Energy Transition Pathways

A look into long-term energy scenarios, the role of electrification, and net zero emissions strategies

Quentin BCHINI, Sylvain CAIL

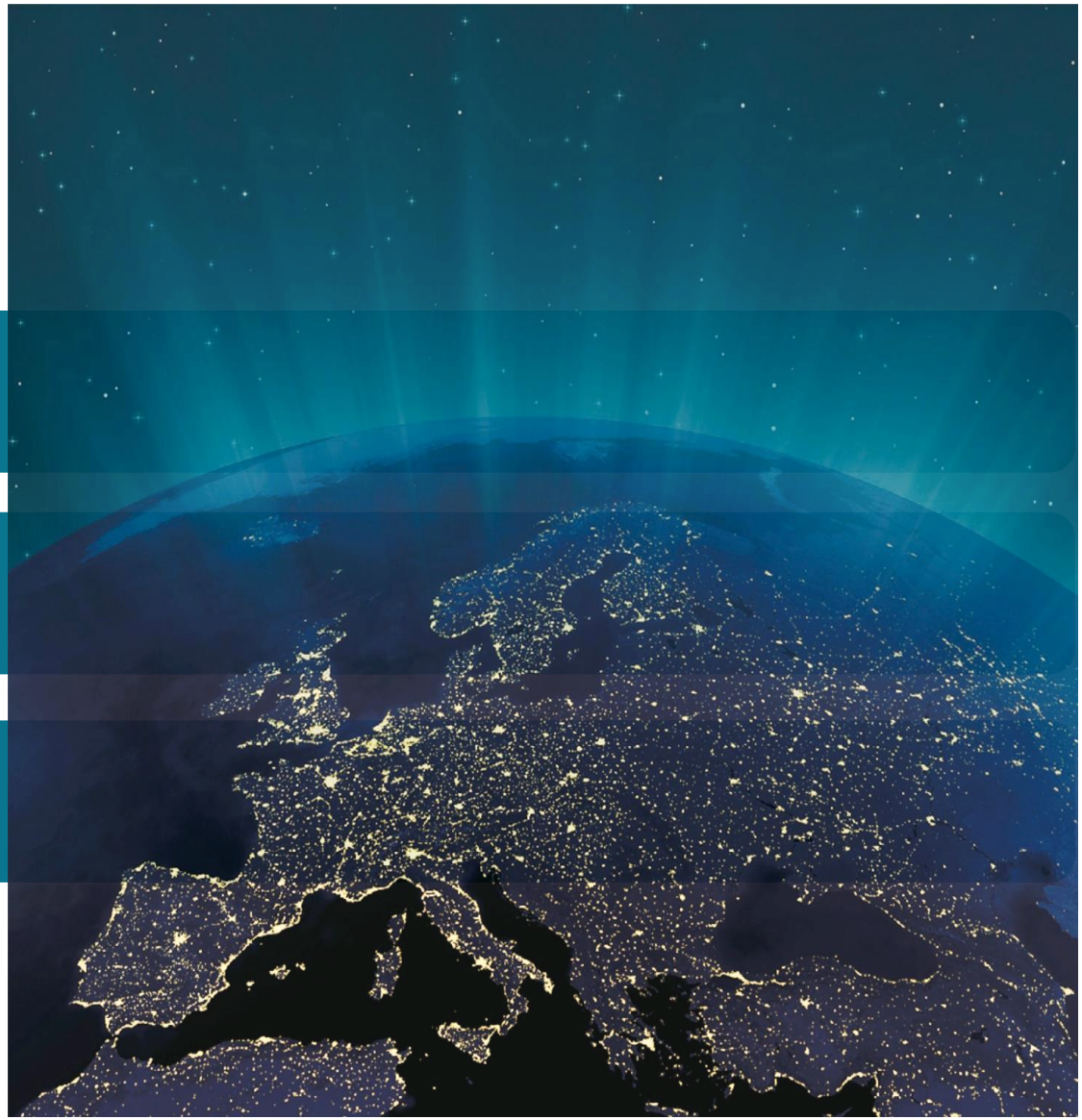
Public Webinar, 4 December 2019

Introduction

- **Enerdata**
  - Independent energy research and consulting company since 1991
  - Headquarters in the Grenoble (French Alps) research cluster, subsidiary in Singapore
  - Global network of partners
  - Global reach: clients and projects in Europe, Asia, Americas, Middle East, Africa

- **This Webinar**
  - Date/Time: 4 Dec. 2019, at 10am and 4pm CET
  - 40-45 min: Topic *Energy Transition Pathways*
  - 15-20 min: Questions & Answers
    - Please ask your questions in the *Questions* box at anytime during the webinar
    - Answers will be provided after the presentations

Contents



- EnerFuture
- Electrification
- Net Zero Emissions

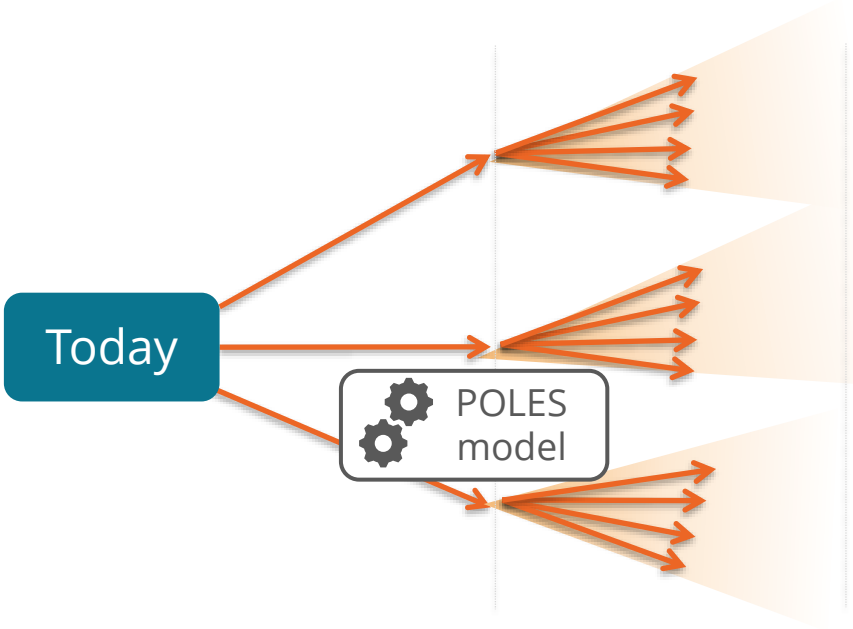
EnerFuture

Introduction to Long-Term Scenarios

EnerFuture: Global Energy Scenarios through 2050

Alternative assumptions for key drivers : resources, climate and energy policies, available technological options …

With identical macro-economic hypothesis: population, GDP growth…



2050

Demand
Global & regional dynamics, fuel mix, efficiency…

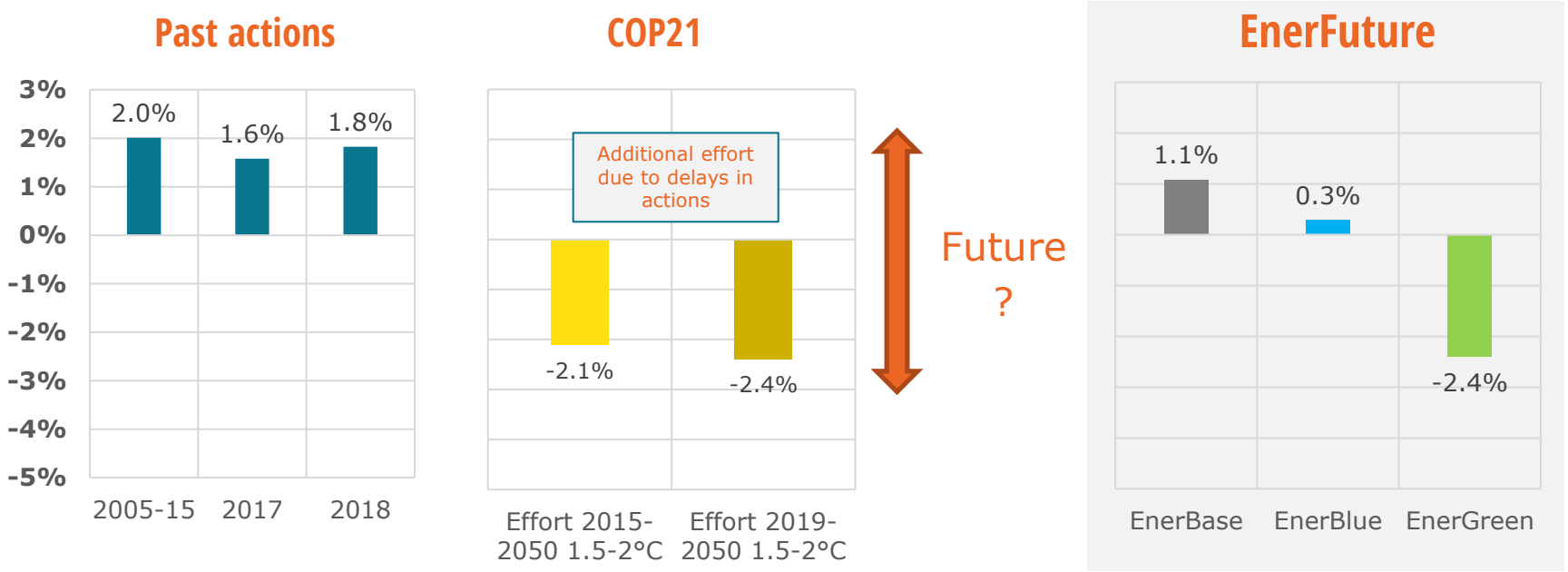
Supply & Prices
Availability, self-sufficiency, trade, bills …

Sustainability
CO_2 emissions…

… allows us to explore different pathways for energy markets

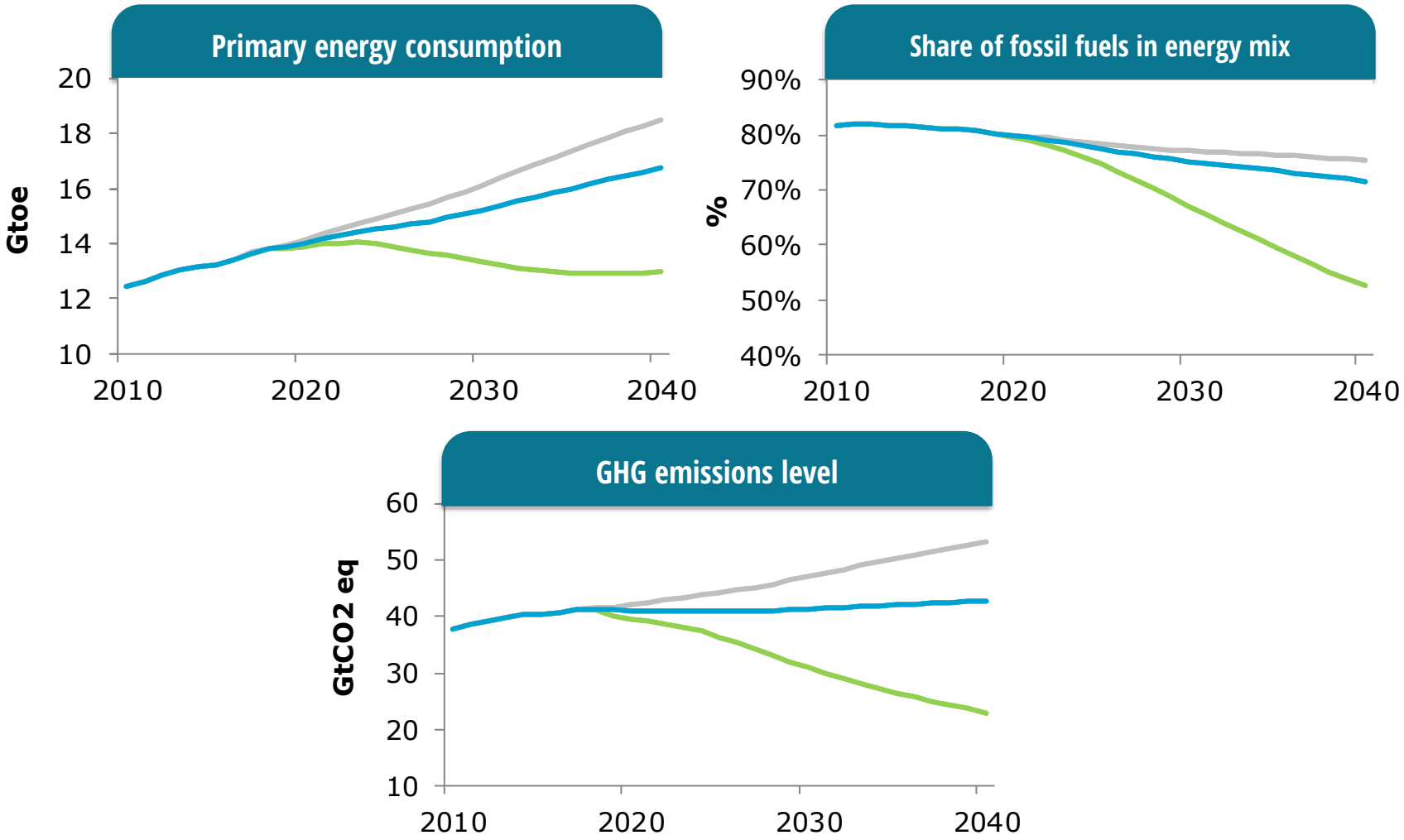
From Rhetoric to Actions: a Need for Scenarios

Variation in CO_2 emissions, World



- **+1.8% growth** of CO_2 emissions in 2018 vs. 2017
- COP21: Limiting temperature growth to 2°C in the long-term required average cut of **2.1%/year** in CO_2 emissions from 2015 to 2050
- Insufficient efforts since 2015: Now average cut of **2.4%/year** required through 2050

EnerFuture: a Range of Possible Futures



Source: EnerFuture

EnerFuture Scenarios: EnerBase

EnerBase

Climate and energy policies

- Efforts to mitigate GHG emissions close to historical trends
- Policies lacking climate ambition, not compatible with NDC targets

Energy demand

- Limited improvements in energy efficiency
- High demand growth in developing countries, and moderate in OECD

Energy supply and prices

- Fossil fuels share doesn't significantly decrease
- Moderate development of renewables
- Fuel prices increase (driven by rising demand and geopolitical context)

The EnerBase GHG emissions trajectory could lead to a temperature increase between 5°C and 6°C.

+35%	Energy demand continues to grow: +35% over 2017-2040
75%	Fossil fuels still account for almost 75% of the primary mix in 2040 (81% in 2018)
<20%	RES remains under 20% of primary mix in 2040
+29%	GHG emissions grow by +29% over 2017-2040, reaching over 53 GtCO2eq

EnerFuture Scenarios: EnerBlue

EnerBlue

Climate and energy policies

- GHG emissions mitigation efforts
- Climate policies in line with NDC objectives.

Energy demand

- Demand growth controlled through energy efficiency
- Energy demand increasing in developing countries, and stable in OECD

Energy supply and prices

- Progressive diversification towards renewables
- Fossil fuels largely remain dominant, though their share is decreasing
- Slowly increasing international fuel prices

The EnerBlue emission trajectory could lead to a temperature increase between 3°C and 4°C.

+22%	Energy demand grows by +22% over 2017-40 (+40% in Non-OECD)
23%	RES share grows up to 23% by 2040. Fossil fuels market share down to 70%
-2.6% /year	Energy intensity yearly average improvement (close to EnerBase)
43 $GtCO_2e$	GHG emissions roughly stabilized around 43 GtCO2eq

EnerFuture Scenarios: EnerGreen

EnerGreen

Climate and energy policies

- Strong efforts towards GHG emissions mitigation
- Ambitious climate policies, with NDC objectives revised upwards

Energy demand

- Considerable improvement of energy efficiency
- Global stabilisation of energy demand, with significant decrease in OECD

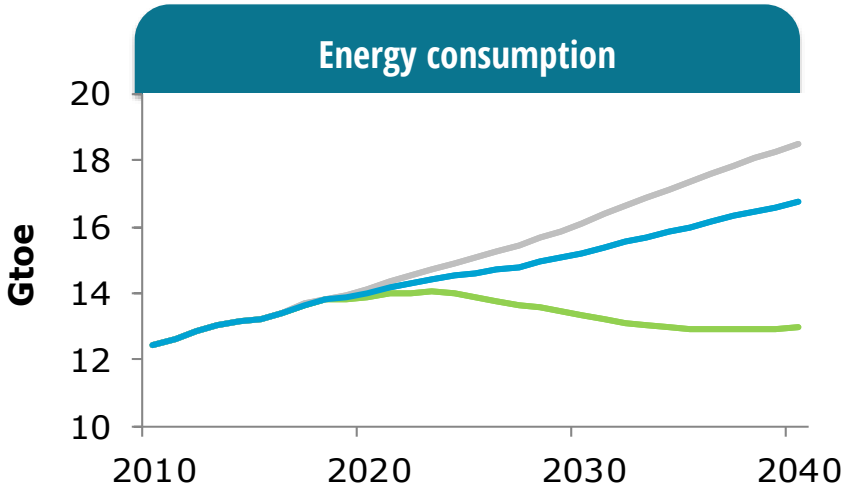
Energy supply and prices

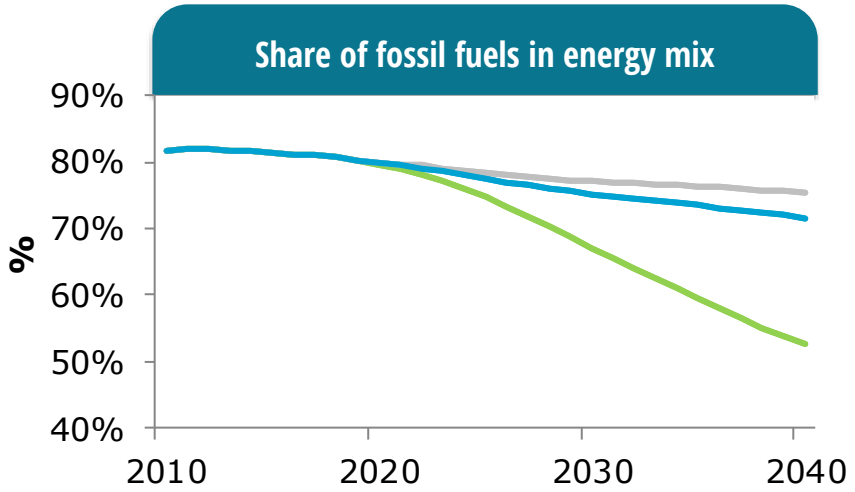
- Strong development of renewables; fossil fuels in decline
- Significant carbon taxations balance fuel prices driven down by lower demand

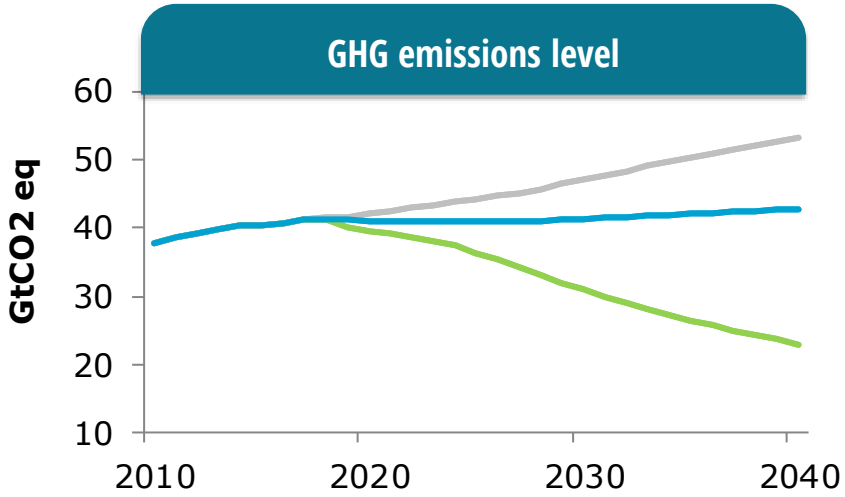
The EnerGreen scenario explores a world in which temperature increase is limited to around 1.5°C to 2°C.

13 Gtoe	Global energy demand stabilisation – big change in energy intensity reduction
53%	Fossil fuels share ~ 53% by 2040, coal share halved
70%	RES and nuclear represent over 70% of power capacities in 2040
23 $GtCO_2e$	GHG emissions reach 23 GtCO2eq in 2040

EnerFuture: a Necessary Breakthrough





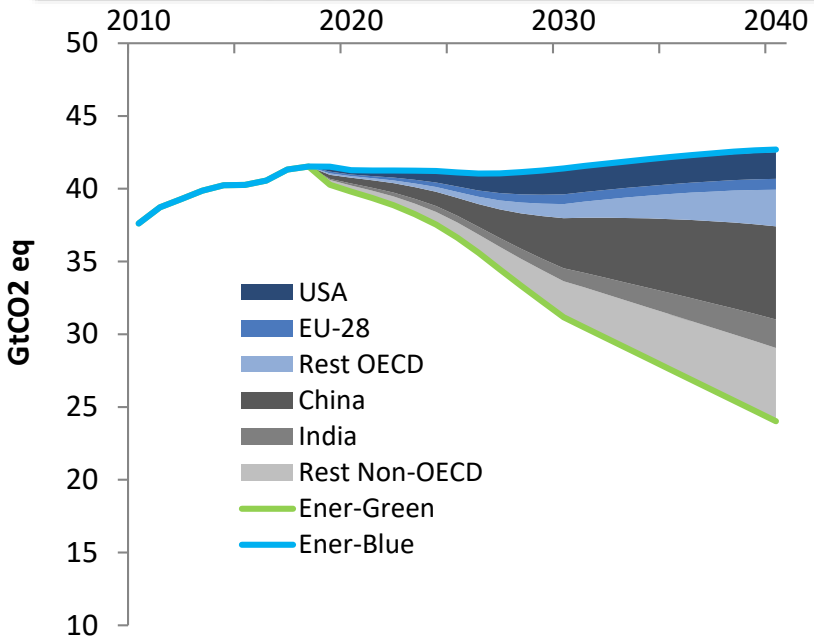


Average evolution (%/yr)	*2010-17*	*2017-40*		
	-	EnerBase	EnerBlue	EnerGreen
Energy intensity of GDP	**-2.0%**	-2.3%	-2.6%	-3.6%
Carbon intensity	-2.0%	-2.5%	-3.3%	-5.8%
Carbon factor	0.0%	-0.2%	-0.7%	-2.2%

Source: EnerFuture

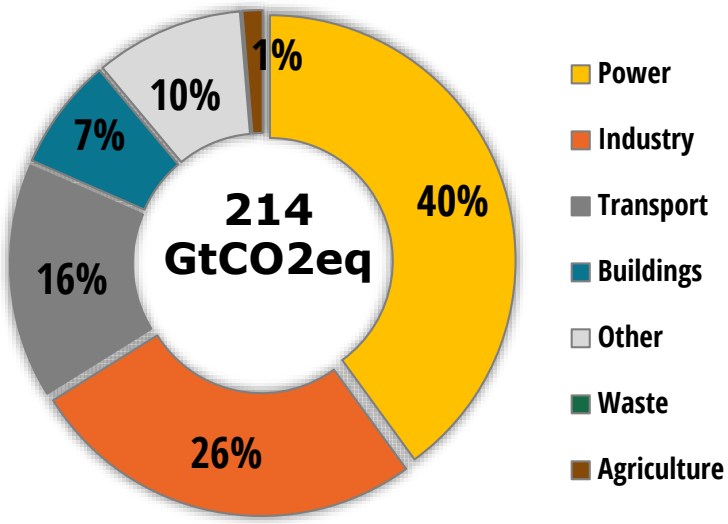
Breaking down the Abatement between EnerBlue and EnerGreen

Emission differential by region (EnerBlue vs. EnerGreen)



Source: EnerFuture, EnerBlue and EnerGreen scenarios

Cumulative reduction options 2017-2040, world



Source: AERO

Developing countries play a key role in reducing global GHG emissions

The power sector represents more than 40% of emissions reductions needed over 2017-2040 to reach the +2°C target.

Some Takeaways

- Increasing gap between trends and 2° scenario
- Is the role of demand-side efforts (1. technical = efficiency and 2. behavioural = sufficiency) typically underestimated in long-term energy/climate scenarios, compared to decarbonization?
- Importance of electricity in decarbonisation pathways
- Developing countries are key to reach global objectives
- Developed countries → carbon neutral objectives

Electrification

A Pillar of Energy Transition

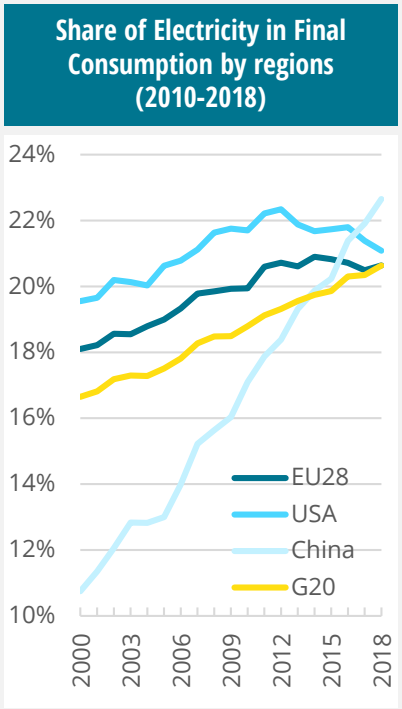
Electrification: a Pillar of Energy Transition

$$CO_2 = population \times \frac{GDP}{capita} \times \underbrace{\frac{energy}{GDP}}_{(1)} \times \underbrace{\frac{CO_2}{energy}}_{(2)}$$

- Electrification allows to improve both energy efficiency (1) and carbon factor (2)

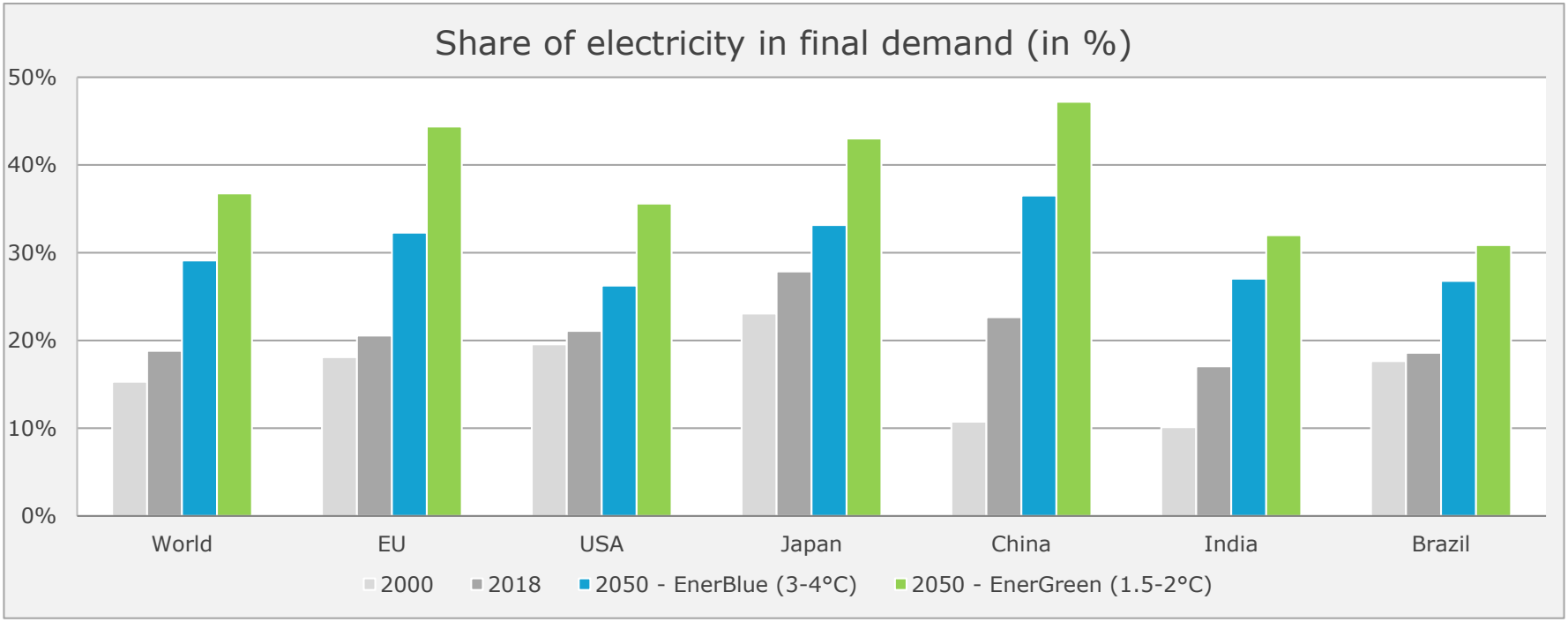
⇒ A key option to mitigate GHG emissions

- More generally electricity fuels economic activity, social development (SDGs…) and help reduce local pollution



Electricity demand is already growing faster (~ x2) than global energy demand

Electrification: Historical and Future Trends



Current trends

- 19% in 2018 (15% in 2000)
- Slow increase
- Stronger trend in % in emerging countries
- Energy demand: +2.0%/y

EnerBlue scenario (NDCs)

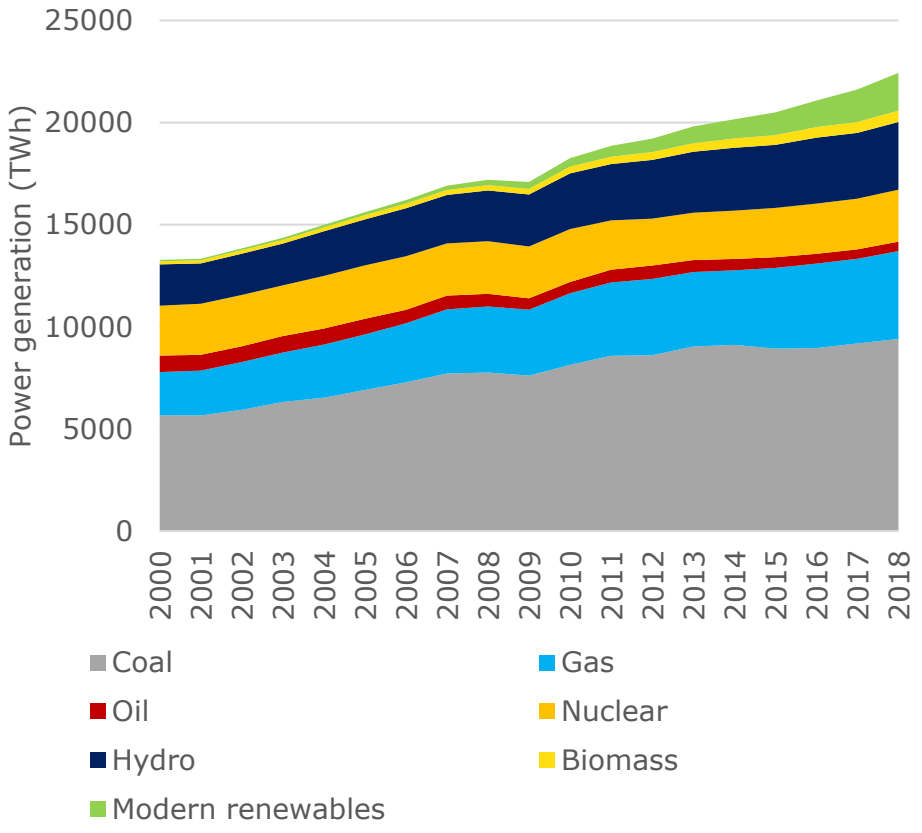
- 29% in 2050
- Energy demand continues to grow: +0.6%/y
- "Demand +" & "share + " = +90% of electricity consumption

EnerGreen scenario (2°)

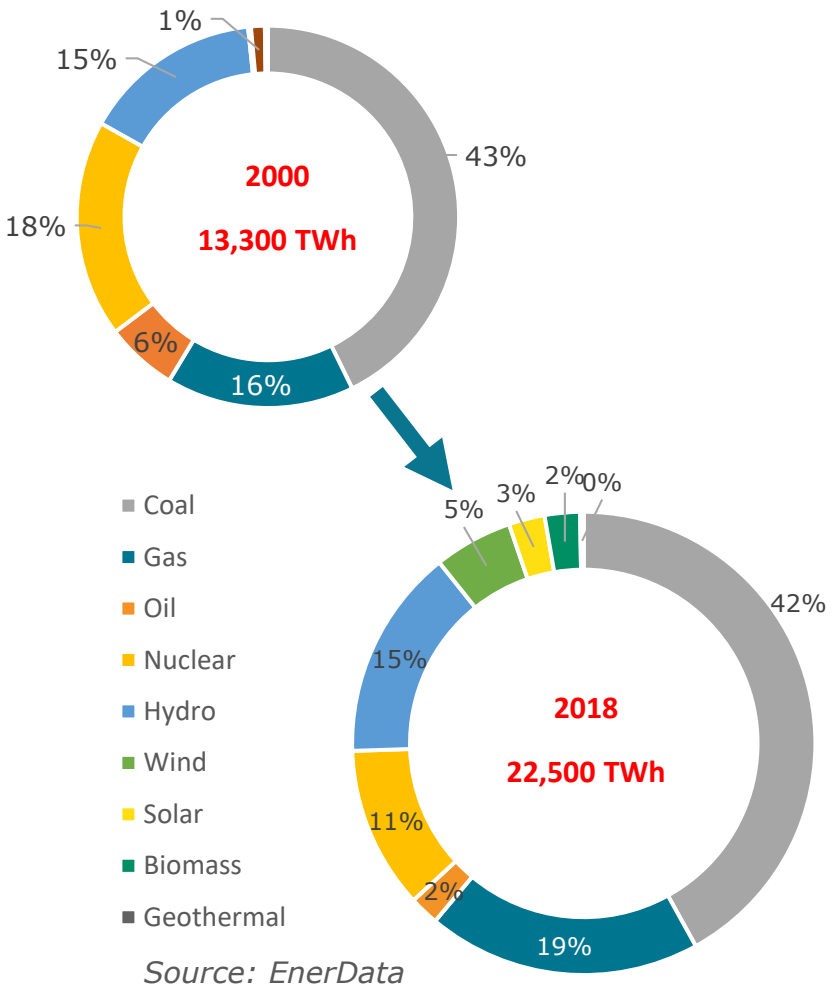
- 38% in 2050
- Energy demand: slight decrease -0.2%/y
- "Demand ~" & "share ++ " = +83% of electricity consumption

Power Mix Decarbonisation: no Big Change so Far

Trends in Electricity Production by Source – G20

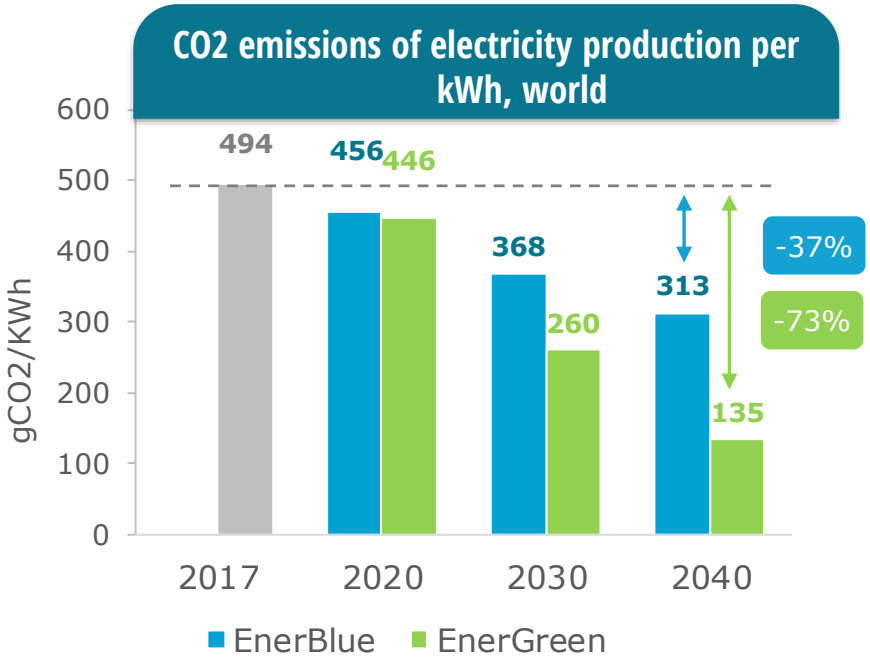


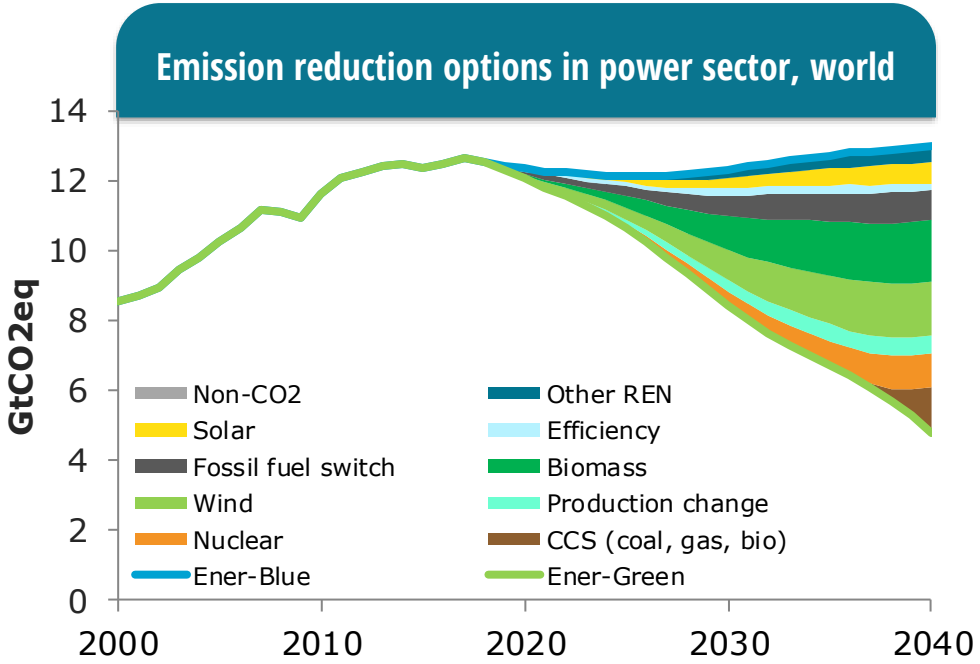
Power Mix – G20 (2000 and 2018)



Source: EnerData

One kWh Generated Will Produce 73% less CO_2 Emissions (2017-2040, EnerGreen)...

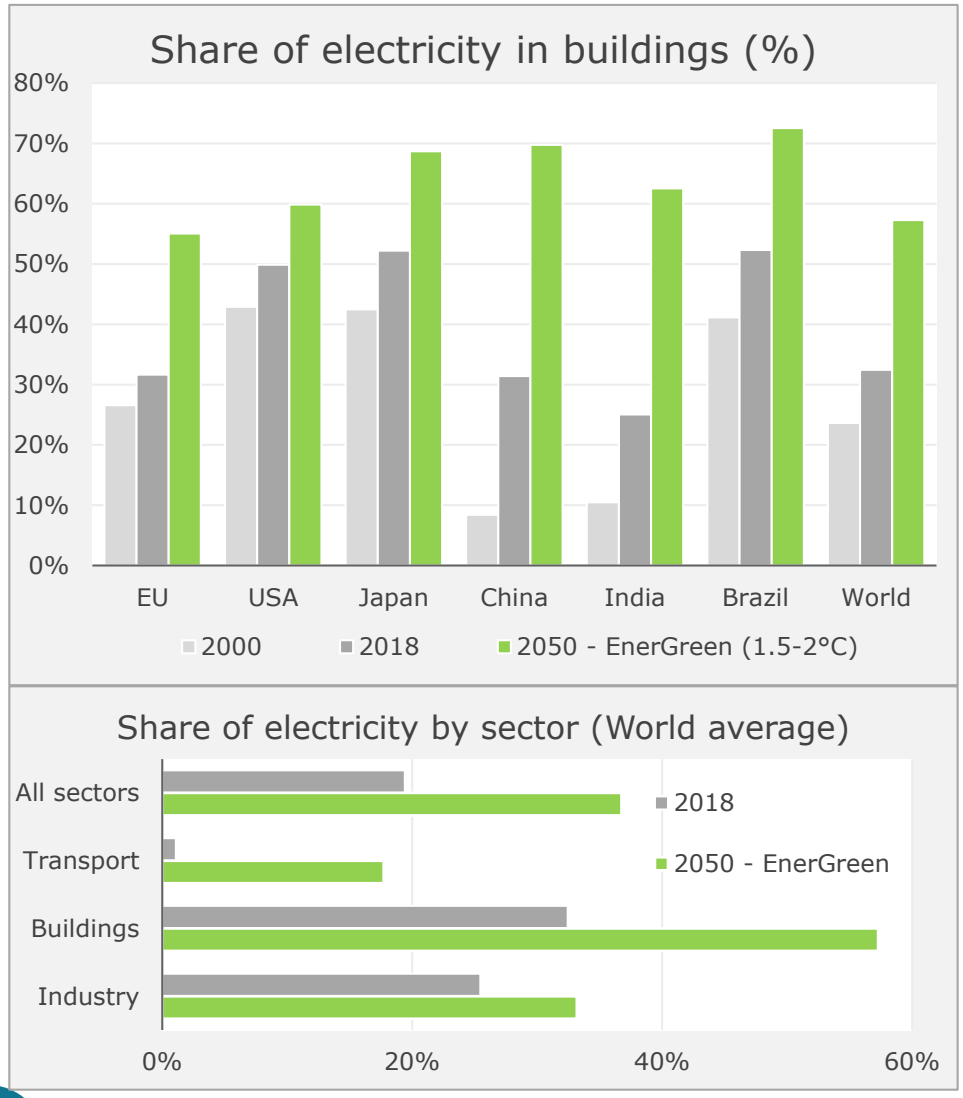




Source: AERO, EnerFuture, EnerBlue and EnerGreen scenarios

...which will mainly be driven by the deployment of RES.

Electrification in Buildings



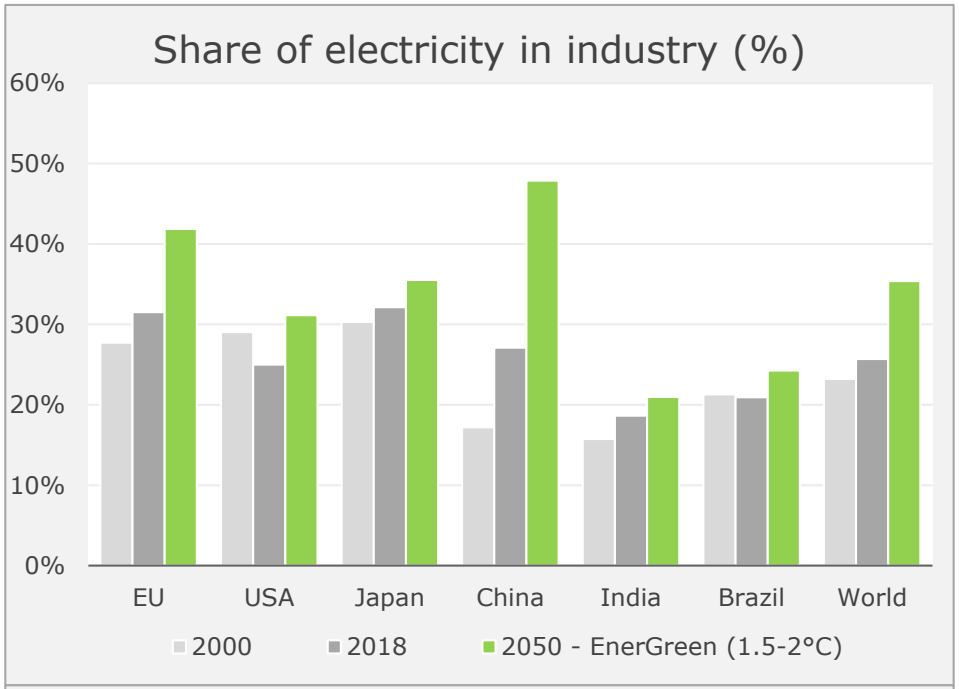
Increase in all countries, strong dynamics in developing countries with lower historical levels

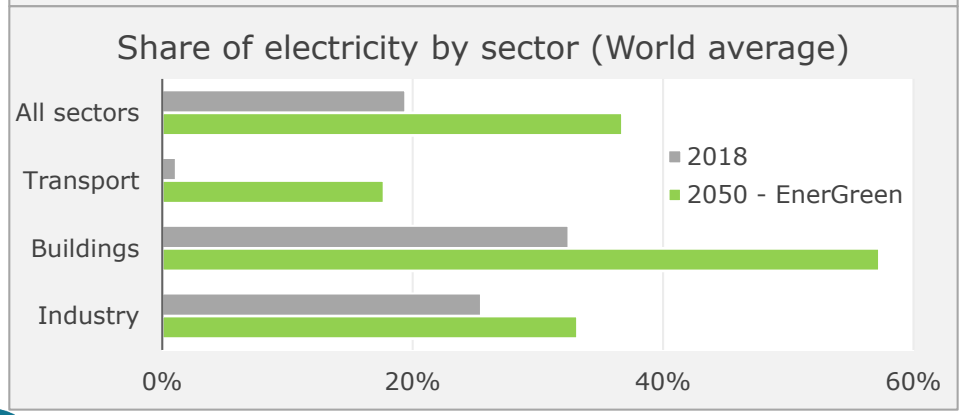
<u>Key drivers:</u>

- **Heat pumps**
  - **High efficiency (impact + and -)**
  - **Increasing cooling needs**
- **Specific uses**
  - **Appliances**
  - **Information technologies & digitalization**

A switch from a gas condensing boiler to an electric heat pump would lead to efficiency improvement up to a carbon factor of around 700 gCO_2/kWh in the power generation sector (e.g. current India)

Electrification in Industry





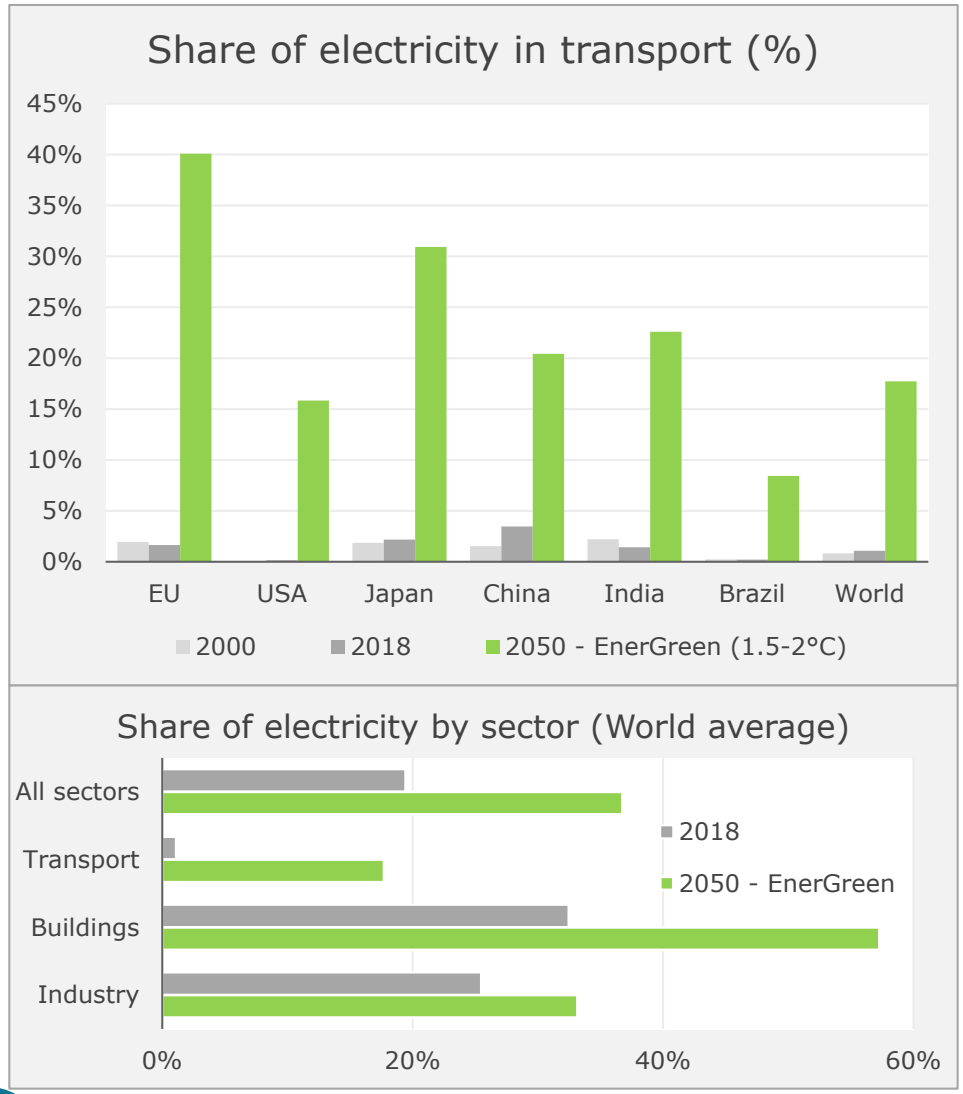
Regular increase of electricity share, but now slower than in other sectors

Key drivers:

- **Mechanisation, robotisation**
- **Electric processes (e.g. electric arc furnace process for steel production)**
- **Development of heat pumps for low temperature uses**
- **Digitalisation**

But some uses are more difficult to electrify (e.g. steam use)

Electrification in Transport



Strong increase of the share of electricity expected in the Transport sector, driven by the fast development of EVs & HEVs

Key drivers

- **In a 2°C scenario, global electric and hybrid fleet could reach over 1 billion by 2040**
- **~15 Mbl/d of oil consumption avoided in 2040**
- **Significant potential in Public Transport growth and electrification**
- **But electrifying other sectors may prove more difficult, especially maritime and air transport**

=> Role of modal shift and sufficiency for sectors with low abatement potential

Electrification and Other Decarbonisation Levers

- In deep decarbonisation scenarios, such as EnerGreen, the share of electricity increases significantly and is largely decarbonized. This raises issues such as e.g. intermittent supply vs. increasing demand, full LCA of RES-E technologies and EVs, etc.

- Improving energy efficiency and energy sufficiency
  - Large cheap reduction potential that must be triggered through adequate policies
  - Limiting abatement efforts to decarbonization could lead to sub-optimal outcome

- Fuel-switching to natural gas
  - From other more carbon intensive fuels
  - Decarbonization potential: biogas, synthetic methane from Power-to-Gas

- Others: Hydrogen, renewable heat

- Issues of competition between emission reductions options

Electrification: Takeaways

- Share of electricity in final consumption has been growing in the past decades…
- And it could reach up to 45% in 2040 in a 1.5-2°C scenario in some regions and 35% globally
  - Heat pumps in buildings
  - Electric vehicles and modal shift in transportation
  - Specific electric heating processes in industry
- Power mix decarbonisation is not significant so far at a global level
- But carbon content of electricity could be reduced by around 75% in 2040 in a 1.5-2°C scenario
- Emission reductions policies cannot be limited to electrification and decarbonization of the electricity sector, as such a limited approach could lead to issues that are partly beyond the usual scope of models analysing global energy transition scenarios

Net Zero Emissions Objective

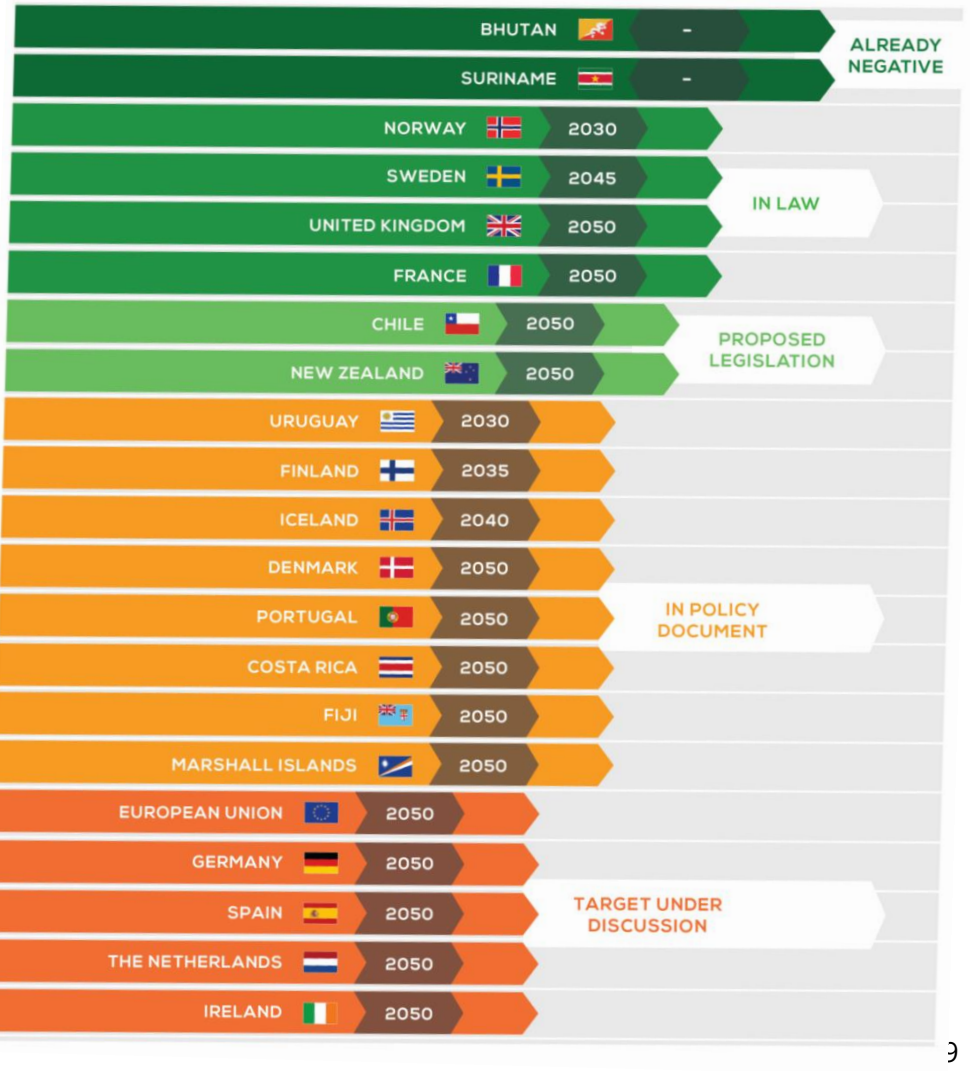
The Solution?

Context

- Since a few years, Net Zero Emissions (NZE) objectives and studies are blooming
  - At country level
  - But also: state, city and company-level

- NZE appears as key-condition, for developed countries by 2050, then for emerging economies, to limit global warming to 1.5-2°C

- How much more ambitious is the approach? Can quick results be achieved? What are the associated risks?



Definitions & Scope

- Net Zero: Emissions = Absorptions
- Scope
  - GHG: all, and not only CO_2 (crucial role of CH_4 in particular)
  - Sectors: all, including
    - Agriculture
    - International transport (aviation + maritime)
    - LULUCF
  - Territorial approach vs carbon footprint approach (consideration of imported/exported emissions)

Enerdata's Recent Experiences

- Longstanding experience in energy and climate scenario building at national and global levels, in particular with energy-related CO_2 emissions

- Since 2018: scope of analysis is widening to all GHG and all economic sectors, with increasing demand for scenarios and analysis, e.g.:
  - NZE in France by 2050, assessing the value of climate action (for France Strategie)
  - NZE in France by 2050 (for EpE, association of French large companies)
  - NZE in the EU by 2050 (for the French Ministry of Energy)
  - Country climate reports (for the French Development Agency)
  - Specific country projects

- Skills and knowledge are evolving
  - More sectors covered, new data required and collected
  - Energy → Energy and climate
  - Mitigation → Mitigation and adaptation
  - New skills and partnerships: agriculture and land-use, food, sociology, macroeconomics

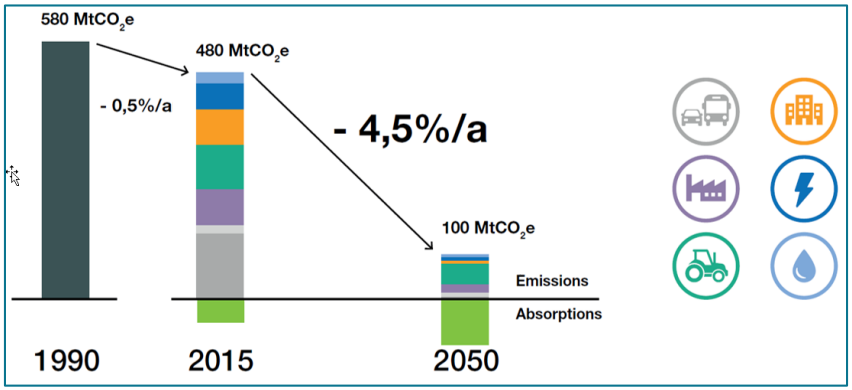
Net Zero Emissions in France by 2050 (1/2)

- General Approach
  - Today: starting point and short-term trends
  - 2050: state of the art and target definition
  - 2020-2050: pathways (back-casting)
  - Short-term conditions for success

- Key topics
  - In-depth analysis by sector
  - Cross-sectoral challenges
  - Approach based on energy vectors
  - Sociologic dimension, in particular households
  - Transparency in « burden-sharing »
  - Results with corresponding targets and short-term action plans

Net Zero Emissions in France by 2050 (2/2)

- Key results
  - Objective is achievable in 2050
  - Using existing technologies and those currently being industrialised
  - Without carbon leakage



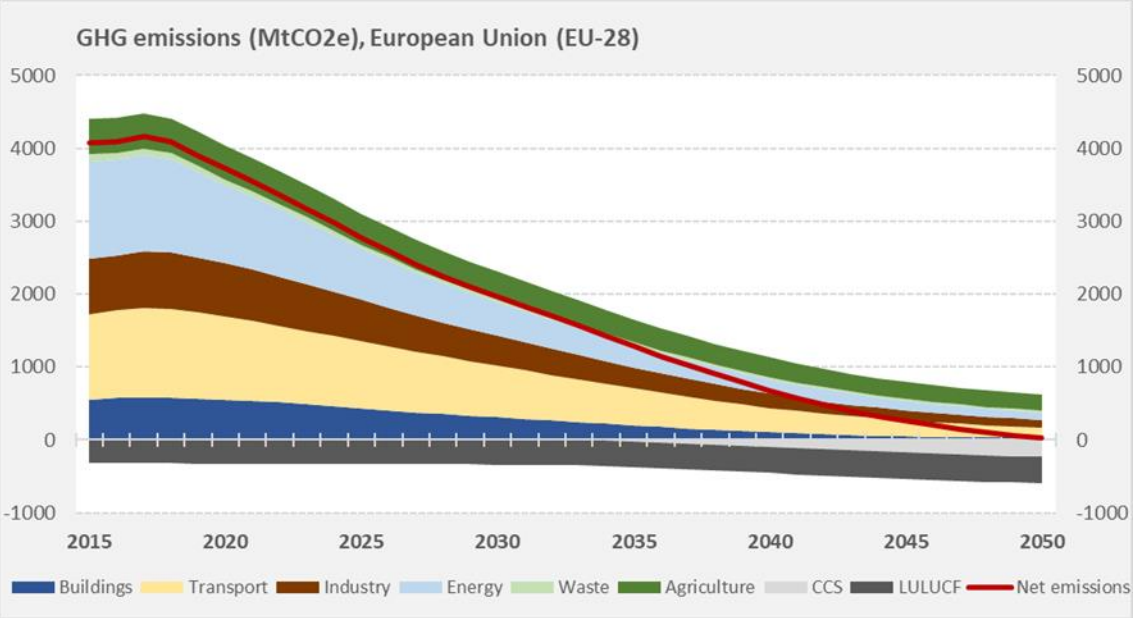
- Key learnings
  - Three main pillars
    - Sufficiency: reduction of useful demand for energy services
    - Efficiency: reduction of energy consumption for a given energy service
    - Decarbonation: reduction of emissions
  - Level of effort (today-2050)
    - Energy consumption: -45-50%
    - Decarbonation: energy -100%, all end-use sectors -70-90%, except agriculture -50%
    - Main changes in energy vectors: electricity "++", solid biomass and heat "+", gas "stable", liquids "--"
  - No major impact in terms of total employment, but major transitions depending on sector

Net Zero Emissions in the EU by 2050 (1/2)

- In this work, approach based on full system modelling
  - POLES: energy and emissions modelling by sector
  - MOSUT: agriculture and LULUCF modelling
  - NEMESIS: macroeconomic modelling

- Net Zero Emissions scenario for the EU: a cost-effective and balanced approach
  - International environment: comparable effort to limit temperature increase to 2°C
  - Lower costs for low-carbon technologies are observed
  - Moderate assumptions about technological progress across all sectors
  - Agriculture and food: a low-meat or "flexitarian" diet (a reduction of about 50% in meat and milk consumption by 2050 compared with today), leads to significant emissions reductions in the agricultural sector
  - Energy: reduction effort is important in all sectors, including energy supply

Net Zero Emissions in the EU by 2050 (2/2)



Drastic economy-wide emissions reductions

Final energy consumption by sector and by vector (EU-28)

	Buildings	Transport	Industry	*Vector*
Consumption 2050 (index 100 in 2015)	**58**	**52**	**55**	***55***
Petroleum Products	1%	20%	15%	*11%*
Natural Gas	3%	0%	5%	*3%*
Coal	0%	0%	1%	*0%*
Electricity	63%	60%	50%	*58%*
Bioenergy	13%	20%	25%	*18%*
Heat	20%	0%	4%	*10%*
Sector	***40%***	***26%***	***34%***	***100%***

Conclusions

- In developed economies, NZE approaches aim to increase ambition to fight climate change and show the need for short-term action

- General approach: 2050 objective, mid-term targets, action plan, monitoring, communication

- Conditions of success
  - Large scope (all sectors, all GHG)
  - Precise methodology
  - Leverage all possible actions (sufficiency + efficiency + decarbonation)
  - Process to involve all stakeholders, with early implementation

- Approach to be complemented by
  - Consumption approach (carbon footprint) vs territorial emissions only
  - Evaluation of objectives/implementation also at subnational level (states, cities, companies)

Contact:

Quentin BCHINI
quentin.bchini@enerdata.net

Sylvain CAIL
sylvain.cail@enerdata.net

About Enerdata:

Enerdata is an energy intelligence and consulting company established in 1991.
Our experts will help you tackle key energy and climate issues and make sound strategic and business decisions.
We provide research, solutions, consulting and training to key energy players worldwide.

https://www.enerdata.net/

Enerdata

Thank you for your attention!

Questions & Answers

More info / useful links

- EnerFuture scenarios
- Global Energy and CO_2 Database
- Power Plant Tracker