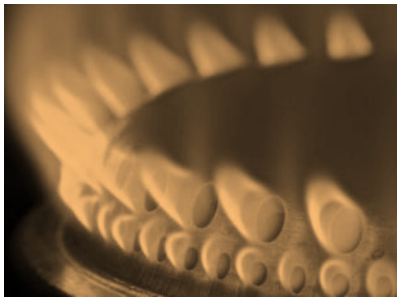
Energy Transition Monitoring: 4 case studies

Enerdata intelligence + consulting

Patrick Criqui,
Senior consulting advisor, Enerdata
Cyril Cassisa
Project manager, Enerdata

1. Observed trends, National Contributions and 2°C trajectories
2. National energy transition dashboards and indicators
3. Energy Transition Monitoring (EnerTraM)… work in progress
4. Three case studies with EnerTraM:
   - ✓ Vietnam
   - ✓ Mexico
   - ✓ Senegal

APPENDIX: France case study

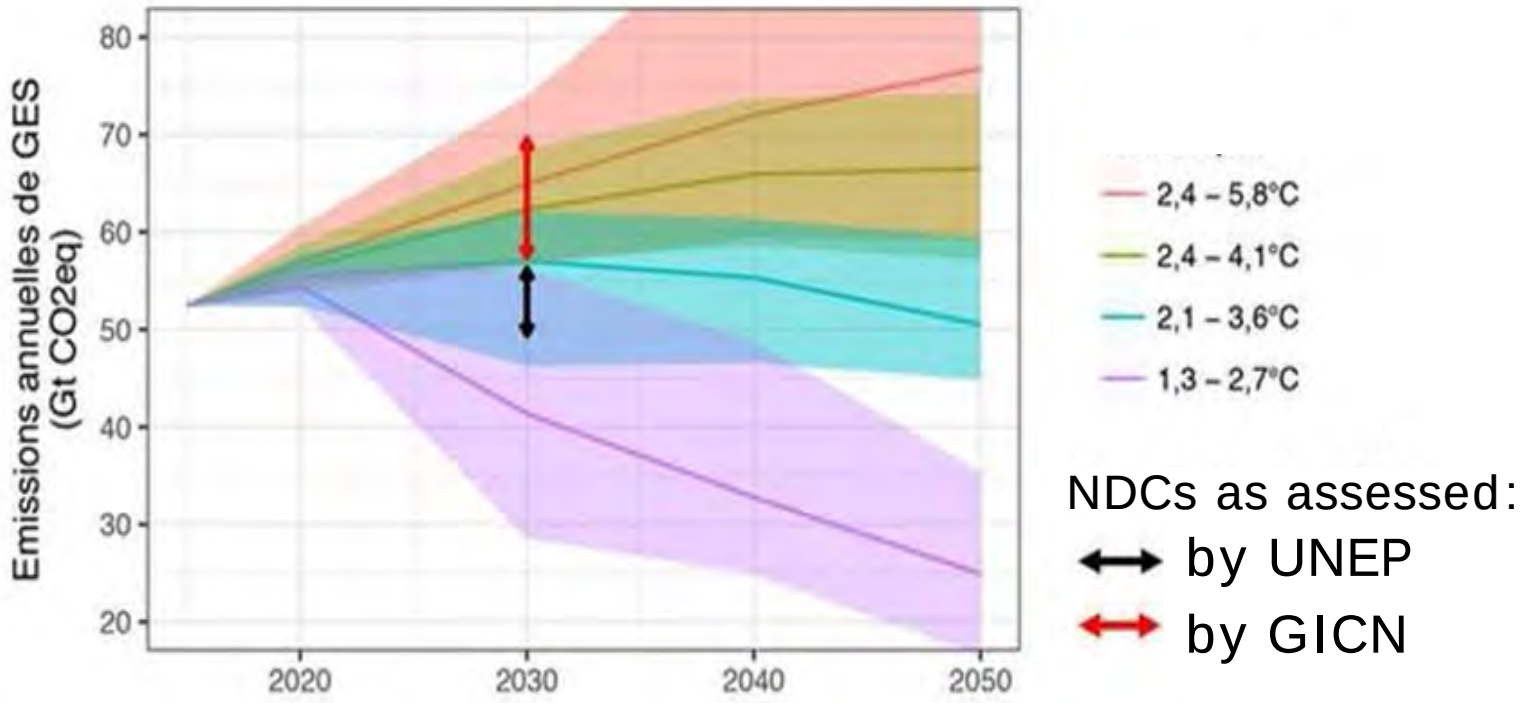



March 2018

Observed trends, National Contributions and 2°C compatible trajectories

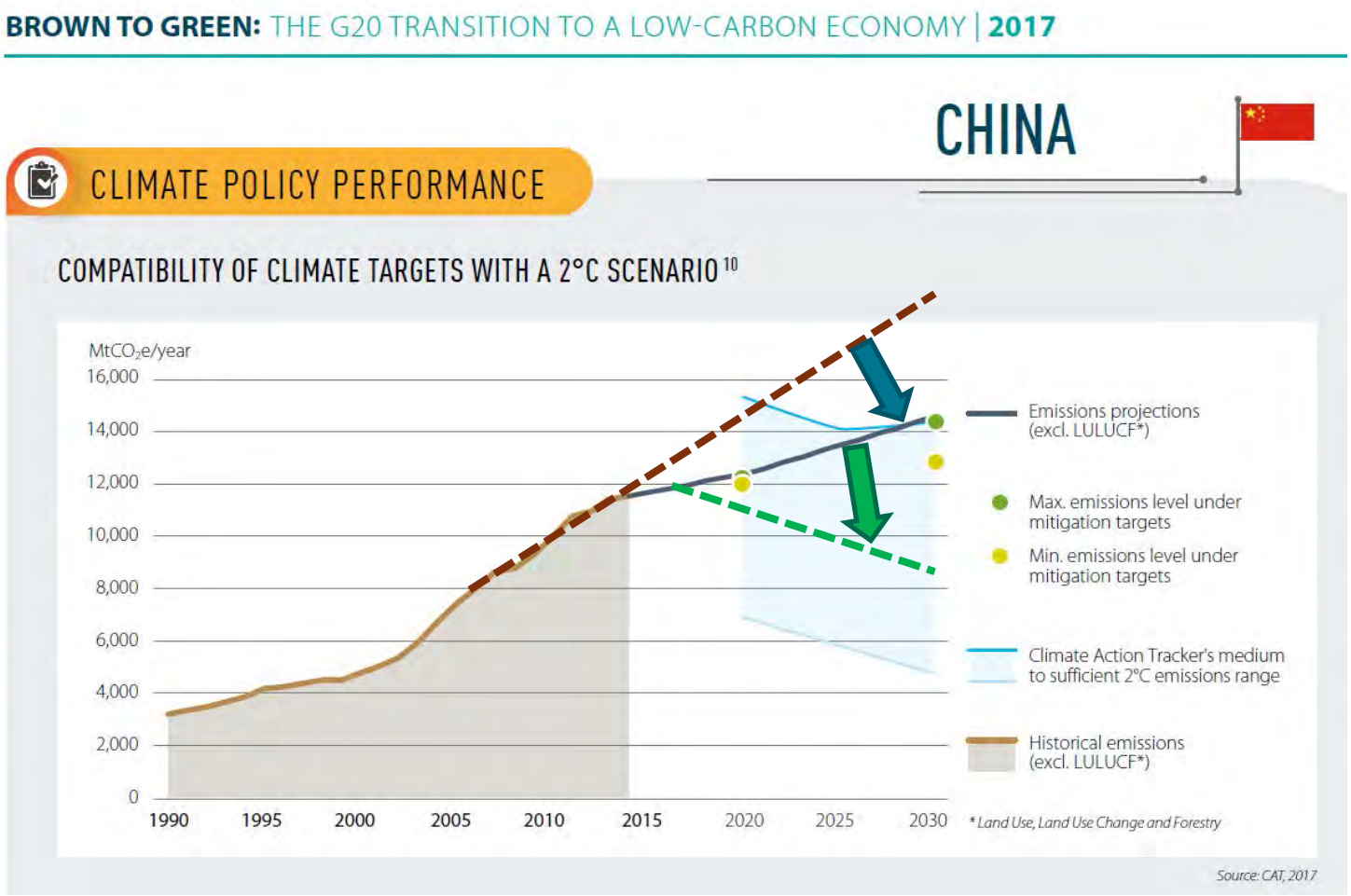
At global level: assessing the gap between NDCs and 2°C scenarios

- In France, the Interdisciplinary Group on National Contributions has performed an assessment of uncertainties in NDCs (Environmental Research Letter, 2018)



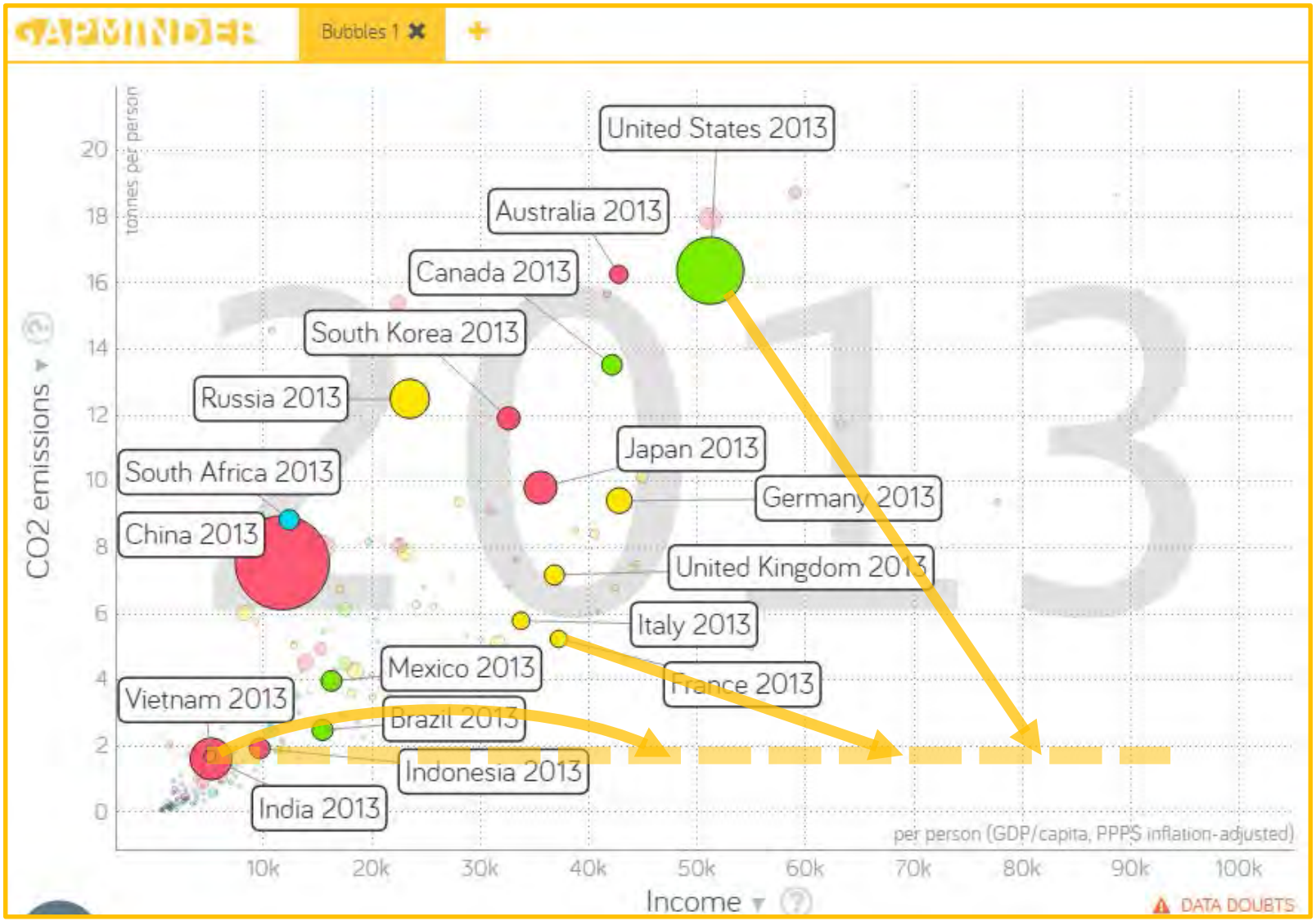
Source GICN

At country level, assessing the “double gap”:
i. between on-going trends and NDCs
ii. between NDCs and 2°C compatible profiles



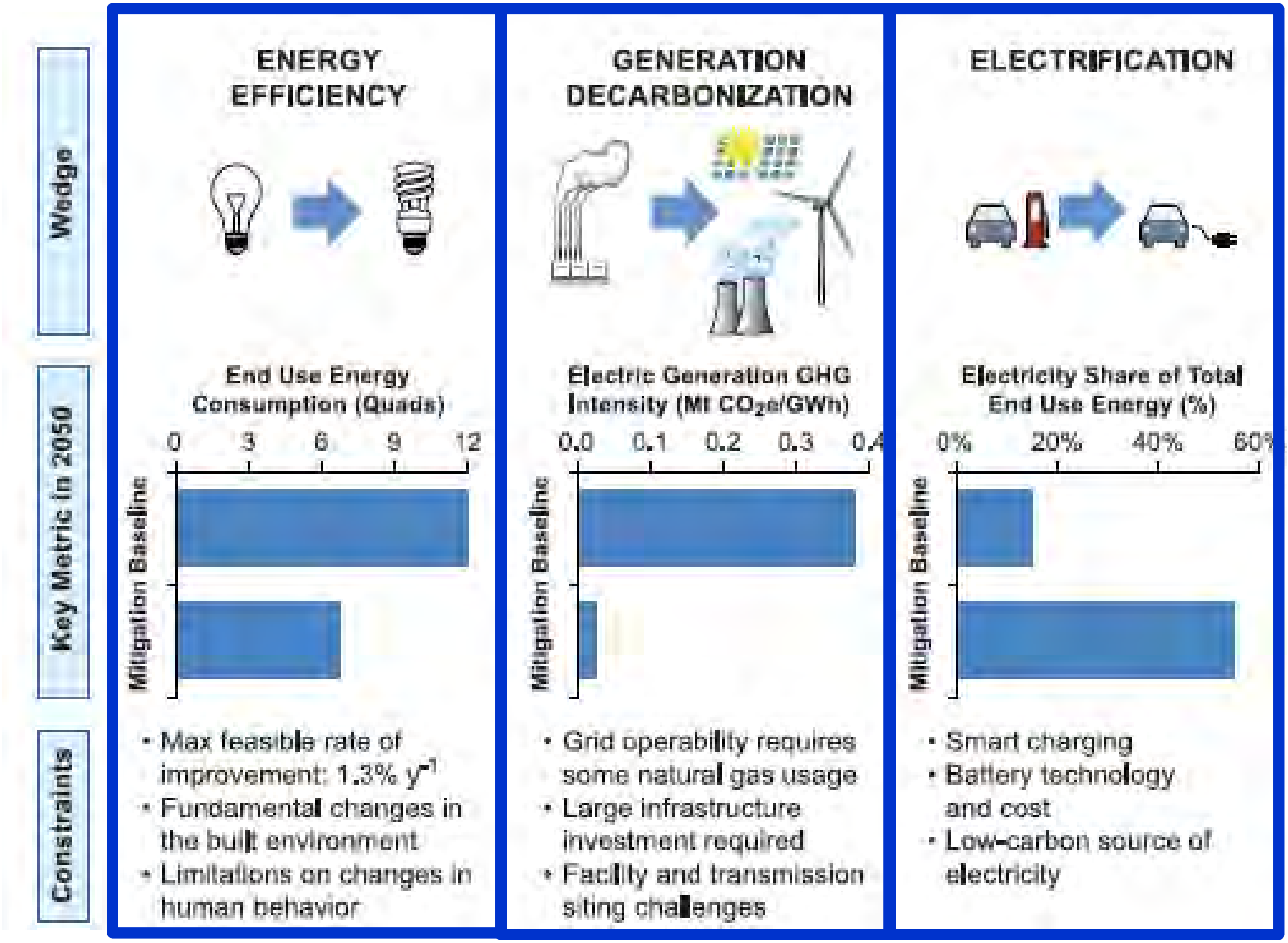
Source: adapted from Climate Transparency

DDPP study: a “focal point” of 1,7 tCO2pc after 2050



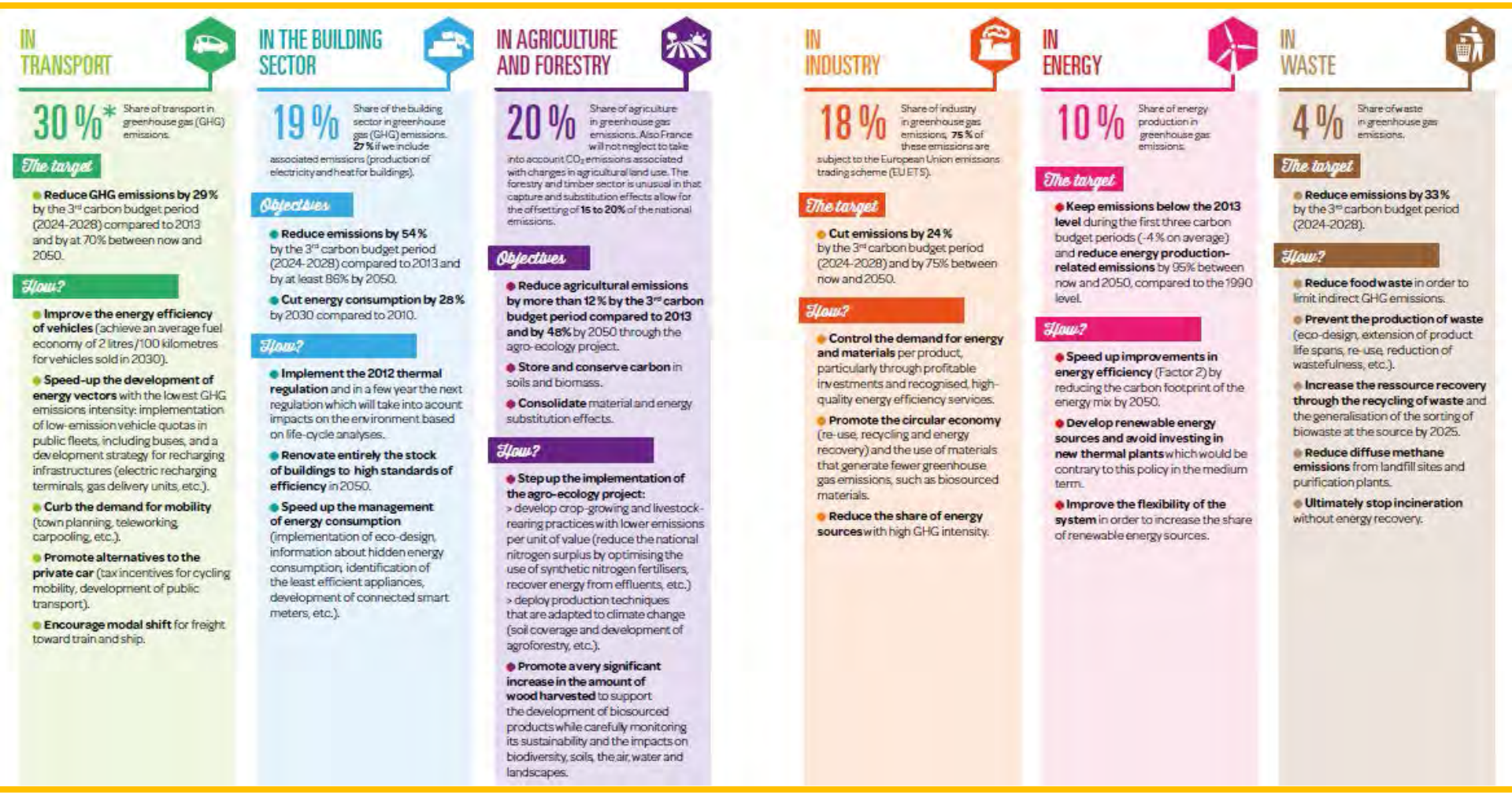
The three pillars of decarbonization

(Jim Williams, E3 San Francisco, Science 2012)



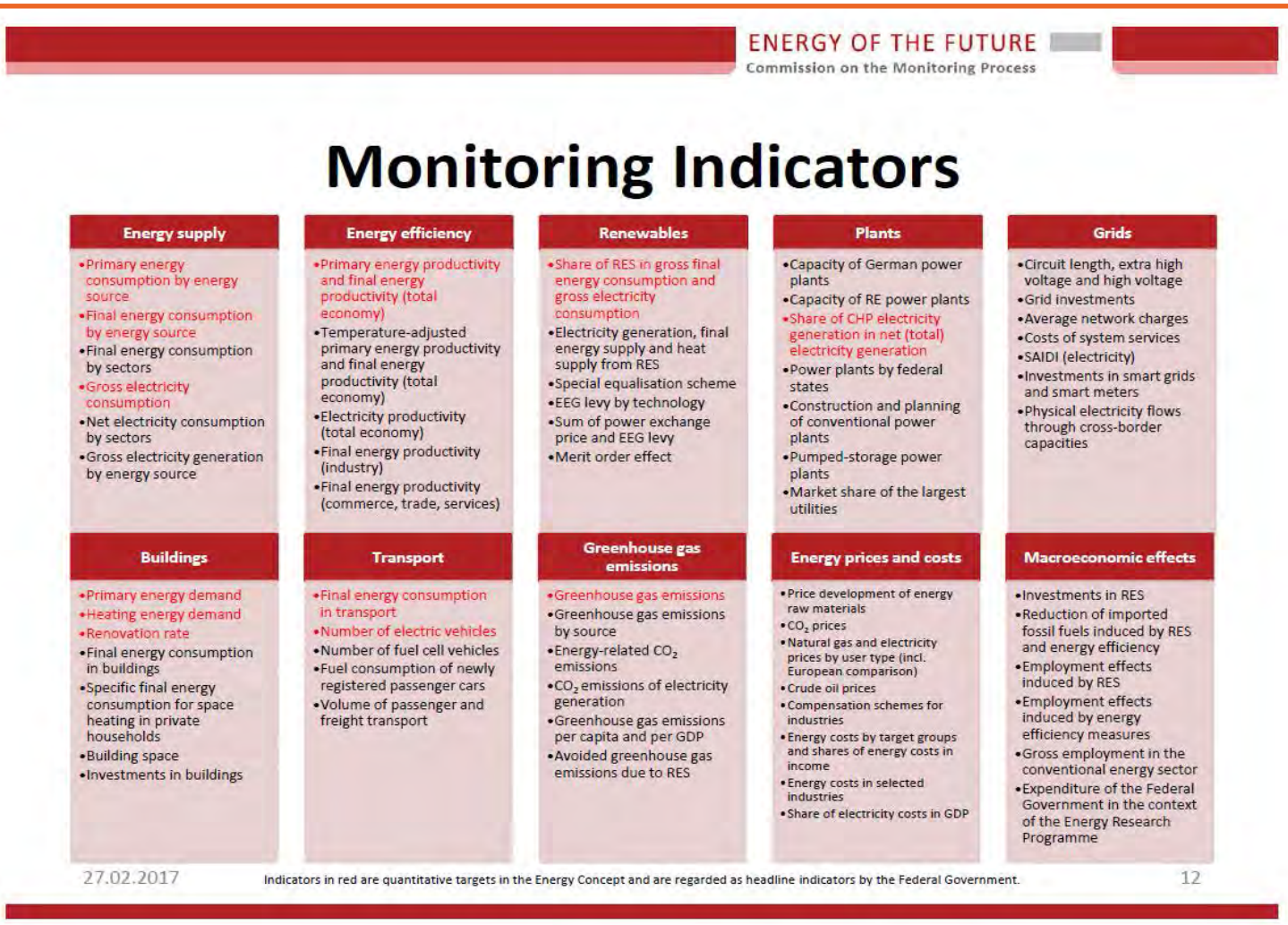
Examples of national energy transiton dashboards and indicators

Monitoring indicators: France



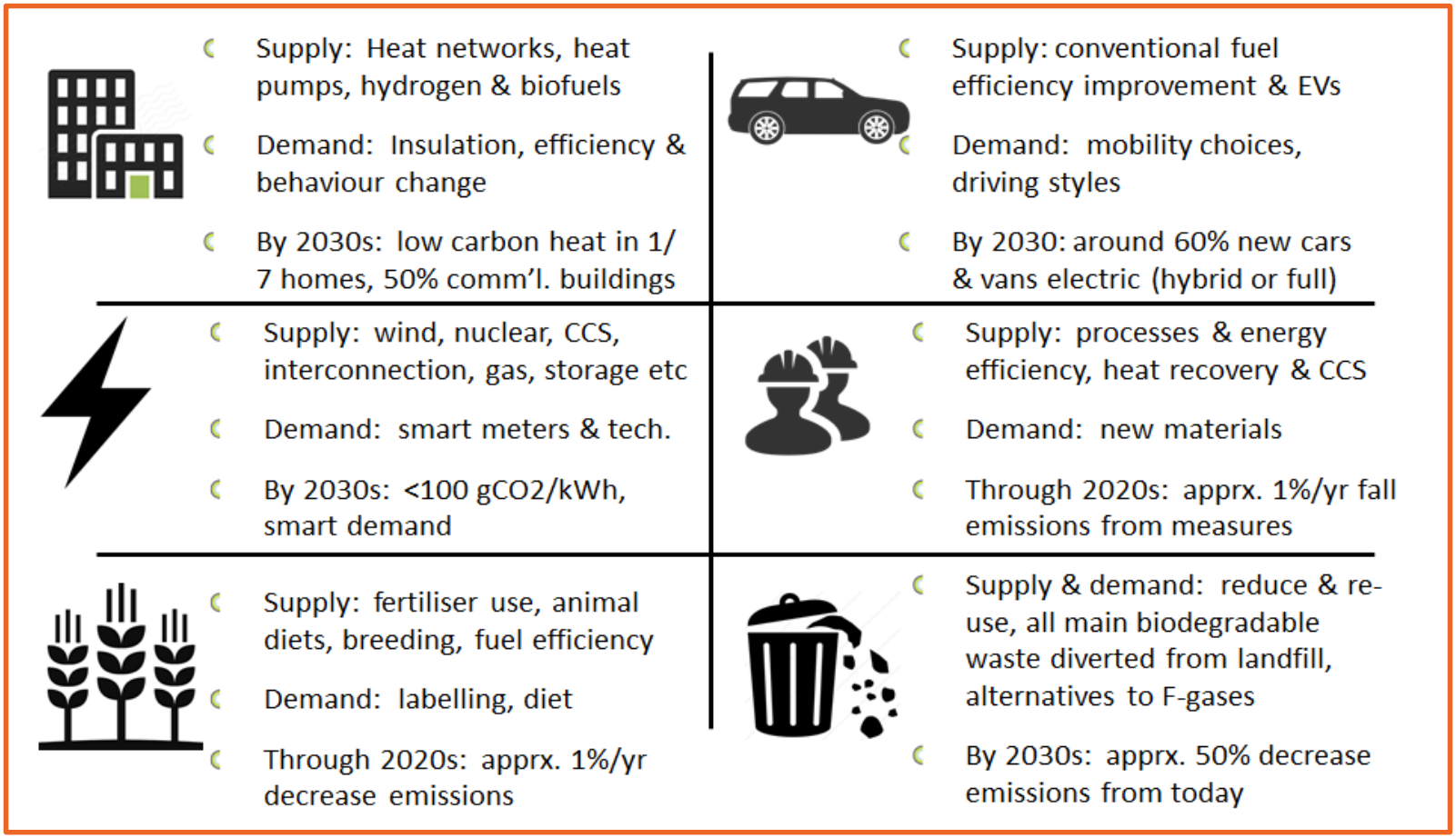
Source: Stratégie Nationale Bas Carbone 2016

Monitoring indicators: Germany



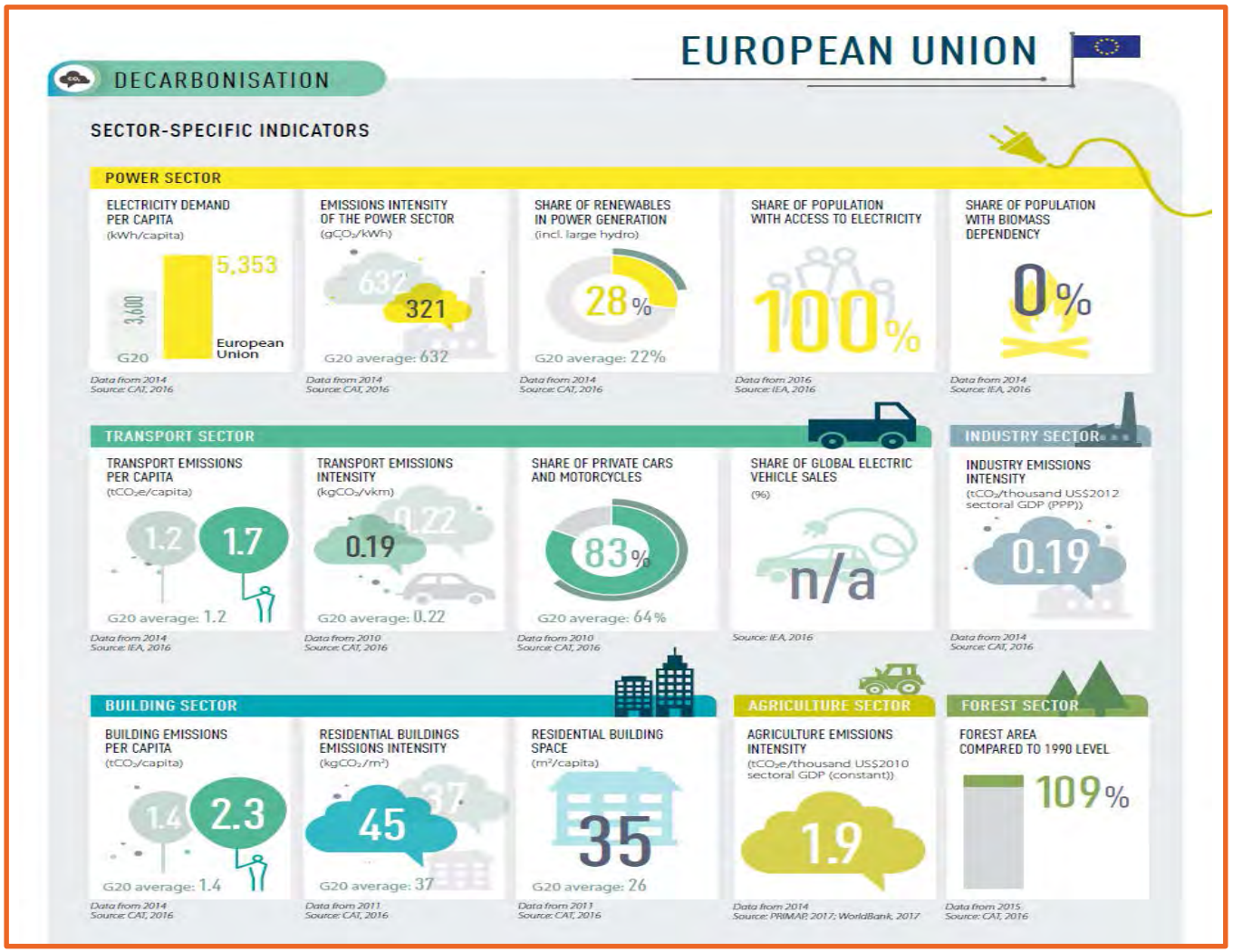
Source: Expertenkommission zum Monitoring "Energie der Zukunft"

Monitoring indicators: United Kingdom



Source: UK – Climate Change Committee

Monitoring indicators: the *Climate Transparency* dashboard



Source: Climate Transparency

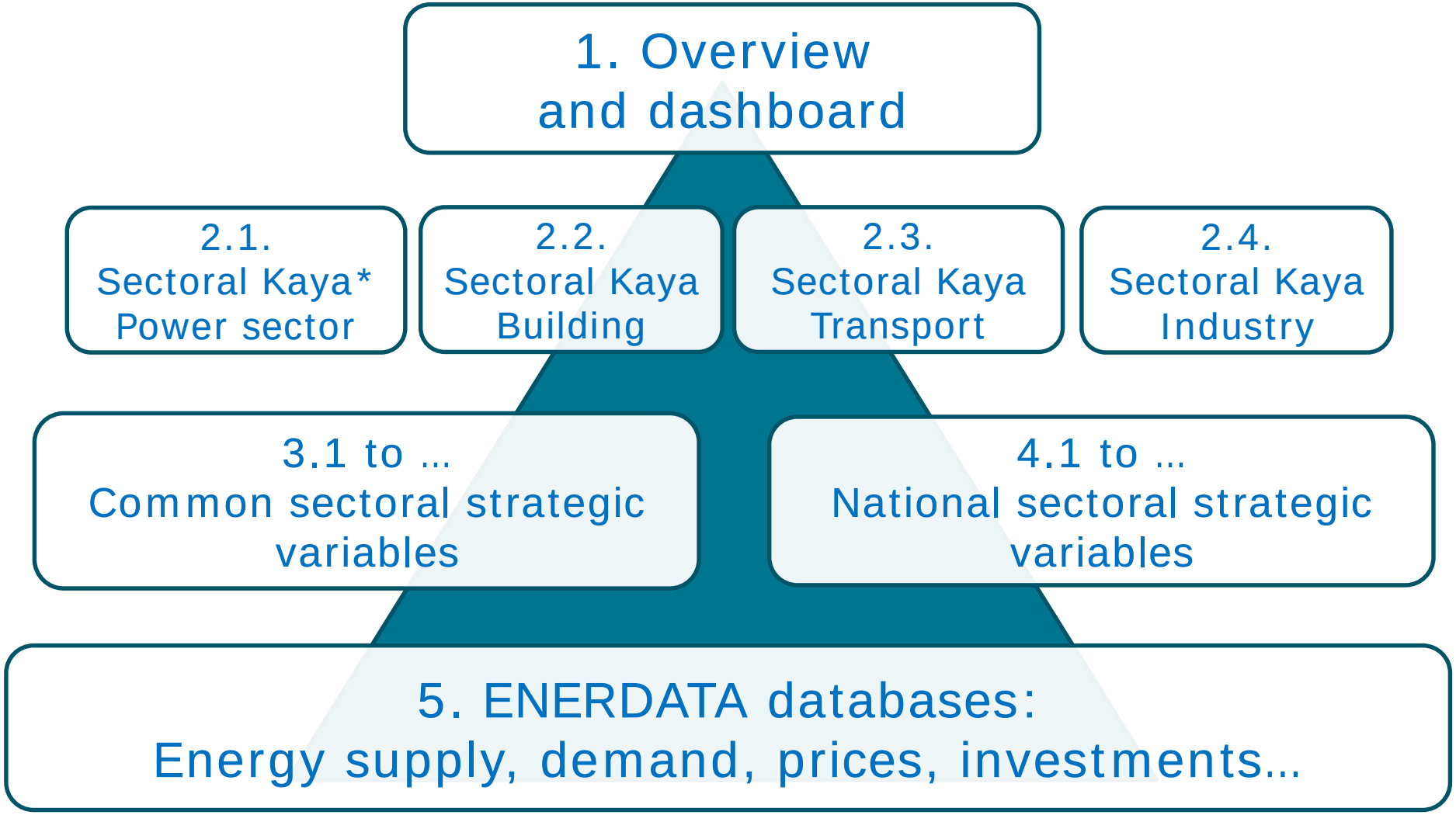
EnerTraM:
Energy Transition Monitoring tool

work in progress...

EnerTraM

- The goal of ENERTRAM is to **develop an information system** with dashboards on: i. on-going trends, ii. sectoral targets and iii. transformation trajectories
- The concept is consistent with the one of **Nationally Determined Contributions (NDCs)** as identified in the Paris Agreement
- It will be highly strategic in the future, with the entry into the phase of **climate policy implementation**
- Through the combination of its **international databases** and of the **EnerFuture scenarios**, ENERDATA is well equipped to ensure the international monitoring of energy transitions

EnerTraM: a set of dashboards



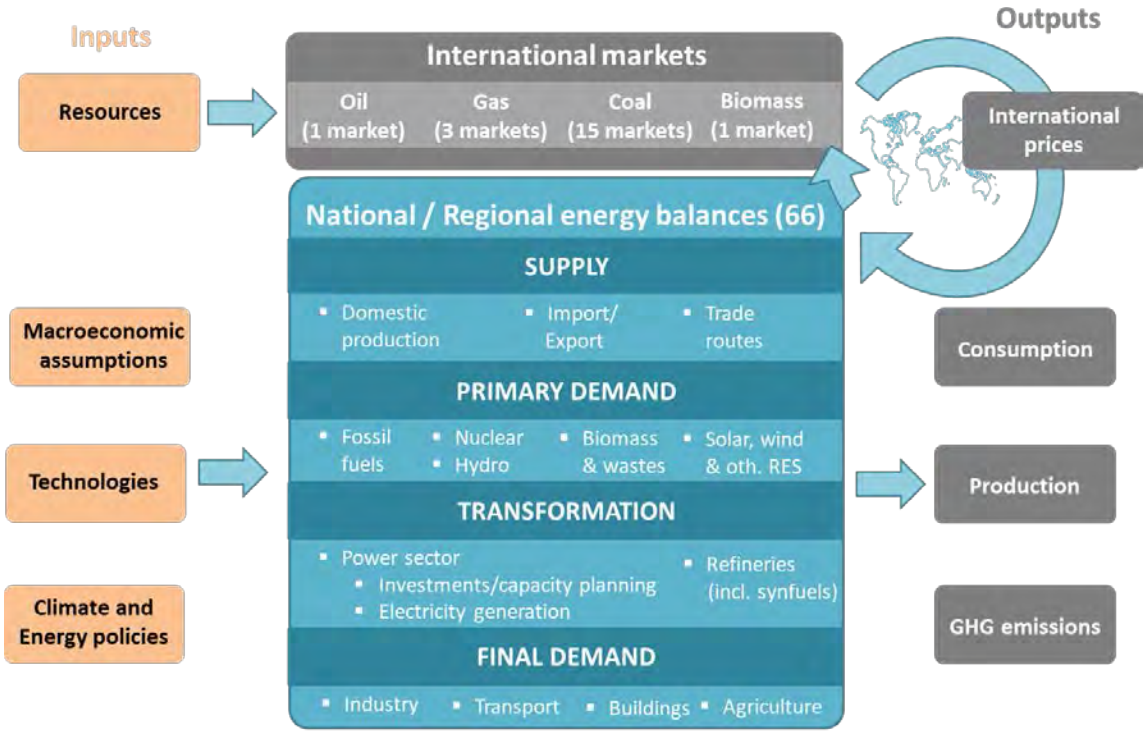
**The Kaya identity identifies the carbon content of energy and the energy content of GDP as key drivers of emissions*

Level 1. A compact dashboard for sectoral strategies

EnerTraM 22 indicators Decarbonization Dashboard						
Headline	GHG emissions per capita (MtCO2e/cap)	CO2 intensity of GDP (tCO2/$)	Carbon factor (tCO2/toe)	Energy intensity of GDP (toe/$)	Primary energy per capita (toe/cap)	Share of fossil fuels in primary energy (%)
Power sector	Electricity demand per capita (kWh/cap)	CO2 factor of the power sector (gCO2/kWh)	Electrification rate (%)	Electrification of final energy mix (%)	Installed coal capacities (GW)	Share of renewables in power generation (incl. large hydro) (%)
Transport and industry	Transport CO2 emissions per capita (tCO2/cap)	Private road transport CO2 emissions per km (gCO2/km)*	CO2 emissions per km of new private vehicules (gCO2/km)*	Kilometer per capita (km/cap)		Industry CO2 emissions intensity of VA (tCO2e/$)
Building, agriculture and LULUCF	Building CO2 emissions per capita (tCO2/cap)	Residential building emission intensity (kgCO2/m2)*	Service building emission intensity of VA (kgCO2/$)		Agriculture GHG emissions intensity of VA (tCO2e/$)	Carbon sinks capacity (MtCO2e)

POLES: an integrated world energy model

- POLES is a world energy model initially developed for the EU Commission and currently used at CNRS, JRC-IPTS and ENERDATA
- The model represents 66 country energy models connected together through international energy market modules
- The model is used to produce ENERDATA's annual outlook **EnerFuture**
- Currently **EnerFuture** represents 3 scenarios:
  - ✓ EnerBrown: fossil intensive
  - ✓ EnerBlue: NDC compatible
  - ✓ EnerGreen: 2°C compatible



Energy transition in Vietnam:

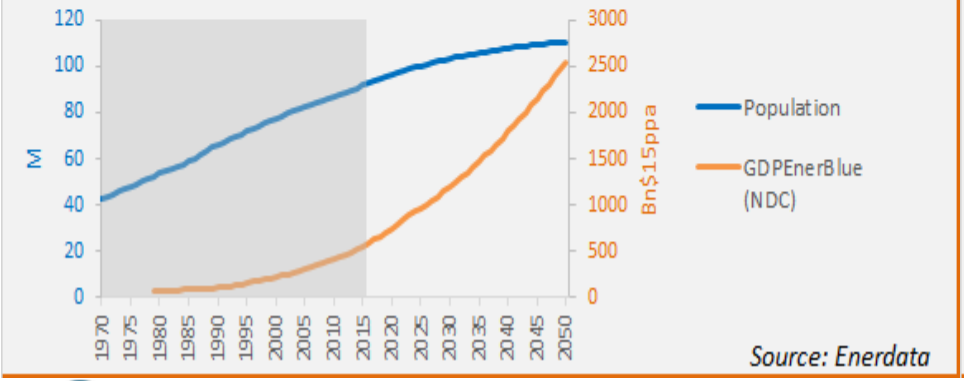
NDC Scenario (EnerBlue)
2°C Scenario (EnerGreen)

Vietnam: Overview

- Vietnam is an emerging nation with 6,4%/yr growth in the past 15 years, a still low urbanization rate, but 98% electrification rate
- This explains a high level of per capita consumption of electricity, with a growth rate of 12% in the 2000-2015 period
- Per capita emissions amount to 2.2 tCO2, i.e. one third of world average

Socio-economic data 2015

Population:	92 million
Population growth since 2000:	18 %
Density:	279 cap/km2
Urbanization rate:	3 %
GDP:	553 Bn$15ppa
Share of industry in GDP:	30 %
Share of services in GDP:	45 %
Share of agriculture in GDP:	24 %



Source: Enerdata

Key energy & climate data 2015

Energy consumption per capita:	0,80	tep/cap
Electrification rate:	98	%
Electricity consumption per capita:	1565	kWh/cap
CO2 emissions (excl. LULUCF):	203	MtCO2e
CO2 emissions (excl. LULUCF) per capita:	2,2	tCO2e/cap

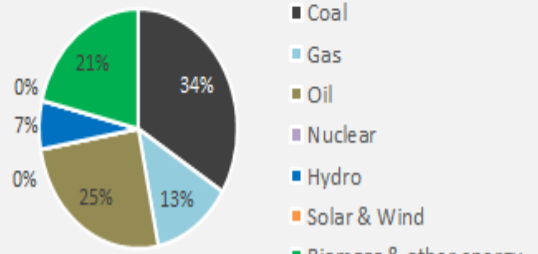
Highlights :

+6.5% annual increase in total primary energy consumption since 2000

+18 GW increase in electricity capacity since 2010

40% of total electricity generation from hydro (2015)

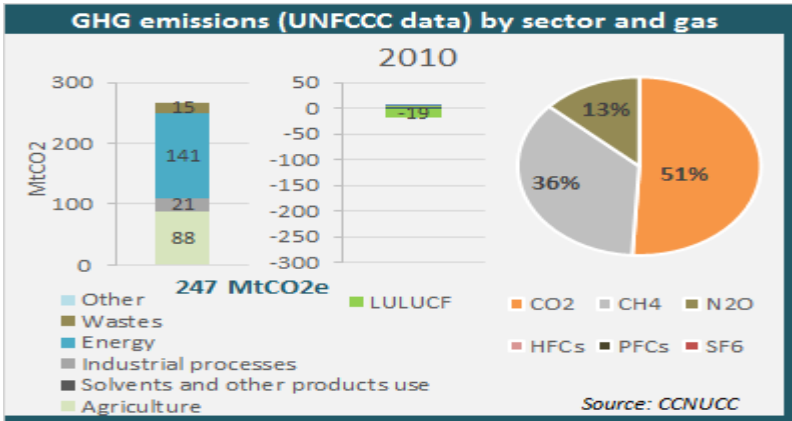
Primary energy mix

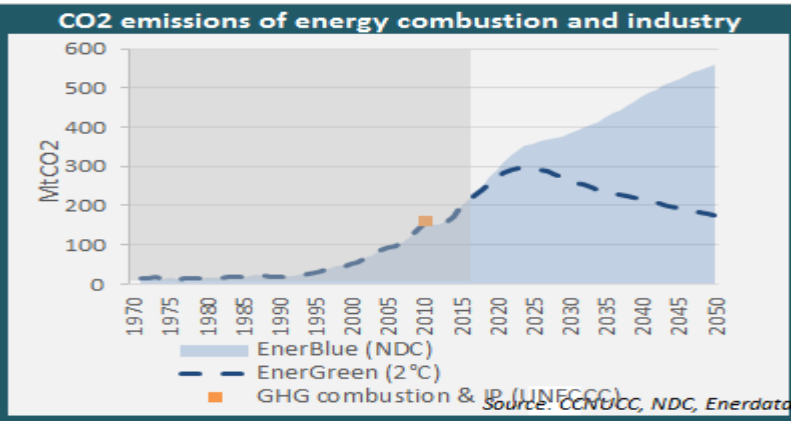


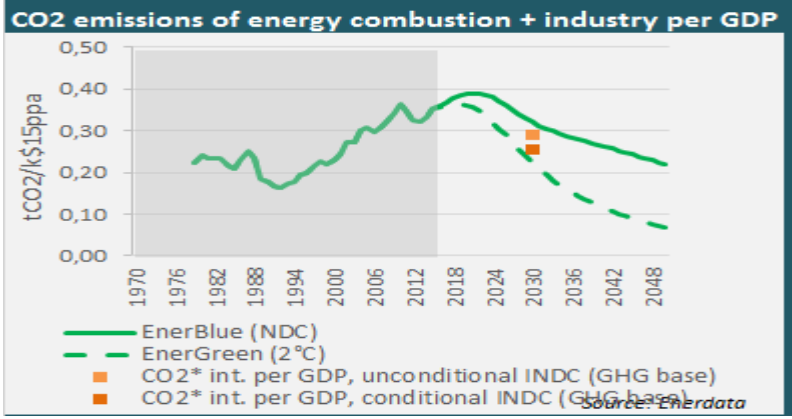
Source: Enerdata

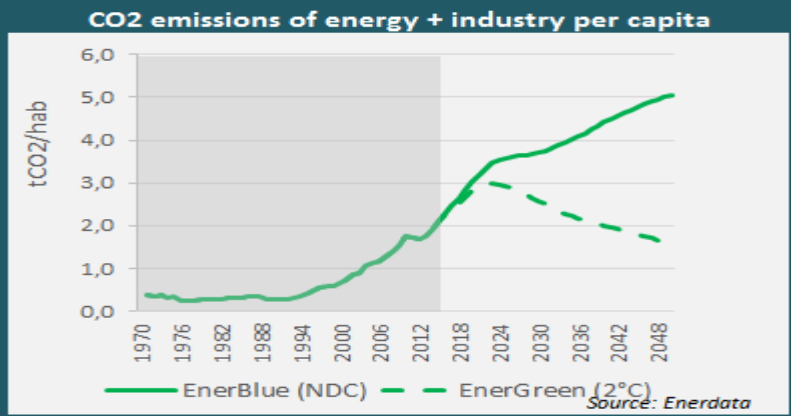
Vietnam: CO2 and GHG emissions

- CO2 represents 51% of total emissions and CH4 from agriculture 36%
- EnerBlue and EnerGreen scenarios are fit to the Vietnam lower and upper ambition NDCs for 2030, but they result in extremely contrasted emission futures in 2050: from 200 to 550-190 MtCO2 and from 2,2 to 5-1,7 t/cap



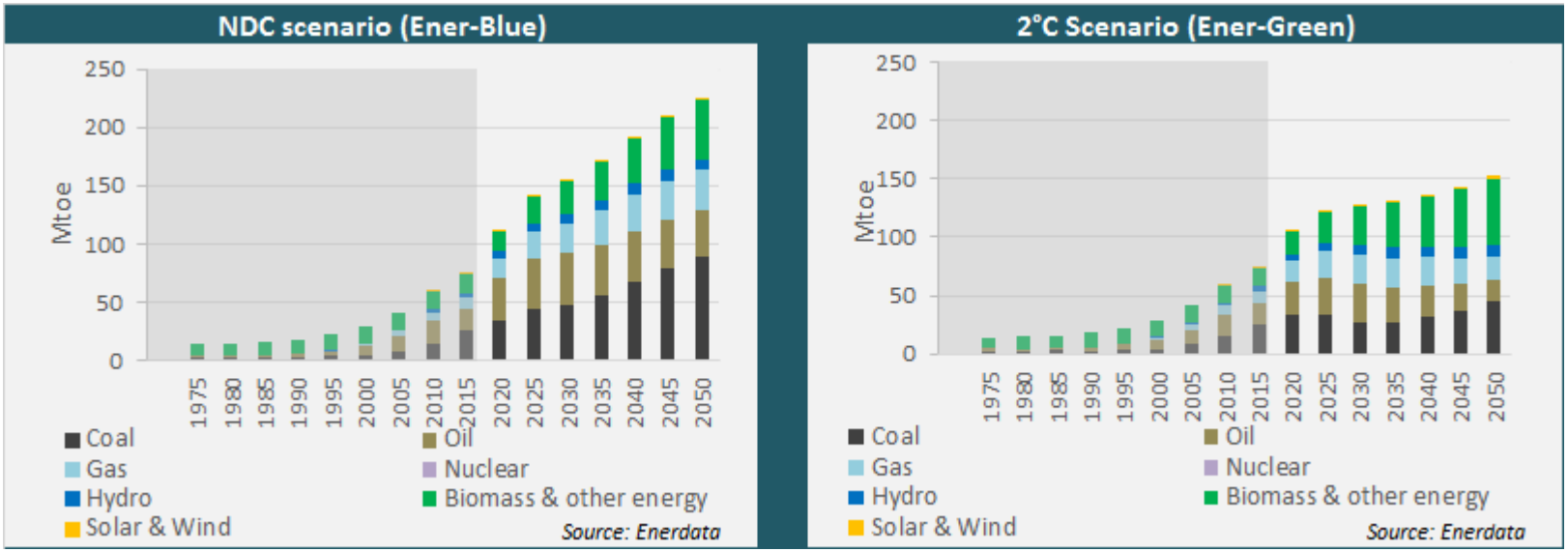






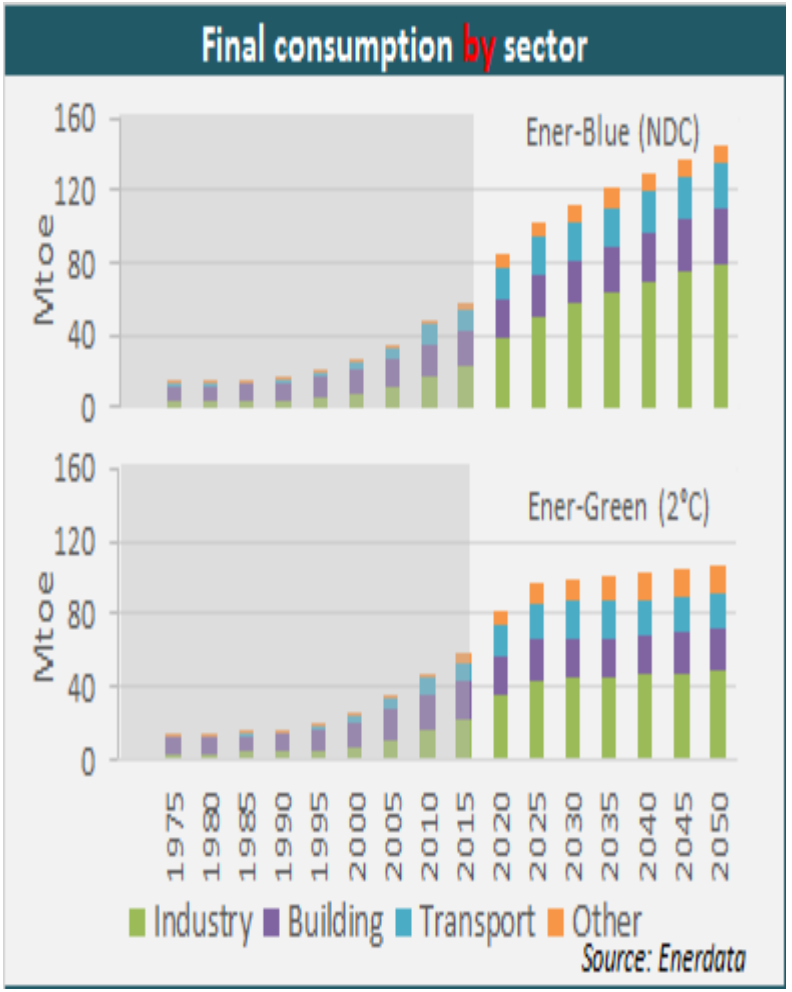
Primary energy by source

- Total primary energy supply, of 75 Mtep in 2015, triplicates in 2050 in EnerBlue (NDC), with coal representing about half of total. In EnerGreen, TPES is only multiplied by a factor of 2 in 2050, with an increased contribution of biomass and twice less coal in absolute terms
- Carbon content of energy has been increasing since 1990 while energy content of GPD remained constant since 2000. Carbon content decreases in EnerBlue and still more in EnerGreen. Energy efficiency improvements limit emissions in EnerBlue and even allow to reduce them after 2025 in EnerGreen



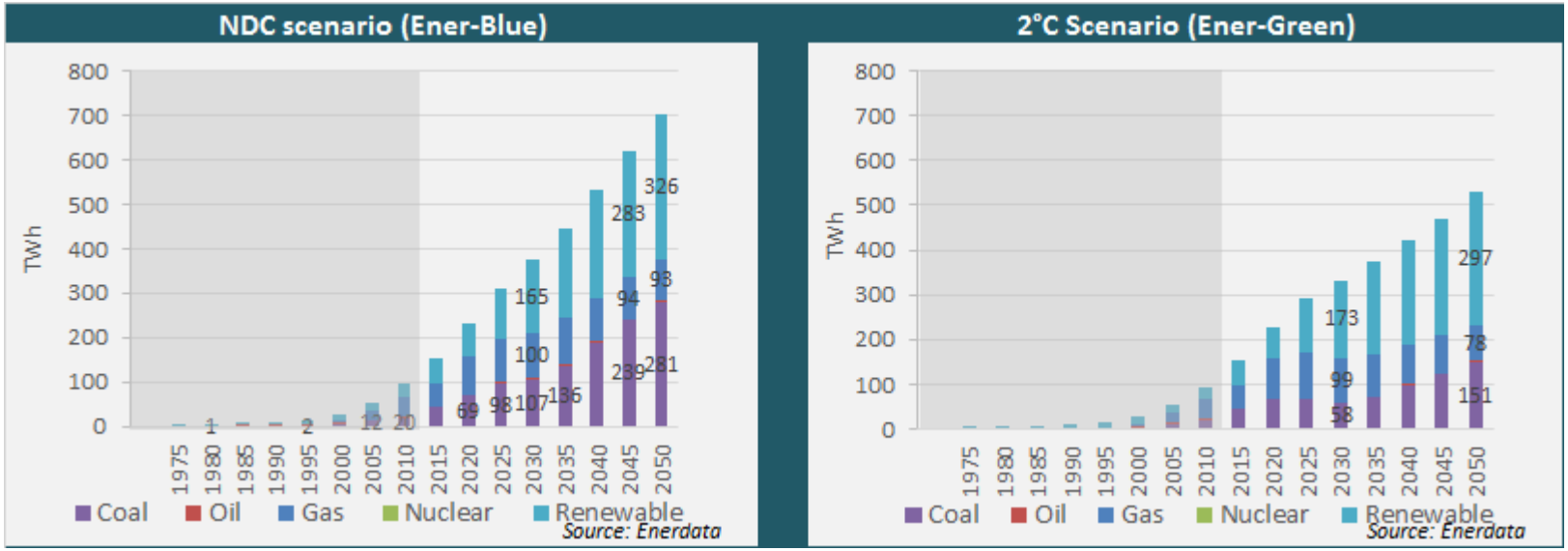
Final energy by sector

- In EnerBlue, industry consumption is expected to grow much faster than in EnerGreen, reaching almost 2 times its consumption by 2050
- In EnerGreen, industry consumption growth is limited by efficiency improvements and represents 50% of final energy consumption in 2050, Building and Transport about 20% each.



The power sector

- Compared to official forecasts (VNEO 2017), lower economic growth prospects and lower electricity demand elasticities result in much lower electricity demand in 2050, 700 and 550 TWh respectively in EnerBlue and EnerGreen (vs. 1 200 TWh in VNEO)
- In EnerGreen, CO2 emissions of the power sector are almost stabilized after 2020, while they continue to grow sharply in EnerBlue at +5,0%/year over 2015-2030



The power sector dilemma in Vietnam

- A coal-based strategy:
  - Coal power plants currently decided today will come online by 2025; they will be only at 2/3 of their technical lifetime in 2050
  - Heavily relying on coal for the 2030 horizon may induce significant capacity and infrastructure investments…
  - with a high risk of “stranded assets” if coal production were to be abandoned due to climate constraints

- A flexible renewable + gas strategy:
  - Relying more on renewables and natural gas may allow a phase-in of diversified low-carbon options
  - In the short term, gas involves twice less emissions per kWh (400 >< 800 gCO2/kWh)
  - In the medium term, gas turbines are the perfect backup to variable renewables
  - In the long term, gas from renewable sources may represent a high share of supply

Priorities for defining a long term decarbonized energy strategy

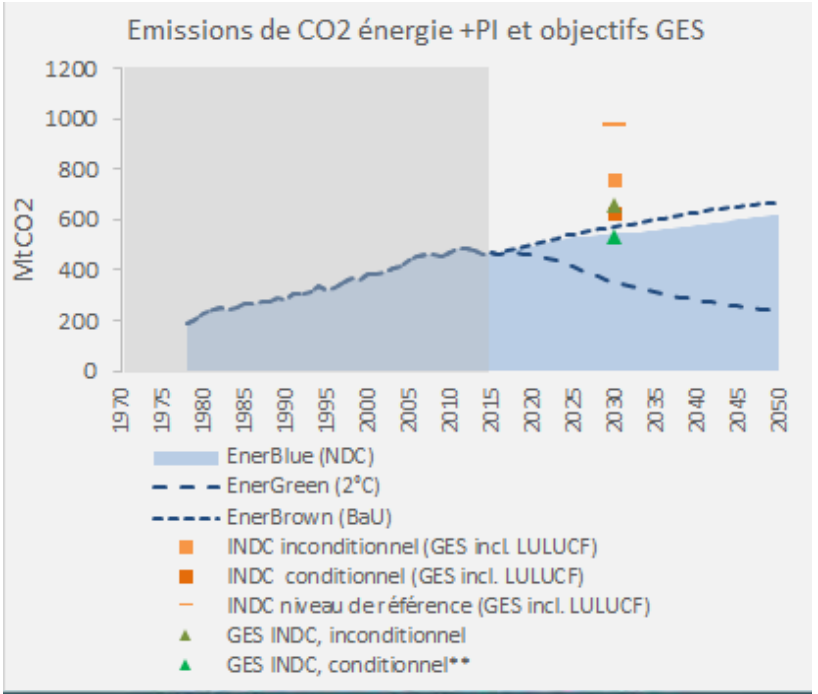
1. Identify the **right balance between supply and demand** actions:
   - In the VNEO 2017 energy savings potentials are only 10% of reference consumption in 2035 (?)
   - 1 200 TWh, for a population of 110 M in 2050, maybe a high guess (France's current consumption is stable at 480 TWh, for a population of 66 M)
2. Unless it is considered that Vietnam can ignore emission constraints in the long term, **avoid carbon intensive supply** options that may:
   - respond to short term needs
   - but induce overinvestment in dirty assets and excessive costs when CO2 price or physical constraints will be introduced (stranded assets)
3. **Prioritize flexible options** that: 1/ allow for future adjustments in the strategy and 3/ contribute to the design and deployment of an energy system that is both clean and efficient

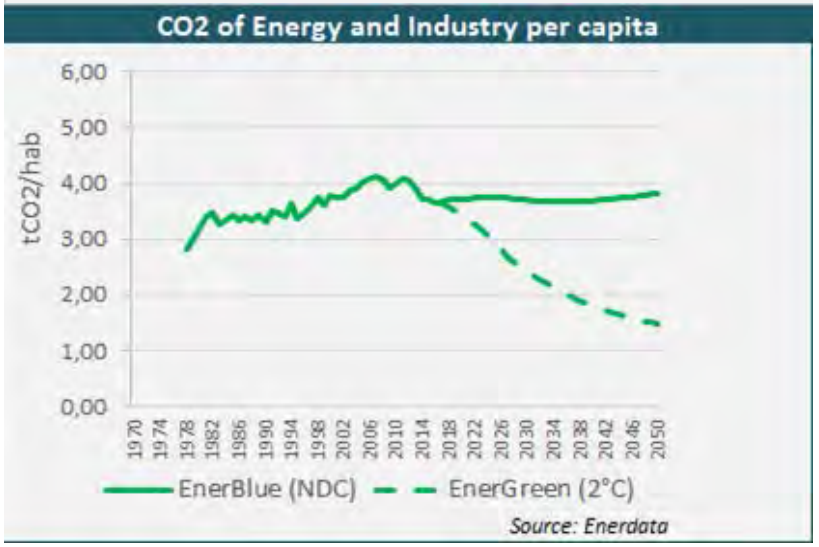
Energy transition in Mexico

NDC Scenario (EnerBlue)
2°C Scenario (EnerGreen)

Overview

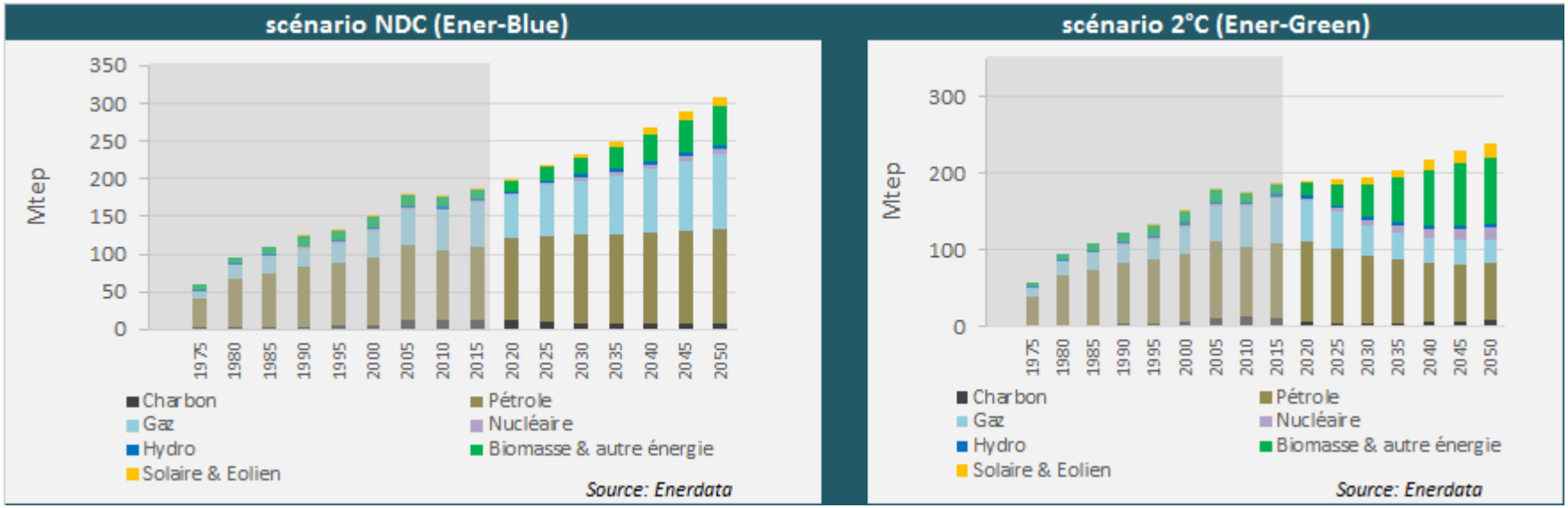
- From 2000 to 2015, Mexico's population has increased by 1.4%/yr, GDP by 2.1%/yr, Energy consumption has been stable and CO2 emissions decreased by 0.2%/yr
- This reflects a relatively low growth compared to other emerging countries
- With 4 tCO2/cap, emissions are below world average and relatively stable since 2000
- The EnerBlue scenario for Mexico extends this situation and is compatible with Mexico's NDC
- EnerGreen displays a significantly different profile with a reduction of per capita emissions down to 1,5 tCO2/cap





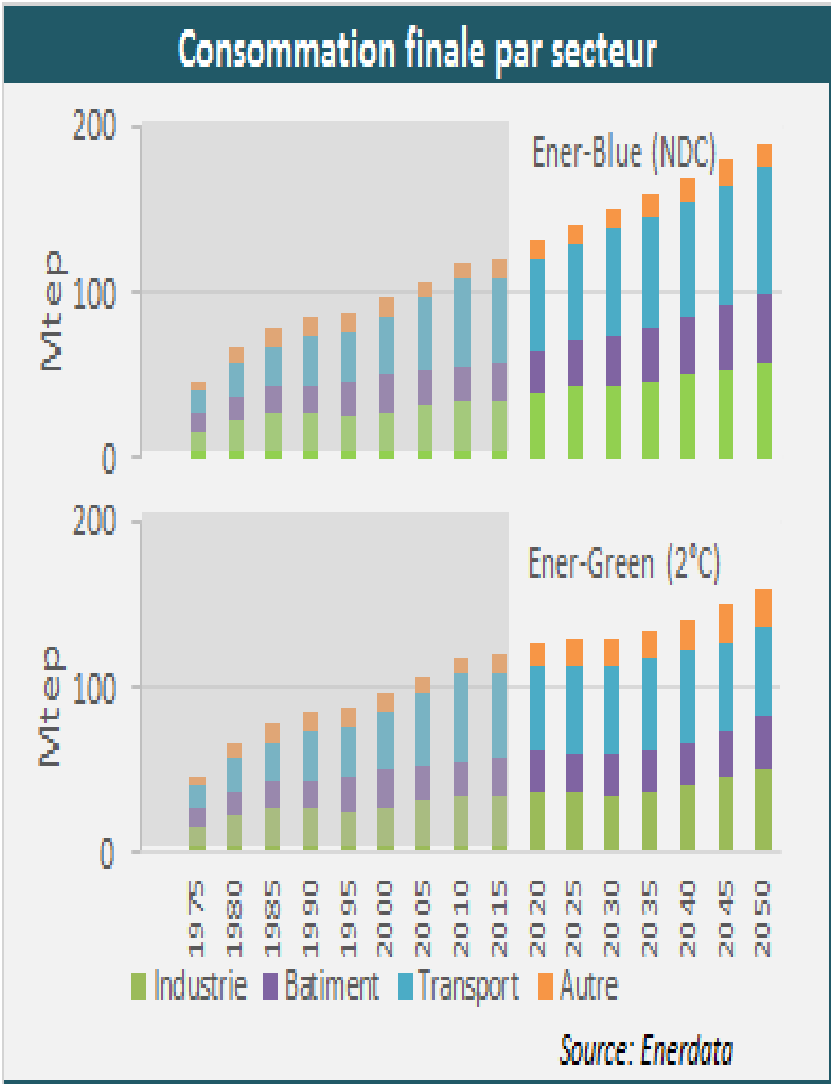
Total Primary Energy Supply

- In EnerBlue, TPES is bound to almost double in 2050, from 180 Mtoe to 300 Mtoe. In EnerGreen 2050 TPES is about 25% lower at 225 Mtoe
- The fuel mix is also very different in EnerGreen, with more than 50% of supply provided by biomass, solar and wind and nuclear



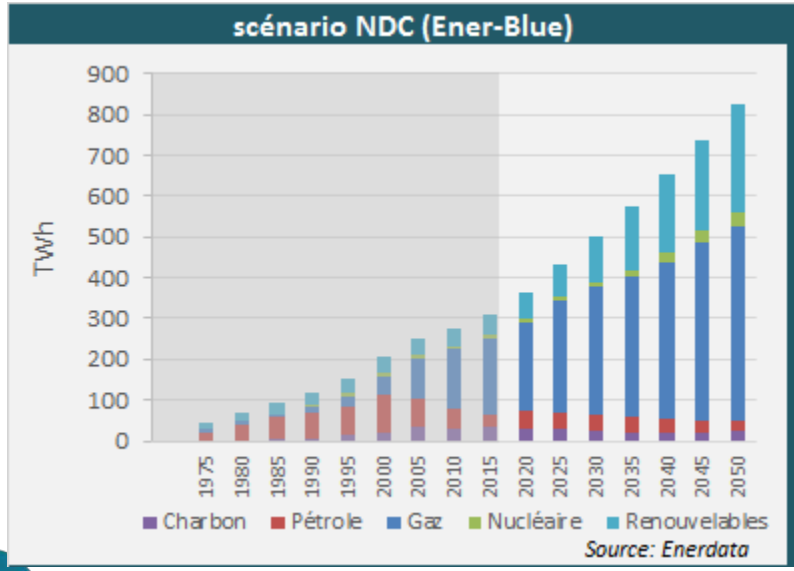
Final Energy Consumption

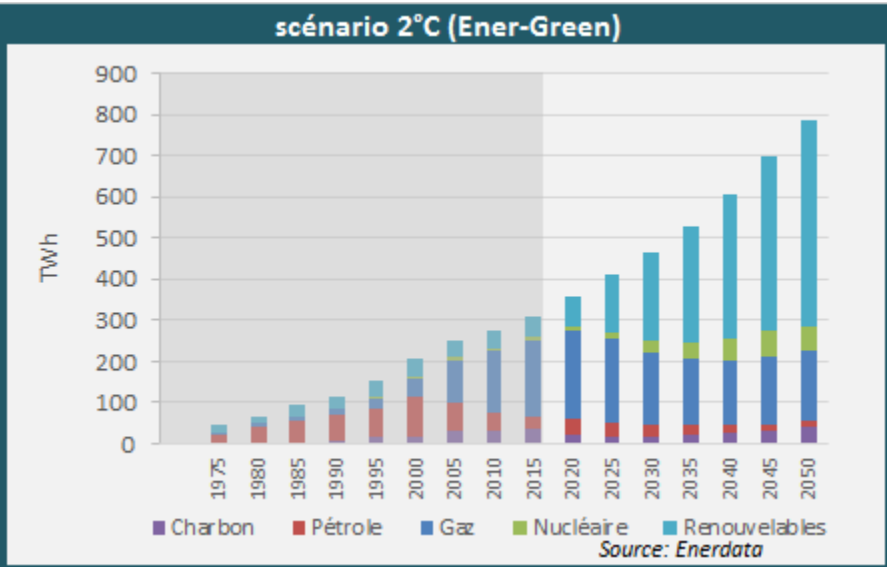
- Final energy consumption is bound to increase in both scenarios, although much less rapidly in EnerGreen: from 110 Mtoe to 200 in EnerBlue and 150 Mtoe in EnerGreen
- From EnerBlue to EnerGreen, industry is almost unchanged, while efficiency improvements beyond ongoing trends are observed in buildings and in the transport sector



Electricity

- Total electricity consumption is unaffected from one scenario to the other, with a yearly growth rate of about 3%/yr: increased energy efficiency in EnerGreen is counterbalanced by further electrification
- The electricity mix is very different, with natural gas representing in 2050 2/3 of total production in EnerBlue, only 1/4 in EnerGreen. In this latter case, renewable provide more than 60% of total, nuclear about 10%
- As a result, the CO2 content of electricity decreases from 450 to 250 gCO2/kWh in EnerBlue, but it is down to 80 gCO2/kWh in EnerGreen





Insights for Mexico

- The comparison of EnerBlue and EnerGreen for Mexico, an emerging country with a relatively moderate expected economic growth rate, shows that **current NDCs are not compatible with deep decarbonisation** (or 2°C compatible) trajectories

- In the transition, critical will be the capacity to **limit energy demand growth through enhanced efficiency** in buildings and industry and through the electrification of transports

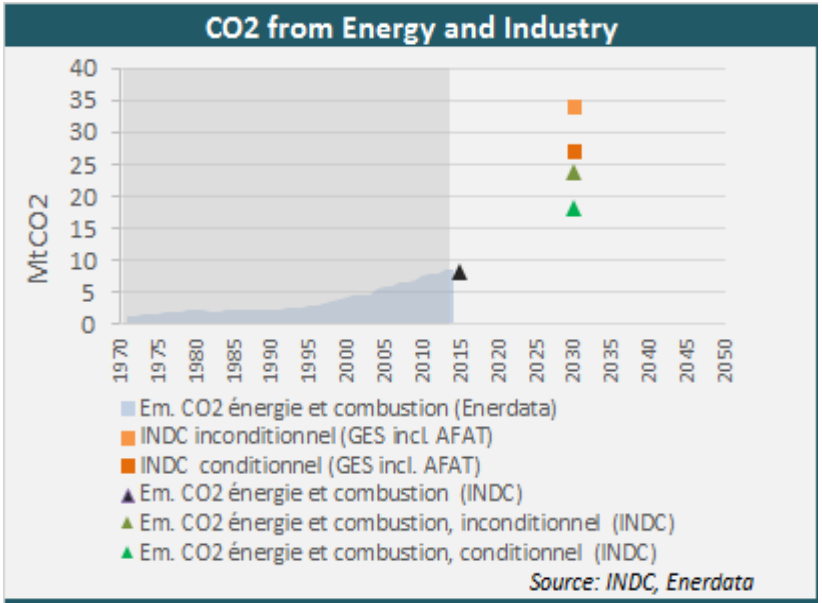
- Critical also will be the choices in the development of the electricity sector. While no scenario incorporates a strong hypothesis for coal based electricity. But **the relative weight of renewable and gas based will be decisive**, resulting in power sector emissions of 200 MtCO2 in EnerBlue compared to only 50 MTCO2in EnerGreen (from current 150 MtCO2)

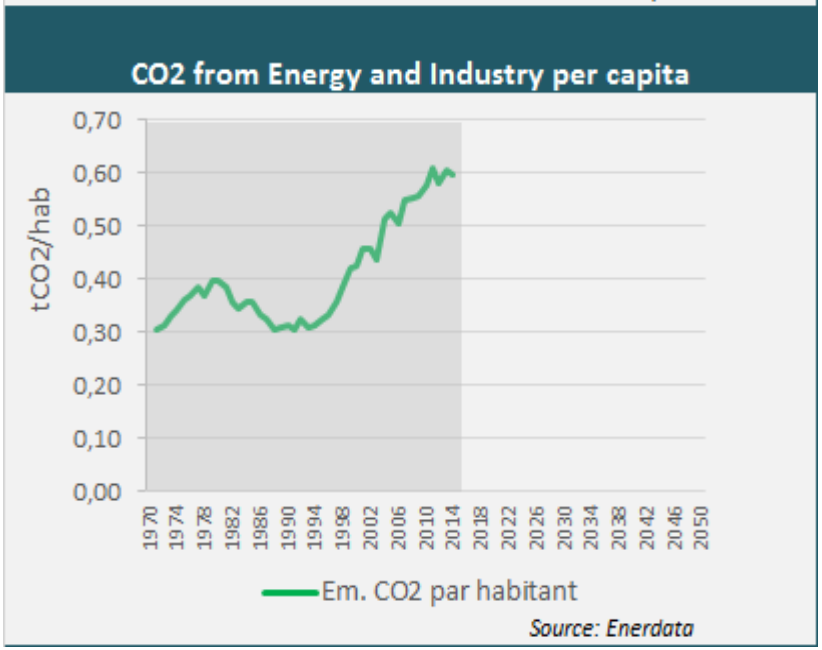
Energy transition in Sénégal:

analysis of on-going trends

Overview

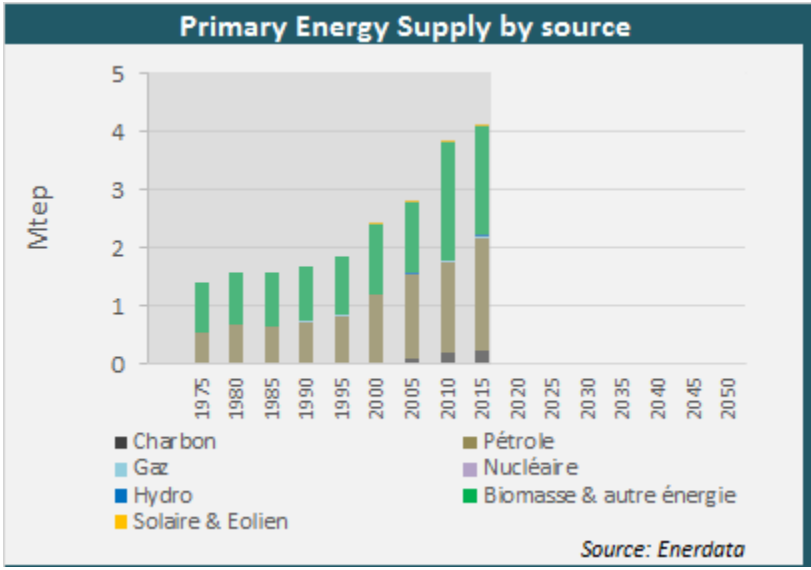
- While no detailed forecast is available for Senegal (not isolated in the POLES model) it is possible to compare on-going trends with existing targets and NDCs
- CO2 emissions of Senegal have risen significantly since the early 90s. However they remain low in absolute terms today at about 10 MtCO2
- Per capita emissions are also extraordinarily low at 0,6 tCO2 per capita, i.e. one tenth of world average…

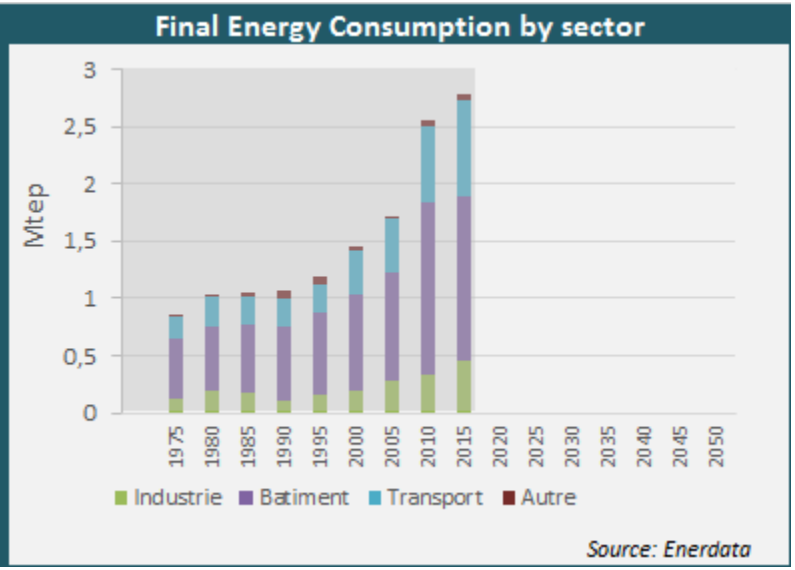




Total Primary Energy Supply and Final Energy Consumption

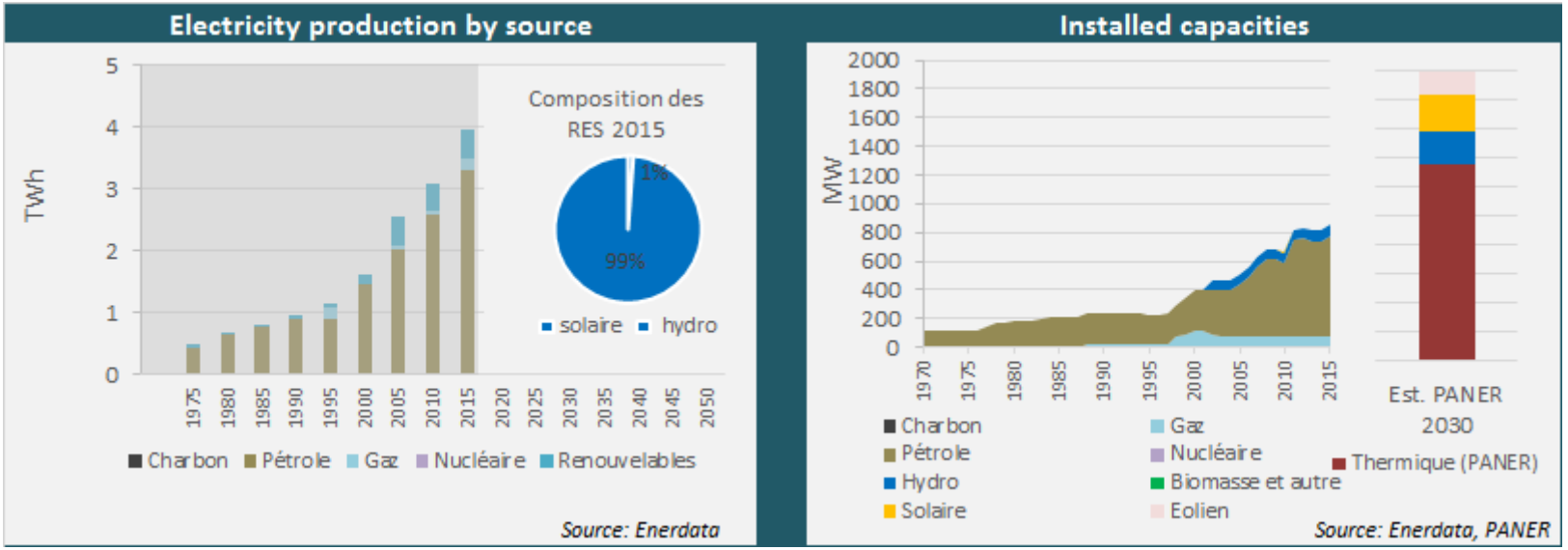
- With a doubling of TPES between 1995 and 2015, the structure of supply has remained remarkably stable, 50% of total energy being provided by oil and the rest by biomass energy. Small quantity of coal are however consumed in recent years
- The sectoral split of Final Energy Consumption is also relatively stable, with buildings, transport and industry incurring similar growth





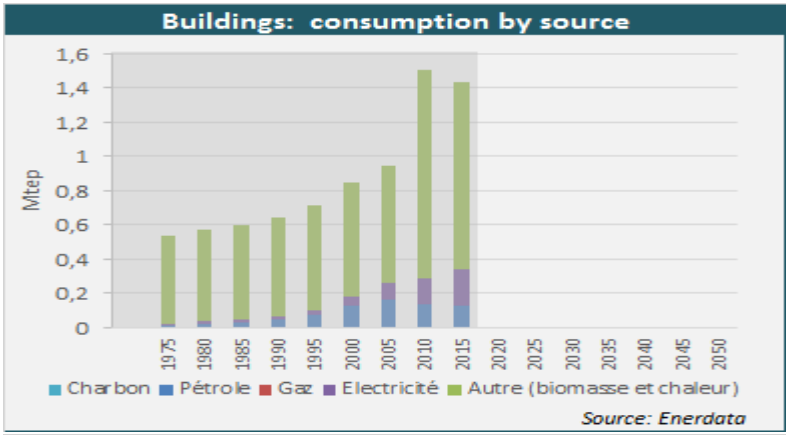
Electricity

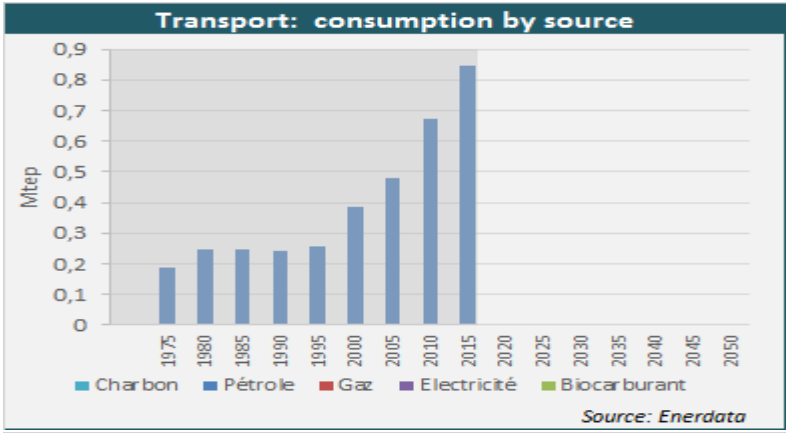
- Electricity consumption incurred a much higher growth rate than other energies, as production has been multiplied by four in the last twenty years, compared to a doubling of TPES
- This corresponds to a rapid, although not full, electrification of the country (55% today)
- Oil provides most of total production. Since 2000 hydro and gas based production however provide one fourth of total

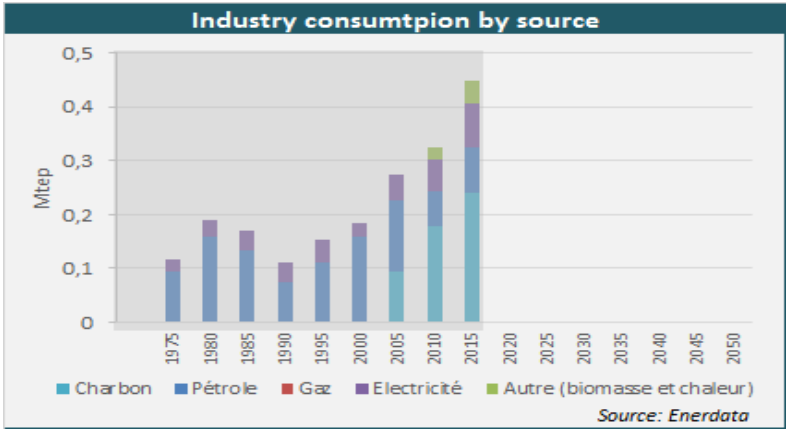


Sectoral consumption by source

- While the three final consumption sector display similar growth profiles, the fuel mix are obviously different with recent changes:
  - In the building sector, the most noticeable one is the recent surge in electricity consumption
  - In transport, oil of course fully dominates
  - In industry, one can note a massive progression of natural gas, while electricity and biomass also progress







Insights for Senegal

- Senegal is an emerging country with relatively moderate economic growth (4%/yr)
- However **energy demand is expected to grow rapidly** in the near future, due to:
  - take-off of transport and industry
  - substitutions to traditional biomass in households' consumption
- **Electricity will be a key sector for energy transition** as its share will grow in energy for building, while the electrification of transport raises particular challenges in low-income countries
- **Natural gas,** both as a final carrier in industry and a primary source for electricity production will be a major issue
- **Renewables and gas** should be considered as complementary alternatives to coal in the power sector

Conclusions:

- Energy Transition Monitoring will be key in enhancing the ability of governments to develop effective and efficient climate and energy policies
- The diversity in national circumstances and priorities so as the diversity in data and modelling doesn't prevent to analyse energy transitions within a common framework and with common insights
- This is at least what hopefully comes out of the case studies presented here
- The work will go on…

Enerdata

www.enerdata.net

Tel: +33 (0)4 76 42 25 46
Fax: +33 (0)4 76 51 61 45

47, av. Alsace Lorraine
38000 Grenoble, France

Contact :

Prof. Patrick Criqui,
Senior consulting advisor
Enerdata, France

research@enerdata.net

Thank you for your attention !

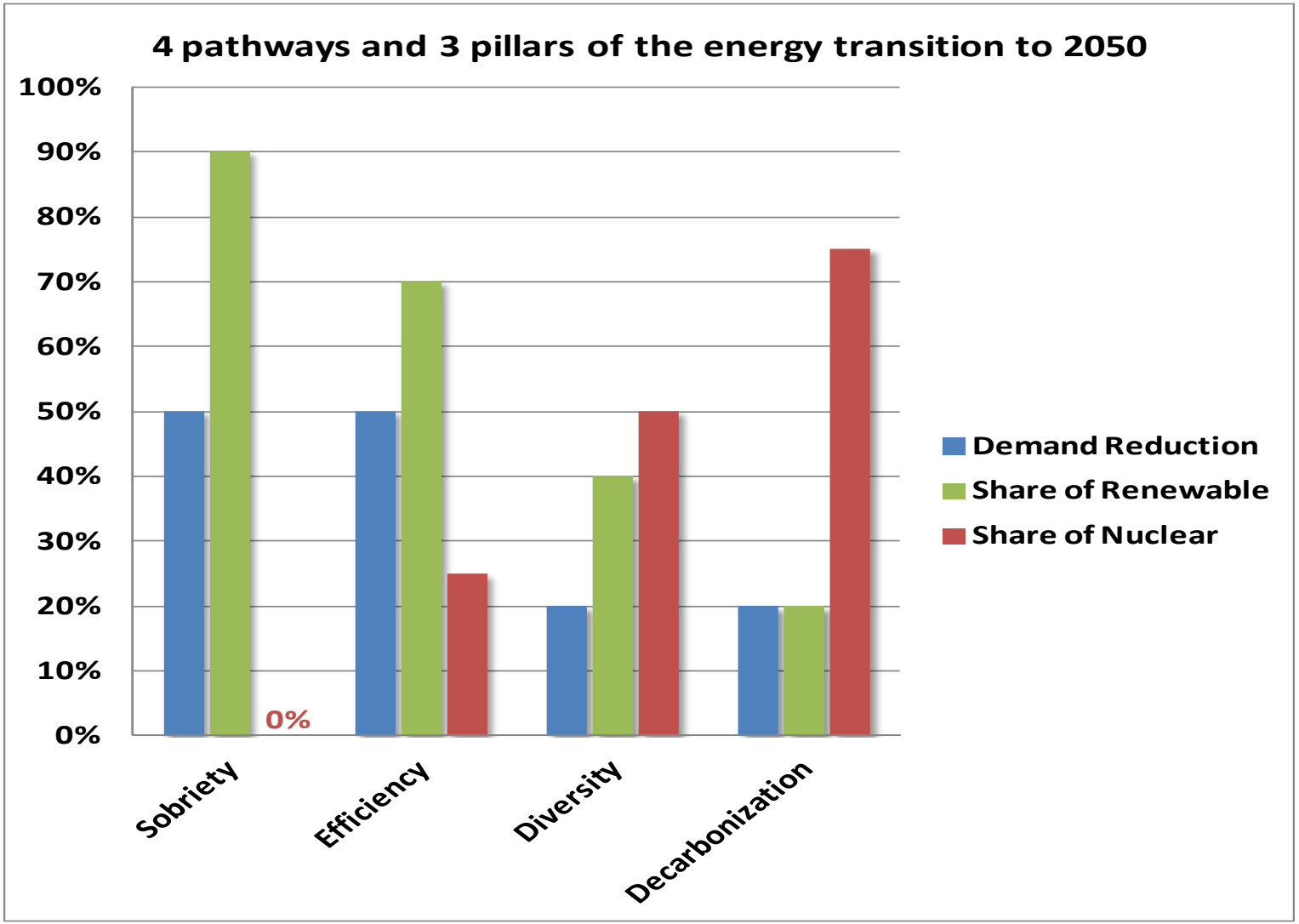
Enerdata

APPENDIX

Energy transition in France:

National policy and targets
NDC Scenario (EnerBlue)
2°C Scenario (EnerGreen)

The 4 trajectories identified in the 2013 debate still reflect the different plausible futures



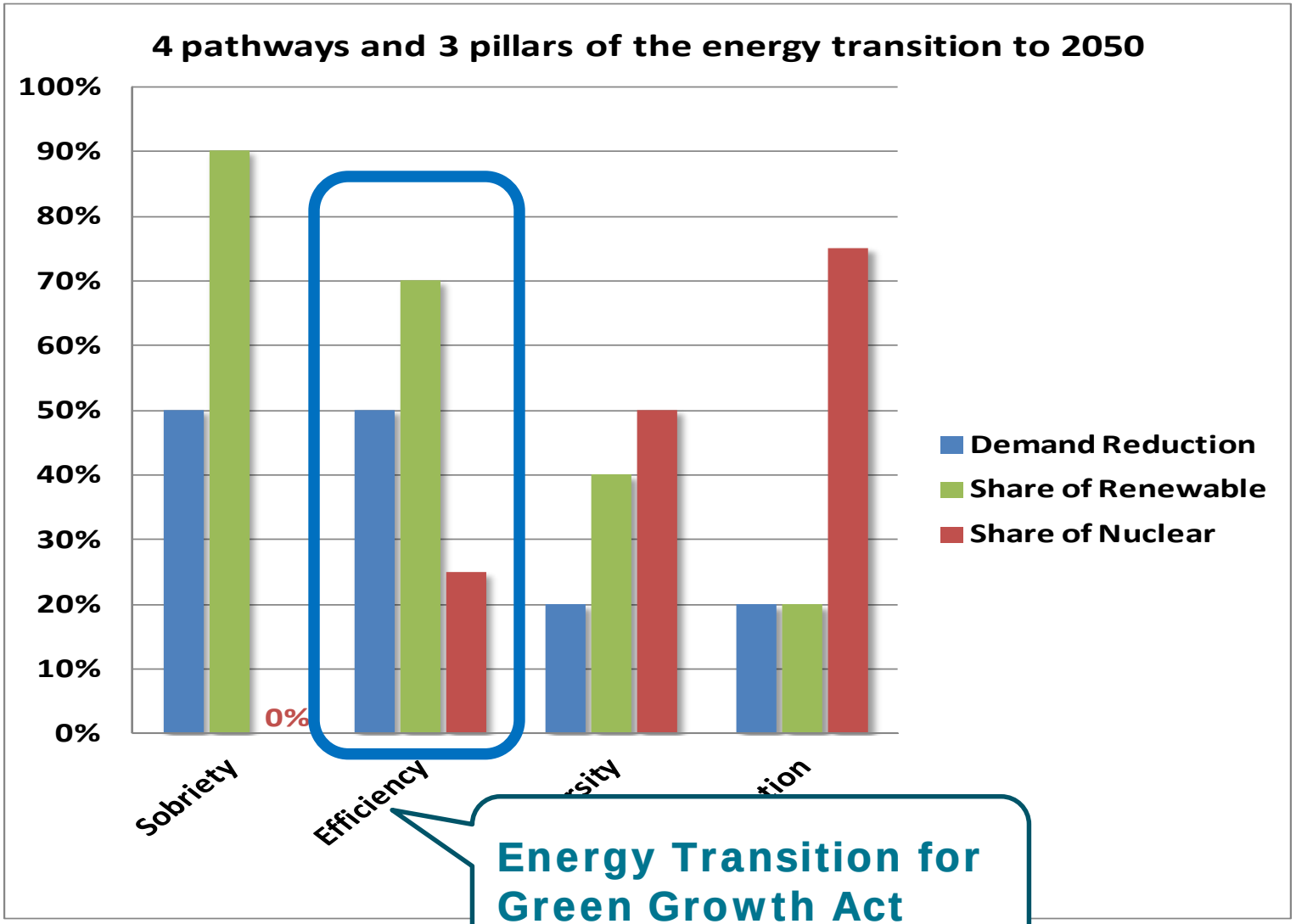
Quantitative targets of the 2015 Energy Transition Act are mostly consistent with the EFF trajectory

	Ref year	2020	2025	2030	2040	2050
greenhouse gas emissions	1990			-40%		-75%
final energy consumption	2012			-20%		-50%
fossil energy consumption	2012			-30%		
share of renewables in overall consumption		23%		32%		
share of renewables for heating				38%		
share of renewables for fuel				15%		
share of renewables for gas				10%		
share of renewables for electricity				40%		
share of nuclear power in electricity generation			50%			
loading docks for electric vehicles				7 million		
thermal rehabilitation projects per year		500,000	500,000	500,000	500,000	500,000

The 5 year Plurennial Programing for Energy (2016)

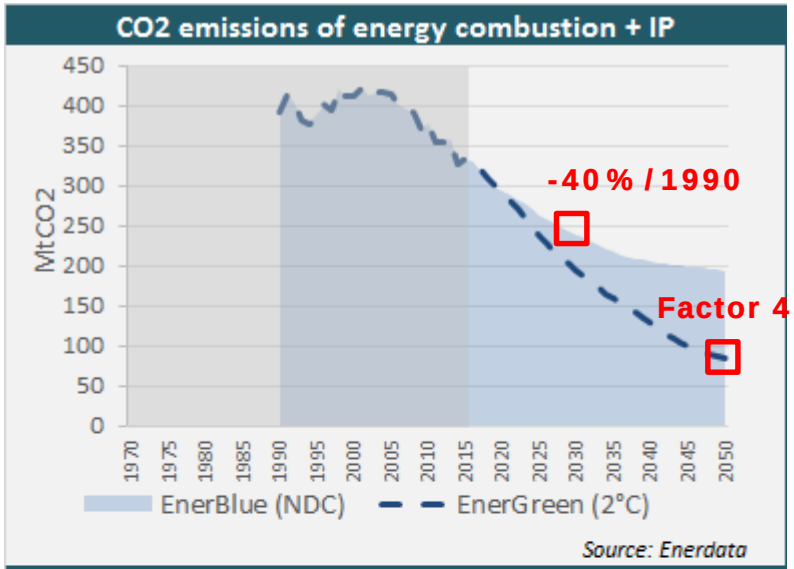
	2014	2018	2023	2023
			bas	haut
Eolien terrestre	9 300 MW	15 000 MW	21 800 MW	26 000 MW
Solaire photovoltaïque	5 300 MW	10 200 MW	18 200 MW	20 200 MW
Hydroélectricité	25 300 MW (62 TWh)	25 300 MW (61 TWh)	25 800 MW (63 TWh)	26 050 MW (64 TWh)
Eolien en mer posé		500 MW	3 000 MW (entre 500 et 6000 MW de plus de projets engagés, en fonction des concertations sur les zones propices, du retour d'expérience de la mise en oeuvre des premiers projets et sous condition de prix)	
Energies marines (éolien flottant, hydroliennes, etc.)			100 MW (entre 200 et 2 000 MW de plus de projets engagés, en fonction du retour d'expérience des fermes pilotes et sous condition de prix)	
Bois-énergie	357	540 MW	790 MW	1 040 MW
Méthanisation	85 MW	137 MW	237 MW	300 MW
Géothermie électrique		8 MW	53 MW	
Déchets, biogaz de décharge et de STEP	~1200 MW	~1350 MW	~1500 MW	
TOTAL	41 GW	52 GW	71 GW	78 GW

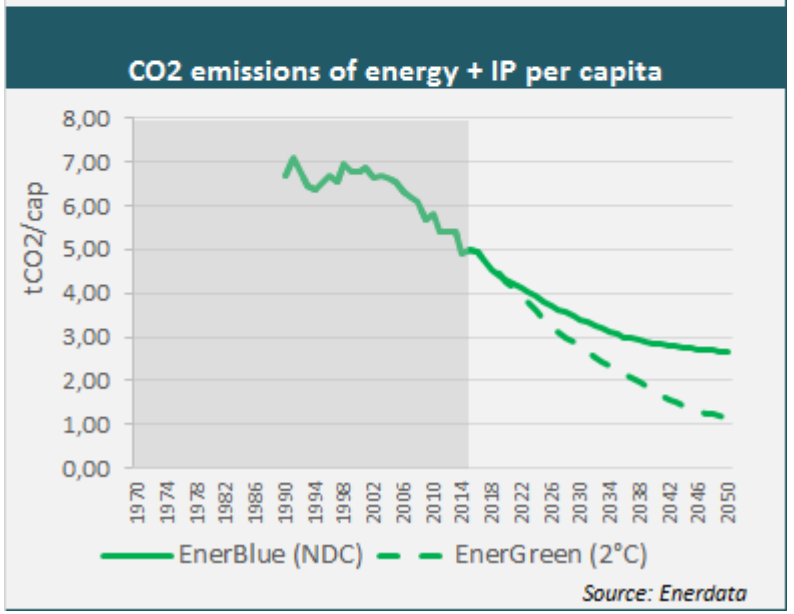
The Efficiency trajectory is currently the benchmark of French energy policy



The EnerFuture scenarios for France

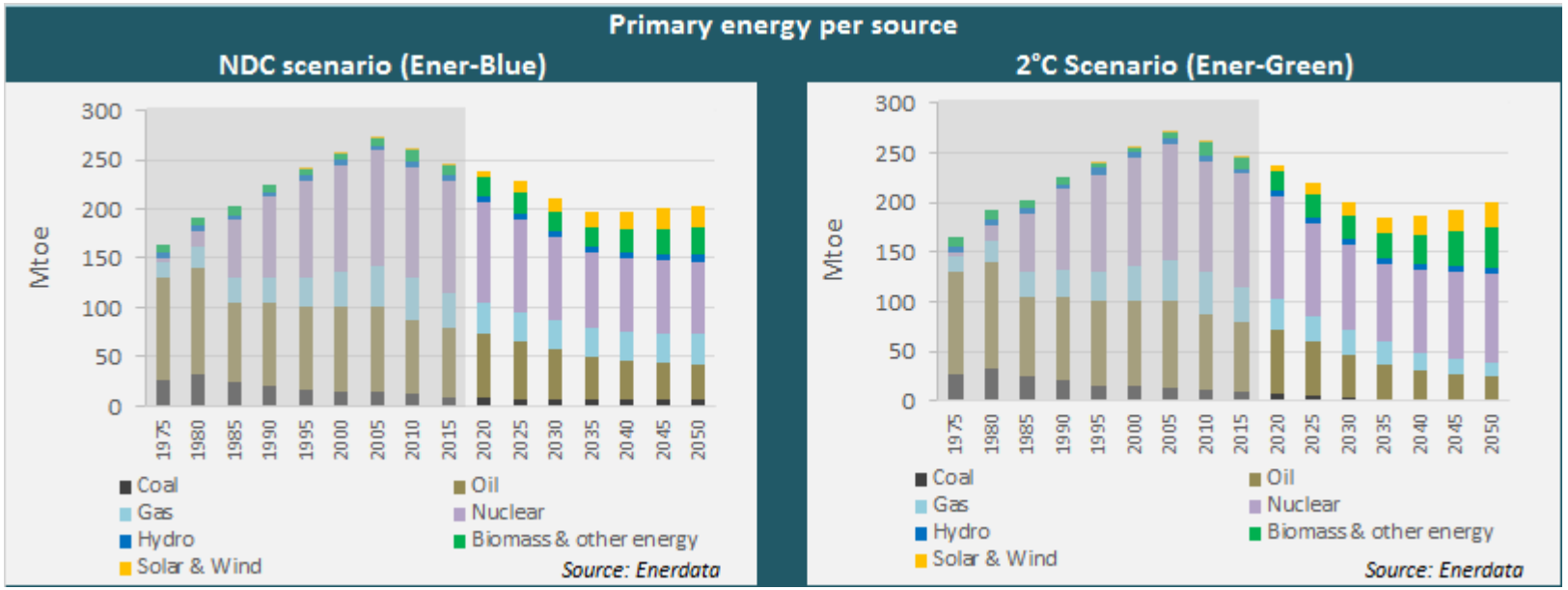
- EnerBlue reflects the French NDC to 2030, which is aligned with the European target of -40% emissions/1990
- EnerGreen corresponds to the “Factor 4 reduction” national target, i.e. -75% in 2050
- While per capita emissions are already low for an industrialized country (5 tCO2) they should decrease to 3 tCO2 and 1 tCO2 respectively in EnerBlue and EnerGreen
- New policies aim at still lower levels to reach Zero Net Emissions in 2050





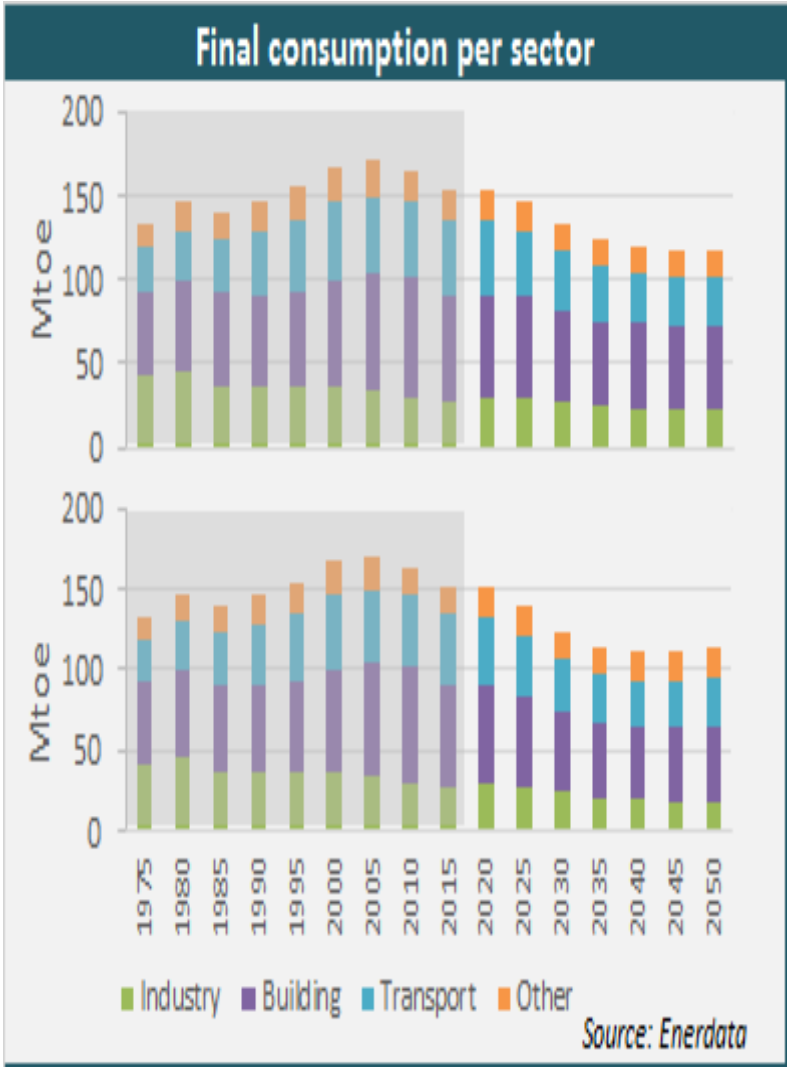
Total Primary Energy Suppply

- Since 2005 trends in TPES are in line with EnerBlue and EnergGreen
- The two scenarios do not differ much in terms of level of TPES, but in EnerGreen coal phase-out is complete after 2030, while 2050 oil and gas use is two times lower in EnerGreen than in EnerBlue



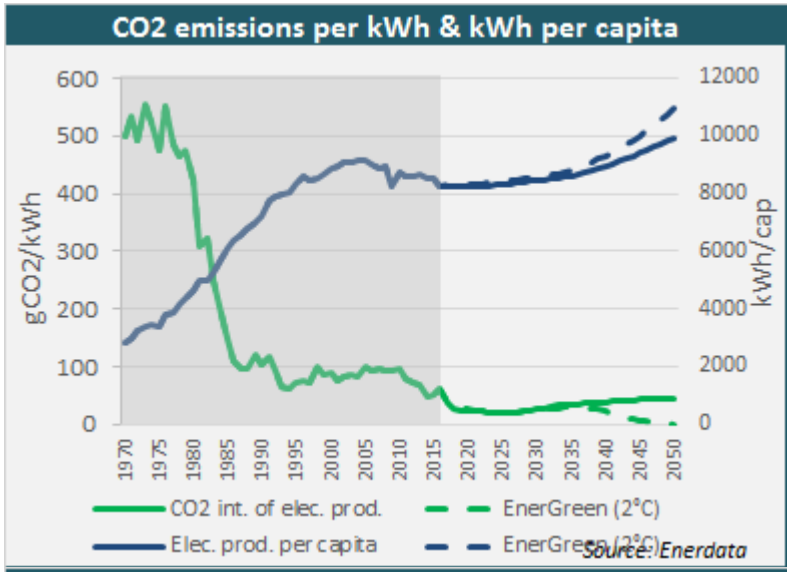
Final Energy Consumption

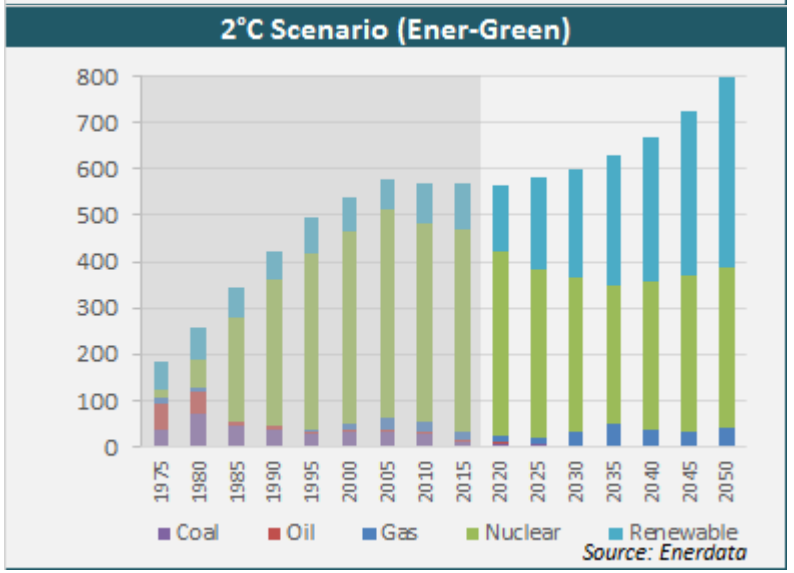
- In both scenarios Final Energy Consumption is 25% lower in 2050; this is a lesser reduction compared to the Efficiency official scenario
- The sectoral split is also very similar from one scenario to the other, indicating that the deeper decarbonisation in EnerGreen is largely due to a larger contribution of zero or low carbon energy carriers



Electricity

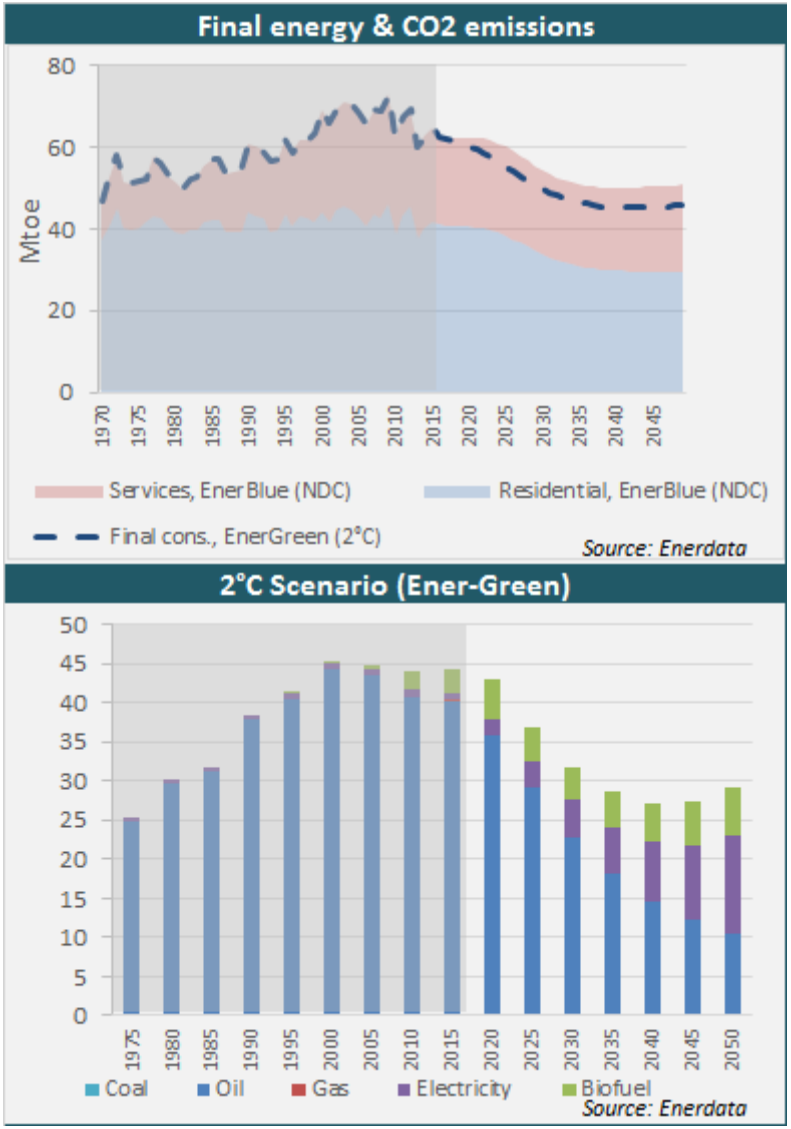
- From the mid 70s to the mid 90s, France electricity sector has undergone a dramatic transformation process with an almost full nuclearization of the power sector
- As a result the carbon content of the kWh went down from 500 to less than 50 g/kWh
- New French policy supposes that the share of nuclear in power generation will be brought down, From current 75% to 50%
- In EnerGreen, nuclear and renewable represent almost 50% of production each, with a small residual production from natural gas





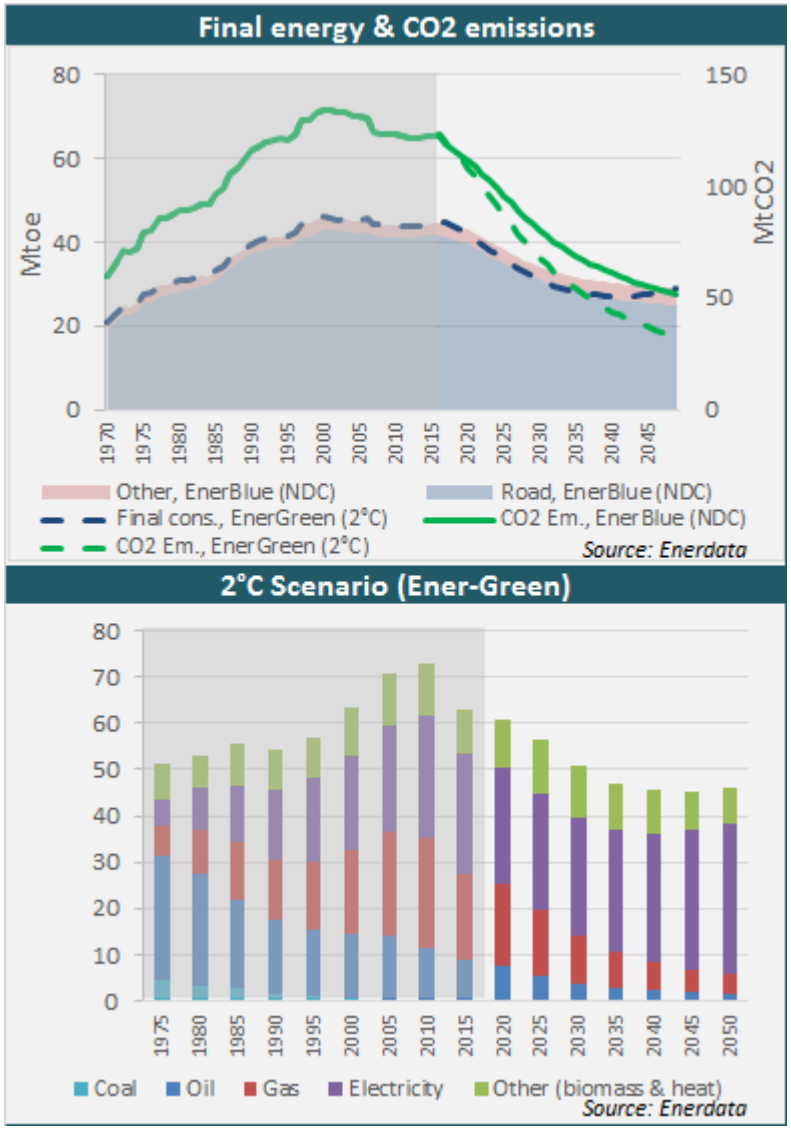
Building

- Energy consumption in buildings is already decreasing and is expected to still decrease of one third by 2030
- The official policy supposes still stronger reductions, but success in imposing deep thermal retrofit of all existing buildings is not granted
- Consequently, EnerGreen supposes an increased contribution of decarbonized carriers, electricity and biomass, for supplying energy supply in buildings



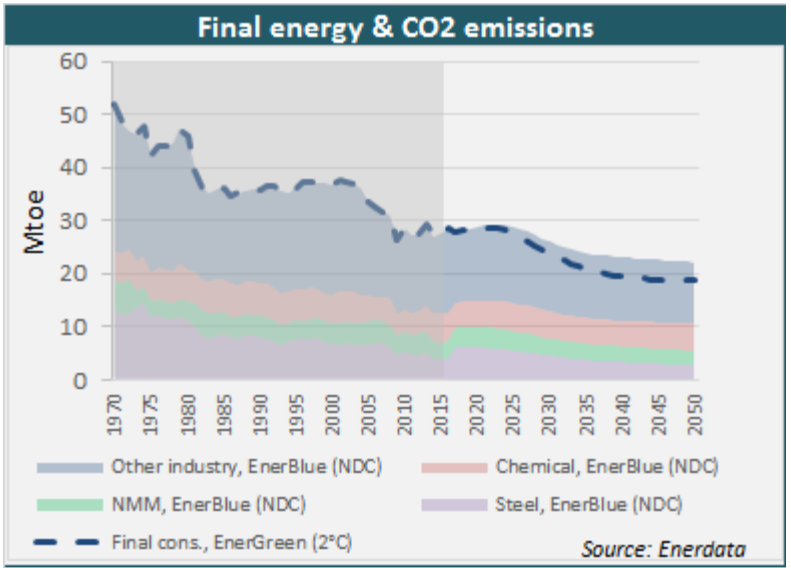
Transport

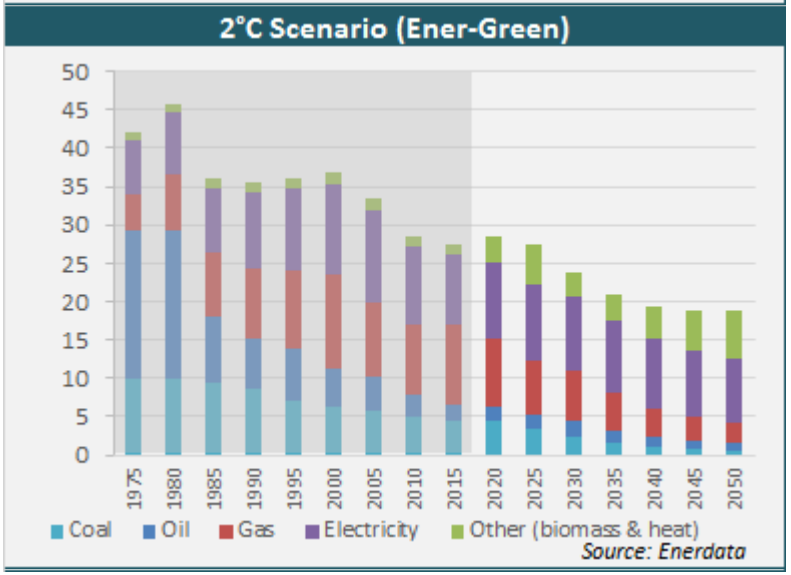
- While energy consumption in transport has levelled since 2000 the projected scenario supposes a gentle but regular reduction of consumption by 20% in 2050
- This implies a strong decarbonisation of the energy carriers: oil as a transport fuel almost disappears by 2040
- According to EnerGreen electric vehicles gain most of the market shares, while other scenarios also consider a strong contribution of low carbon gas vehicles (from bio resource or methanation)



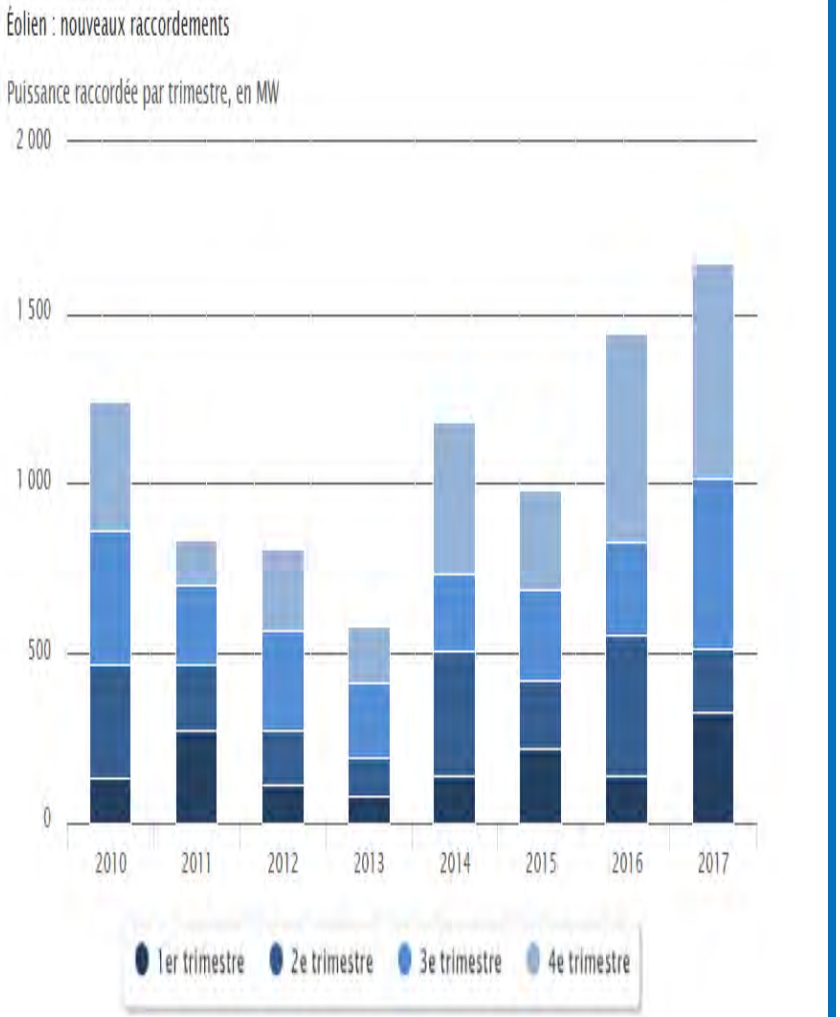
Industry

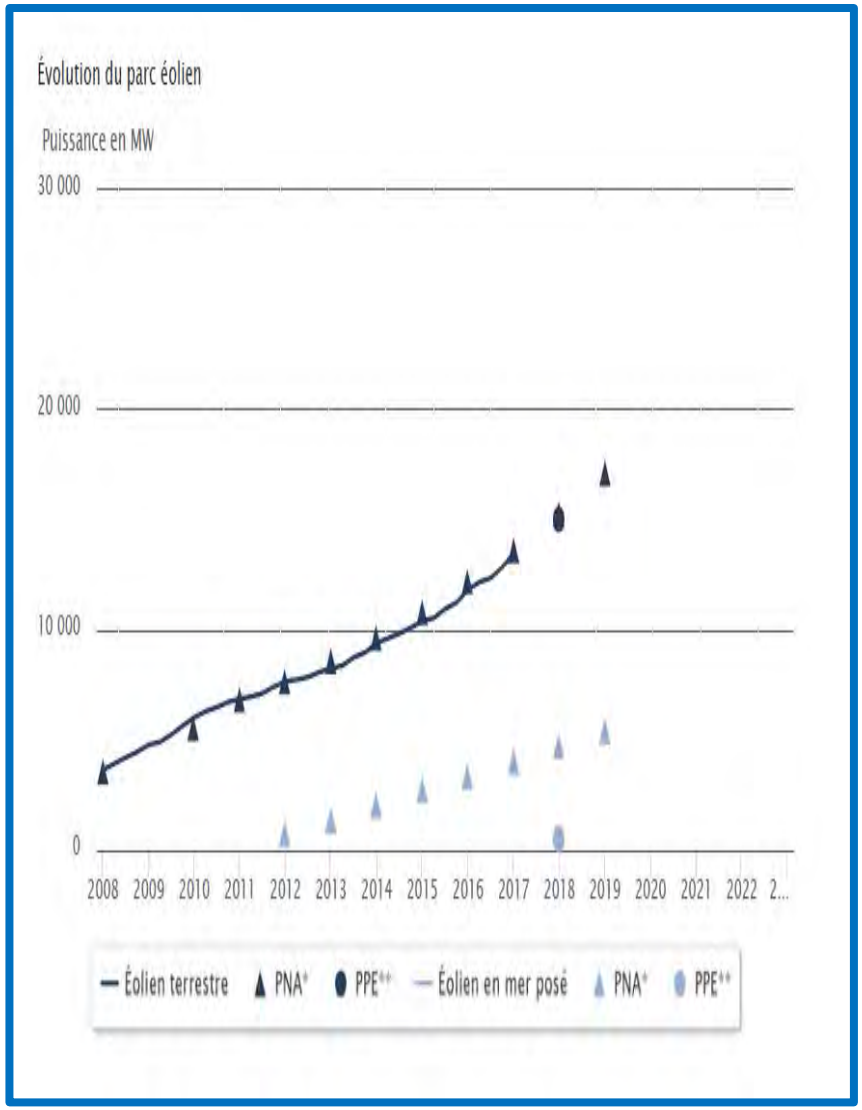
- As many European countries –maybe still more than others – France has incurred a deep desindustrialization movement in the past 40 years
- As a consequence energy consumption of industry has been reduced by 40% in the same period
- While public policies have tended to encourage reindustrialisation, the outcome is still not clear
- Energy consumption and emission reduction in the future should be considered as obtained through higher efficiency and lower carbon intensity of energy carriers
- This is what is simulated in EnerGreen with a further 30% reduction of consumption and biofuels and electricity representing more than 2/3 of supply to industry



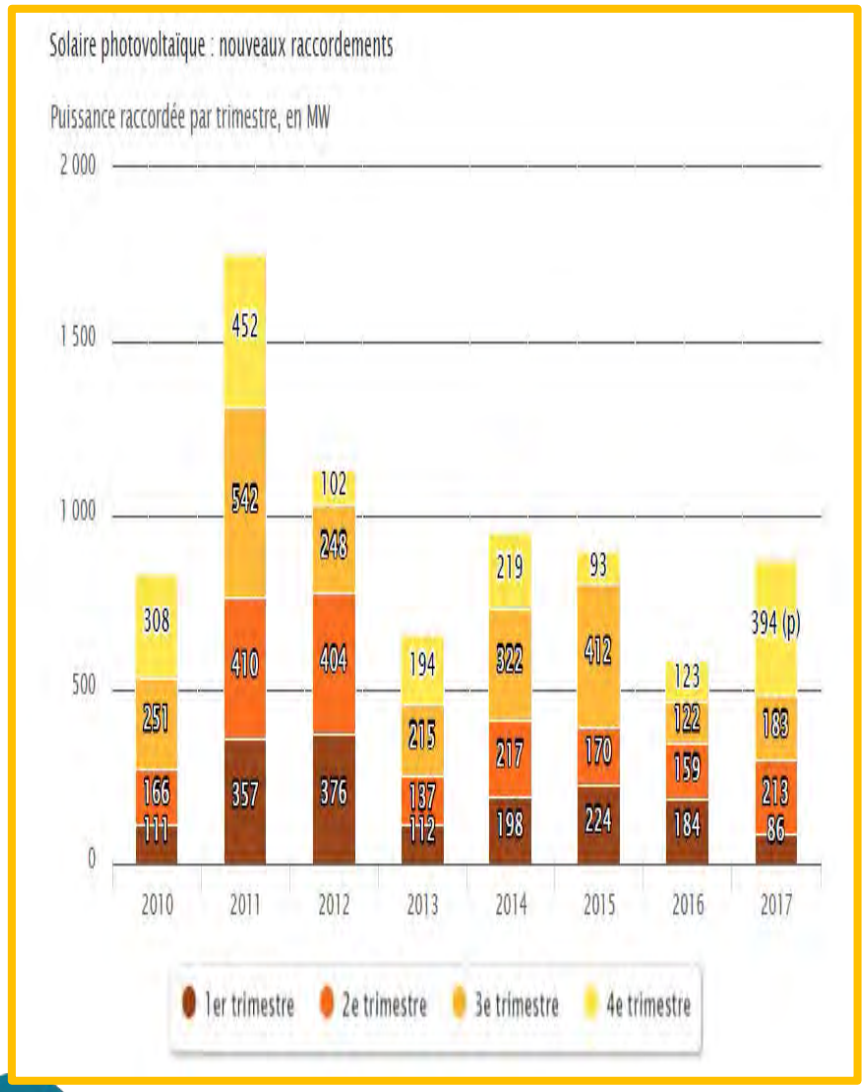


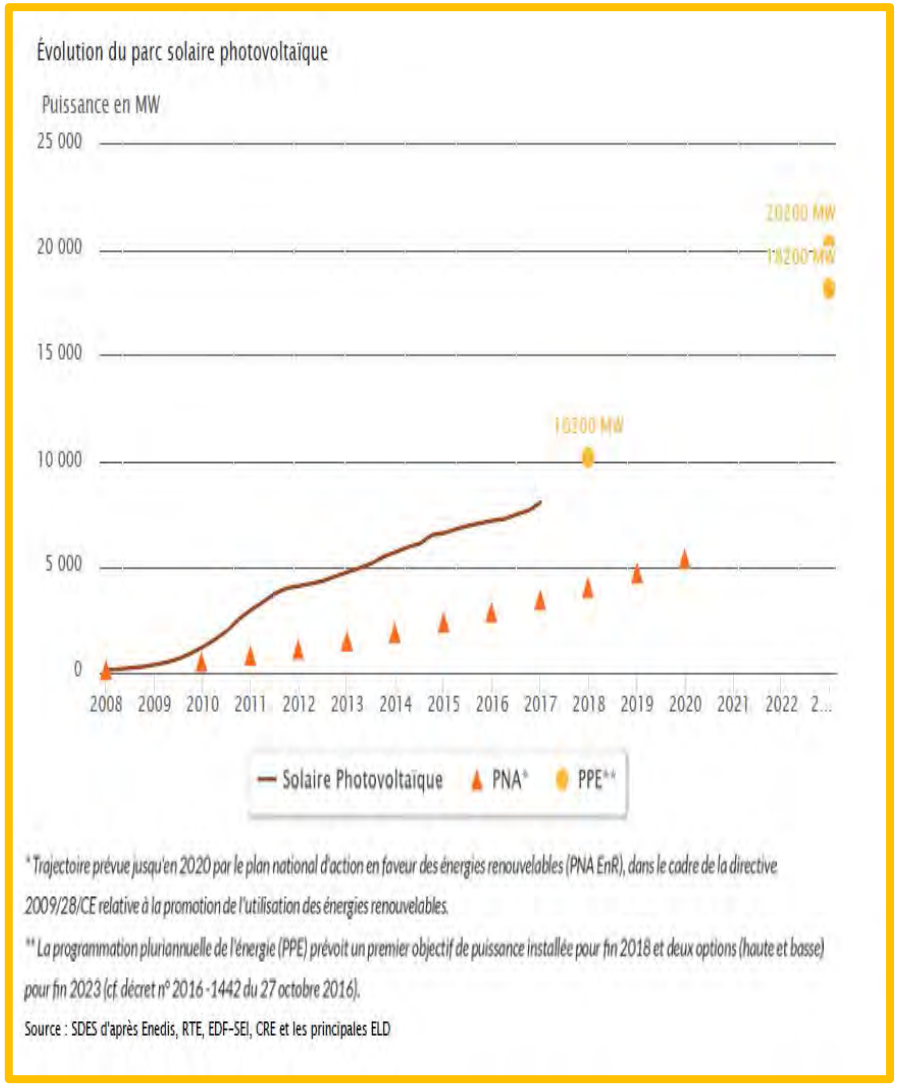
Facts and targets-1: Wind



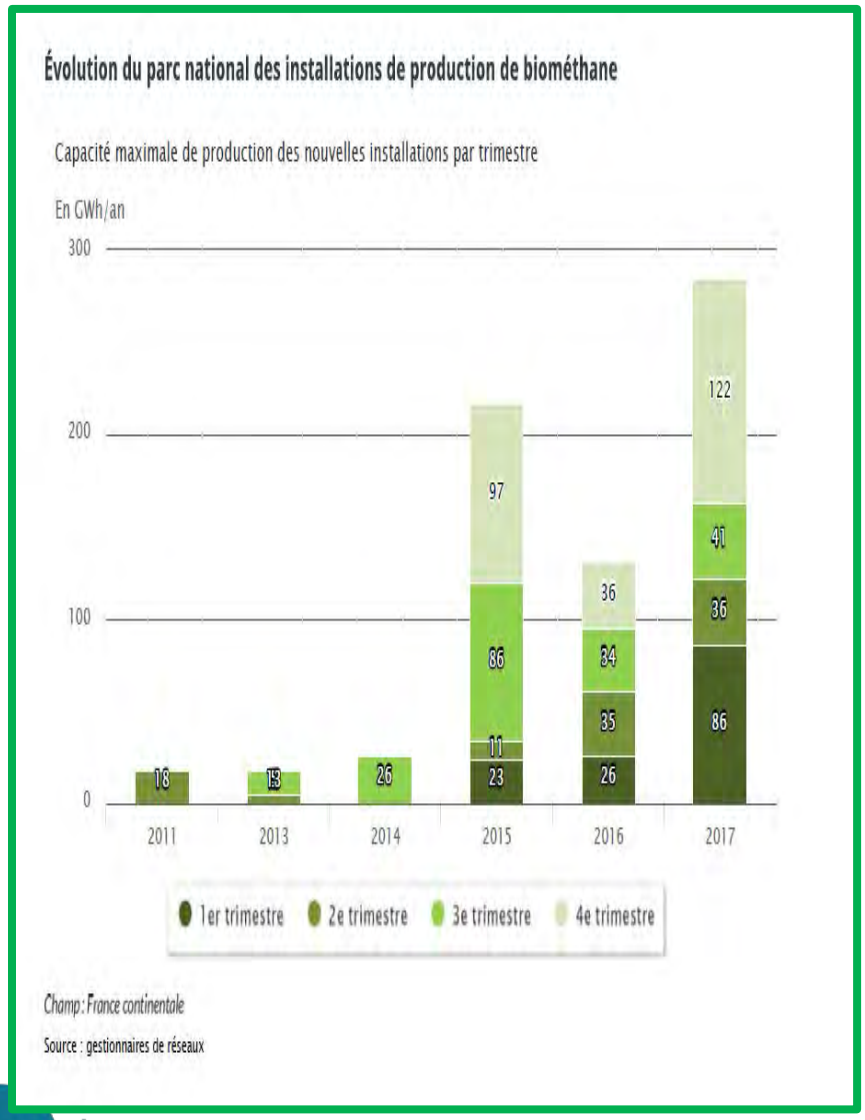


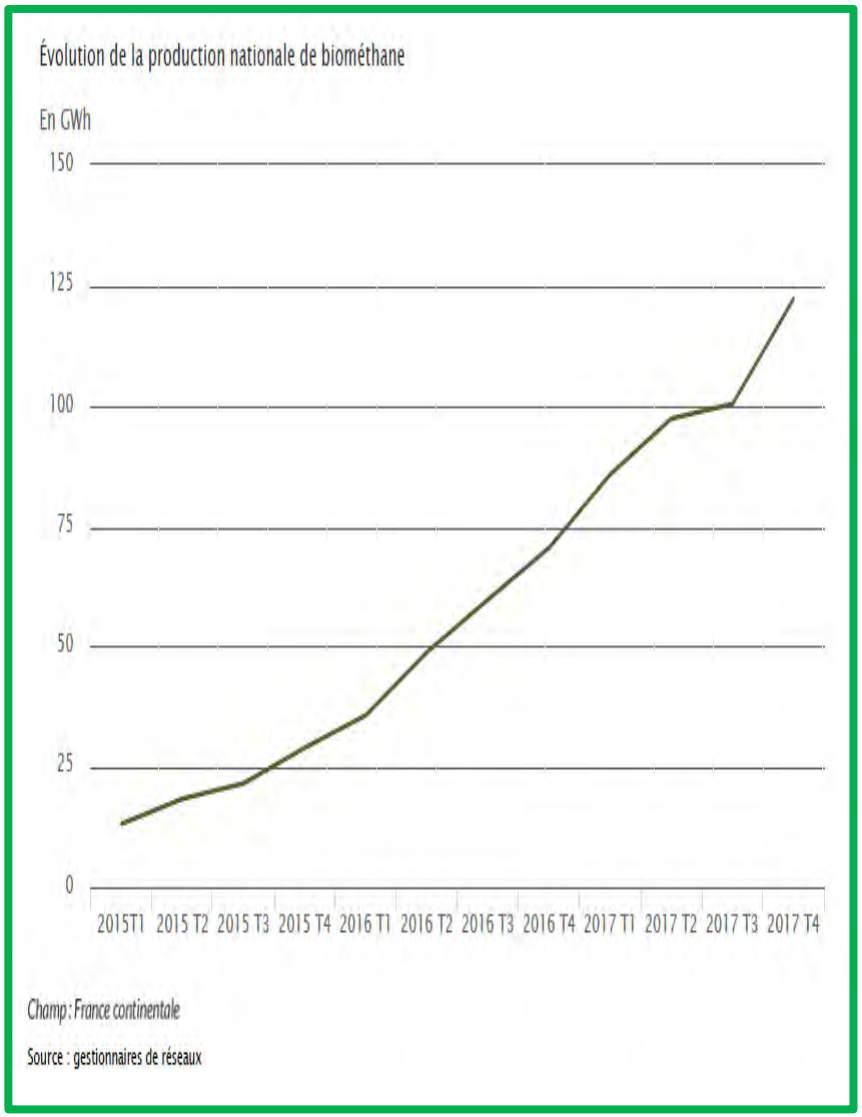
Facts and targets-2: Photovoltaics





Facts and targets-3: Biomethane





Challenges and debates in French energy transition

- One of the most controversial issue is the **reduction of the share of nuclear energy to 50%** by 2025-2030; opponents exist from both sides: pro- or anti-nuclear
- This decision largely stems from political deal between centre-left and green parties, but it also makes sense in a technical perspective in order to diversify the electricity mix and **make room for more renewable**
- One key challenge for official policies will be the critical target of **reducing consumption by 50% in 2050**; this might be particularly difficult for the complete retrofitting of the building stock
- The most-recent debate covers the question of **failure or success of existing sectoral policies**, which is typically a monitoring issue…

ANNEXES

Benchmarking of energy transition studies: examples…

	Nom	Organisation	Couverture pays	Site Web / Rapport
1	AIRS Annual Indicator Report Series	EEA	UE	http://www.eea.europa.eu/airs
2	REI Resource Efficiency Indicator	Eurostat, EEA JRC	Pays UE	http://ec.europa.eu/eurostat/web/environmental-data-centre-on-natural-resources/resource-efficiency-indicators
3	EC Monitoring EU Obj.	Eurostat +	Pays UE 28	Rapport https://ec.europa.eu/commission/sites/beta-political/files/swd-energy-union-key-indicators_en.pdf
4	Odyssée-MURE	ENERDATA	Pays UE 28 + Norvège	http://www.odyssee-mure.eu/data-tools/
5	Indicators for Monitoring the EU Energy System	European Climate Foundation	Pays UE 28	Rapport http://production.presstogo.com/fileroot7/gallery/DNVGL/files/original/489fe6bfc5e745d1b49ca7bce13d9586.pdf
6	Energy Transition Indicators	Insight-E	Pays UE 28	http://www.insightenergy.org/static_pages/energy_transition_indicators
7	RISE Regulatory Indicators for Sustainable Energy	World Bank	111 pays OCDE et Non OCDE	http://rise.esmap.org/indicators
8	GTF- Progress Towards Sustainablity	IBRD, WB, IEA	111 par région	http://gtf.esmap.org/
9	OECD stats	OECD	35 + 9 Non OCDE	http://stats.oecd.org/
10	Global SDG Index and Dashboard	UN-SDSN	34 Official OECD + 147 Unofficial	http://indicators.report/
11	DDPP	IDDRI/SDSN	16 pays (75% des émissions mondiales)	http://deepdecarbonization.org/countries/visualization-of-country-scenarios/
12	CAT data portal	Climate Analytics, Ecofys, PIK, NCI	39 + G20	http://climateactiontracker.org/decarbonisation/intro

Global Energy Data: historical data on economy, energy, emissions

Enerfuture: demand & supply projections

Odyssee: detailed energy consumption

Austria
Belgium
Bulgaria
Croatia
Czech Rep.
Denmark
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Netherlands
Malta
Poland
Portugal
Romania
Slovakia
Slovenia
Spain
Sweden
Luxembourg
Cyprus
Estonia
Latvia
Lithuania
Norway
United Kingdom

Other countries (132)

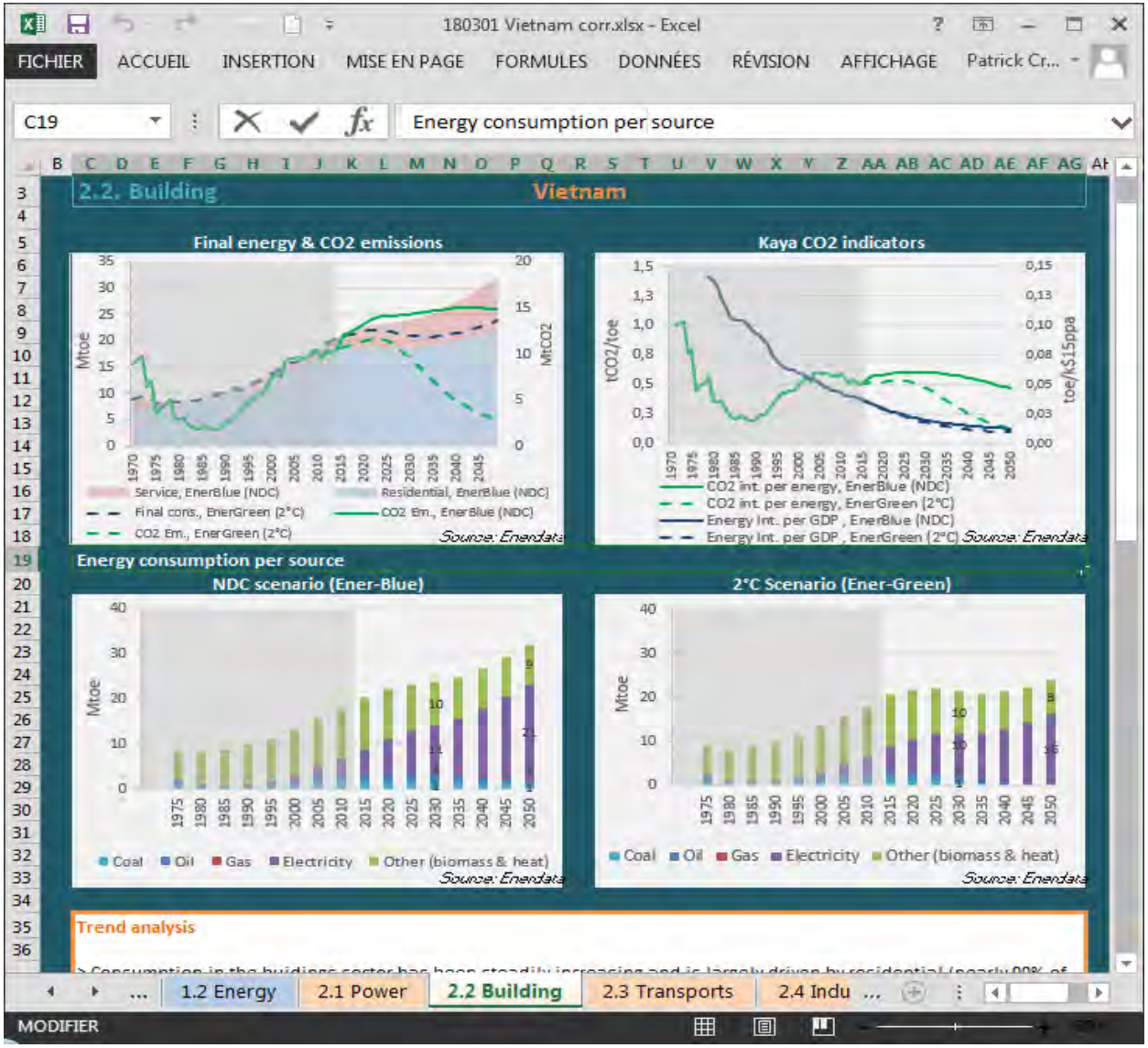
Iceland
Switzerland
Ukraine
Vietnam
Chile

China
Turkey
Mexico
United Arab Emirates
India
Russia
Argentina
Indonesia
Brazil
Japan
Malaysia
South Korea
Canada
Thailand
United States
Egypt
Australia
South Africa
Iran
Saudi Arabia

Enerdemand: detailed energy consumption

Enerdata

1/ The EnerTraM excel



2/ Measuring the gaps