot,p,t} = -(S_t^{CO2} - S_{t_0}^{CO2})c_{M,p,t}(S_t^{CO2}, I_t) + m_{M,p,t}E_{M,p,t} + VA_{Tot,p,t}$$

– Assets Value :

$$R_{s,p,t} = \sum_{\tau=t}^{\infty} \frac{VA_{s,p,\tau}}{(1+r)^{\tau-t}}$$

– Extended Assets Value :

$$RA_{p,t} = R_{p,t} + \sum_{\tau=t}^{\infty} \frac{-(S_{\tau}^{CO2} - S_{t_0}^{CO2})c_{M,p,\tau}(S_{\tau}^{CO2}, I_{\tau}) + m_{M,p,\tau}E_{M,p,\tau}}{(1+r)^{\tau-t}}$$

EMISSIONS : $E_{s,p,t}$

- Current emissions permanently increase the stock of CO₂ at every future date
- Climate Damage :

$$-E_{s,p,t} \sum_{\tau=t}^{\infty} \frac{\sum_{s,M} c_{s,p,\tau}(S_t^{CO_2}, I_t)}{(1+r)^{\tau-t}} = -E_{s,p,t} C_p(S_t^{CO_2}, I_t)$$

- We find the social cost of carbon: possible separation 'Within GDP' and 'Beyond GDP' (by isolating the effect on households)
- Emissions have an effect on the discounted sum of future income
- Depends on the future emissions scenario (incorporating the effects of mitigation policies)
- The within-GDP current damage (at date t) is implicitly counted in the GDP.

EMISSIONS : $E_{s,p,t}$

– Mitigation policies: Effect via the carbon budget

Valuation of the regulator : discounted sum of revenue streams

$$\sum_{\tau=t}^{\infty} \frac{\sum_{s,M} m_{s,p,\tau} E_{s,p,\tau}}{(1+r)^{\tau-t}} = \sum_{\tau=t}^{\infty} \frac{\gamma_{\tau} E_{Tot,p,\tau}}{(1+r)^{\tau-t}} = \gamma_t \sum_{\tau=t}^{\infty} E_{Tot,p,\tau} = \gamma_t BC_{t,p}$$

where emissions are the result of the constrained optimisation programme and $\gamma_{\tau} = (1+r)^{\tau-t} \gamma_t$ is the shadow price of carbon.

- Interpretation :
 - Discounted gains to the economy from benefiting from a carbon budget / situation without emissions
 - Gains (or losses) are valued in the economy's assets ('within'), but not isolated
 - Measure of the effort to be made by the economy to decarbonise completely
 - The shadow price is established as a function of the carbon budget
 - In the absence of a mitigation policy, zero value
- Emissions lead to a reduction in the carbon budget by volume

– Adjustment of macro indicators:

- **Capital loss linked to emissions:**
 - **Damage: directly via the cost function**
 - **Mitigation policies: depletion of the carbon budget, valued at the shadow price if it corresponds to the optimal path**
- **Coexistence of the 2 losses because :**
 - **Emissions cause damages despite mitigation policies**
 - **Mitigation policies restrict the economy despite allowed emissions**
- **Accounting decomposition**
 - **Says nothing about how mitigation policies are decided (based on expected damage)**
 - **Distinction from Integrated Assessment Models**

- **GHG emissions as capital consumption**
 - **Climate asset:** as they degrade climate assets, emissions are treated as a form of capital consumption
 - **Effect of French emissions on Global Wealth :** production-based approach, referred to as **CNC-World, Attribution**
 - **Effect of Global emissions on French Wealth:** income-based approach, referred to as **CNC-Fr, Adjustment**
 - **Carbon budget :** emissions make mitigation policies more stringent, referred to as **CCB**
 - In both approaches, emissions lead to a decline in wealth, which negatively affects adjusted economic indicators
- **Adjusted indicators of economic activity :** reflect the sustainability of activity a given year
 - **Net Domestic Product (NDP):** $GDP - \text{Consumption of fixed capital (CFC)}$
 - **Adjusted NDP (NDPA) :** $NDP - \text{CNC-World} - \text{CCB}$
 - **Net Savings :** $\text{Gross Disposable Income (GDI)} - \text{Final Consumption} - \text{CFC}$
 - **Adjusted Net Savings (NSA) :** $\text{Net Savings} - \text{CNC-Fr} - \text{CCB}$

GHG EMISSIONS INVENTORY AND FOOTPRINT (INSEE AND SDES)

- **Production-based approach :**
 - Air emission accounts with monetary production and value added
- **Demand-based approach :**
 - Carbon footprint with monetary final demand (use of the MRIO model FIGARO)

Figure 1 - Greenhouse gases (GHG) emissions in France and globally

GHG emissions	2018	2019	2020	2021	2022	2023
Emissions by resident economic units (France, Mt CO ₂ eq)	475	464	416	440	427	403
Territorial emissions - inventory in SNBC format (Mt CO ₂ eq)	439	429	389	412	396	373
Carbon Budget based on SNBC 2 (Gt CO ₂ eq)	8,1	7,7	7,2	6,9	6,4	6,0
Carbon Meter (Mt CO ₂ eq)	-18	-31	-77	-87	-100	-123
Footprint (France, Mt CO ₂ eq)	704	691	620	666	671	644
Cumulative footprint since 1850 (Gt CO ₂)	37,2	37,9	38,6	39,2	39,9	40,5
Global emissions (Gt CO₂ eq)	51,0	51,3	49,3	51,6	52,0	53,0

PRICES (EXTERNAL INFORMATION)

- Social cost of carbon : Rennert et al. (Nature, 2022)
- Information on the elementary components of the damage function.
- Decomposition between within GDP and beyond GDP (mortality effects)
- High uncertainty

SHADOW PRICE OF CARBON : QUINET (2019), « CLIMATE ACTION VALUE »

- Based on technico-economic and macro-economic models (abatement costs)
- Strongly dependent on the mitigation policies and their implementation

Figure 2 - Social cost of carbon and value of climate action (VCA - shadow price of carbon)

in current euros/ton CO₂ eq

Carbon price	2018	2019	2020	2021	2022	2023
Social cost of carbon	146	149	154	157	162	172
Within the GDP boundary	77	78	81	82	85	90
Beyond the GDP boundary	70	71	73	75	77	82
Value of Climate Action (VCA)	109	115	124	131	141	154

Figure 3 - Contribution of emissions to the adjustment of NDP and net savings

in billions of current euros

Contributions and aggregated and extended indicators	2018	2019	2020	2021	2022	2023
Global damage linked to French emissions	70	69	64	69	69	69
Within the GDP boundary (A)	37	36	34	36	36	36
Beyond the GDP boundary (AH)	33	33	30	33	33	33
Global damage linked to France's carbon footprint	104	103	96	104	109	111
Within the GDP boundary	54	54	50	55	57	58
Beyond the GDP boundary	49	49	45	50	52	53
Damage in France linked to global emissions	225	230	229	243	254	274
Within the GDP boundary (B)	118	120	120	127	133	144
Beyond the GDP boundary (BH)	107	109	109	116	121	131
Consumption of the carbon budget (C)	48	49	48	54	56	57
Aggregated and extended indicators						
Net domestic product (NDP)	1 951	2 010	1 882	2 047	2 153	2 294
Adjusted net domestic product (ANDP), (NDP-(A+C))	1 867	1 924	1 800	1 957	2 061	2 200
Extended ANDP, (ANDP-AH)	1 833	1 892	1 770	1 924	2 028	2 167
Net savings (NS)	111	148	48	129	89	68
Adjusted net savings (ANS), (NS-(B+C))	-55	-21	-120	-52	-100	-133
Extended ANS (ANS-BH)	-162	-130	-229	-168	-221	-264

Notes: The figures shown in this table result from the authors' calculations and are based on past figures. The valuation of the damage caused in France by global emissions is based on its share of global GDP, which amounts to 3%. These are orders of magnitude that may be considerably altered with the use of more precise sources seeking to evaluate damage specific to France. The extended ANDP and ANS also serve to reduce them for damage occurring **beyond** the GDP boundary.

An adjustment of -94 bn€ to move from NDP to NDPA -201 bn€ to move from NS to ANS

Net domestic product reduced by 94bn€, i.e. -4,1%

If we extend 'beyond the production frontier' to take account of health/morbidity costs

→ -5,5%

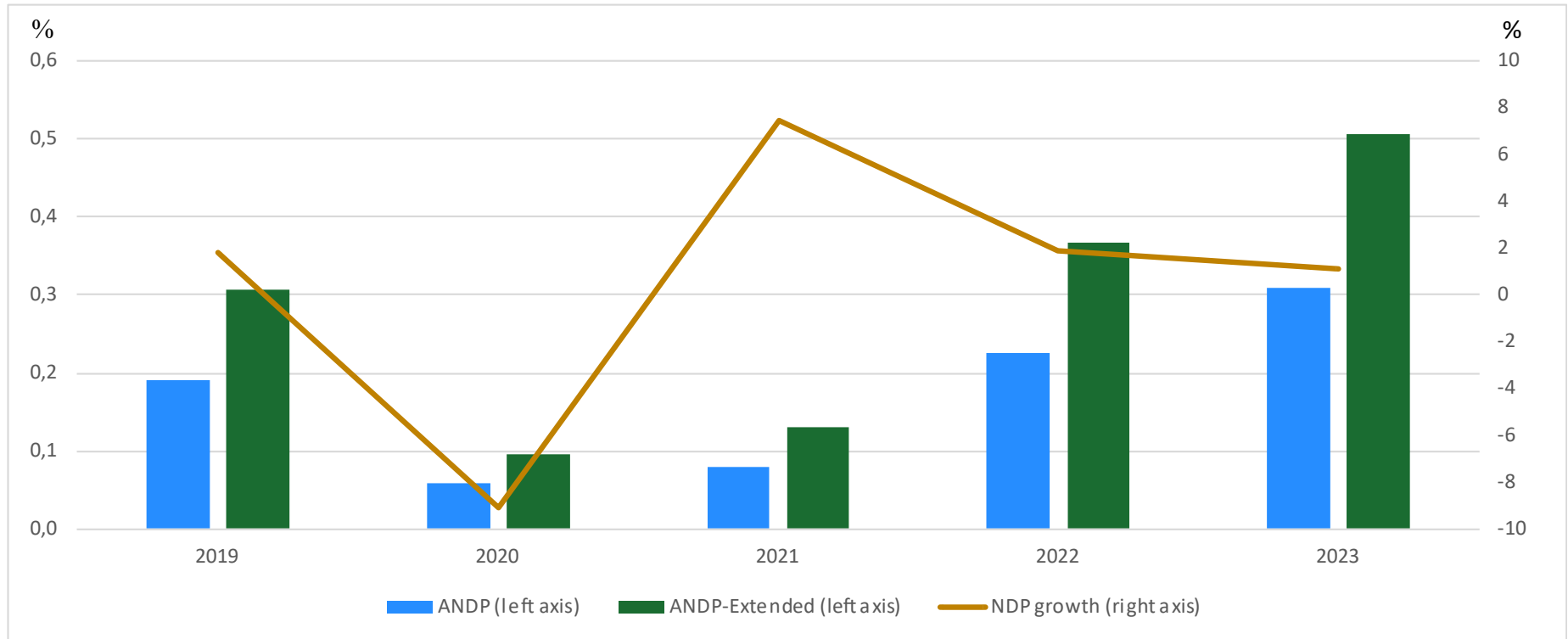


Adjusted net savings of around €200bn

Negative adjusted net savings, unlike usual savings

→ Indicates a lack of sustainability!

Volume growth differential between NDP and Adjusted/Extended NDP



Volume growths of the ANDP and extended NDP are estimated by holding the prices of their components constant at the base date and considering only changes in volumes (eg GHG emissions in teq CO2)

– Carbon meter :

- Valuation (at the social cost) of the excess emissions with respect to targets
- Operational use

– Climatic responsibility

- Valuation of the stock of carbon for which France is « responsible » : social cost
- Cumulative French carbon footprint since 1850

– Carbon Budget

- Valuation of the remaining carbon budget using the shadow price of carbon
- Anticipated cost of decarbonising the economy

Figure 5 - Valuation of assets linked to carbon emissions

in billions of current euros

Category	2018	2019	2020	2021	2022	2023
Deterioration of the climate linked to excess emissions - carbon meter	-3	-5	-12	-14	-16	-21
Within the GDP boundary	-1	-2	-6	-7	-9	-11
Outside of the GDP boundary	-1	-2	-6	-6	-8	-10
Retrospective climate responsibility (cumulative footprint)	5 437	5 637	5 942	6 142	6 479	6 964
Within the GDP boundary	2 848	2 953	3 113	3 217	3 394	3 648
Outside of the GDP boundary	2 589	2 684	2 830	2 925	3 085	3 316
Carbon Budget	883	883	897	898	911	929
in GDP points	37	36	39	36	34	33

- **In any case, these synthetic indicators cannot have the same status as the usual national accounting indicators: status of experimental statistics**
 - Strong forward-looking dimension (estimation of prices)
 - Highlighting of two different costs: damage costs and mitigation expenditure
 - Dependence on announced mitigation policies: indicator likely to be significantly revised
 - Estimation of several asset indicators that can be interpreted (differently) as climate debts
- **Goes beyond a simple juxtaposition of indicators:**
 - Clarification of the framework for interpreting the various indicators
 - Is based on prior work to ensure consistency between national accounting indicators and emissions (footprint and inventory), cf. ANA approach
- **Explains the importance of regularly updating :**
 - Damage trajectory affecting France, by sector and household
 - Anticipated emissions trajectory reflecting mitigation policies
 - Shadow price of carbon (climate action value) and Social Cost of carbon

2023 Bns €	Existing Sectors	Adjustment				Extension (households)			
		Regulator	Climate	Total	Climate - RoW	Regulator	Climate	Total	Climate - RoW
Production	5573,7	41,8	-8,6	5606,9	-2,3	15,6	-7,8	5614,7	-2,1
<i>Standard Inputs</i>	2751,2			2751,2				2751,2	
<i>Adjusted Inputs</i>	33,2			33,2				33,2	
GDP (standard)	2822,5								
Value Added (adjusted)	2789,3	41,8	-8,6	2822,5		15,6	-7,8	2830,3	
<i>Consumption of Capital</i>	528,8	41,8	141,3	711,9	35,2	15,6	128,5	856,0	32,0
<i>Attributed Consumption of Capital</i>	528,8	41,8	35,2	605,8		15,6	32,0	653,3	
Net Domestic Product	2293,7			2293,7					
Adjusted NDP	2260,5	0,0	-149,9	2110,6		0,0	-136,3	1974,3	
<i>Attributed NDP</i>	2260,5	0,0	-37,5	2223,0		0,0	-34,1	2176,9	
Gross Disposable Income	2822,2	0,0	0,0	2822,2					
Consumption	2225,4	0,0	0,0	2225,4					
Net Savings	596,8	0,0	0,0	596,8					
Adjusted Net Savings	68,0	-41,8	-141,3	-115,1		-15,6	-128,5	-259,2	

Thank you !

insee.fr



Sylvain LARRIEU

Département des comptes nationaux

Sébastien ROUX

Programme des comptes nationaux augmentés