

Energy Scenarios to 2040:

What it Takes to Reach INDCs and Beyond

April 2016



Enerdata: a global energy intelligence company

- **Independent** energy research & consulting company since 1991
- Spin-off of CNRS research center
- **Expert** in analysis and forecasting of global energy & climate issues
- **In-house** and globally recognized databases and forecasting models
- Headquartered in the Grenoble (French Alps) research cluster
- Offices in Paris, London and Singapore + network of partners WW
- **Global reach**: clients in Europe, Asia, Americas, Africa



EnerFuture workshop

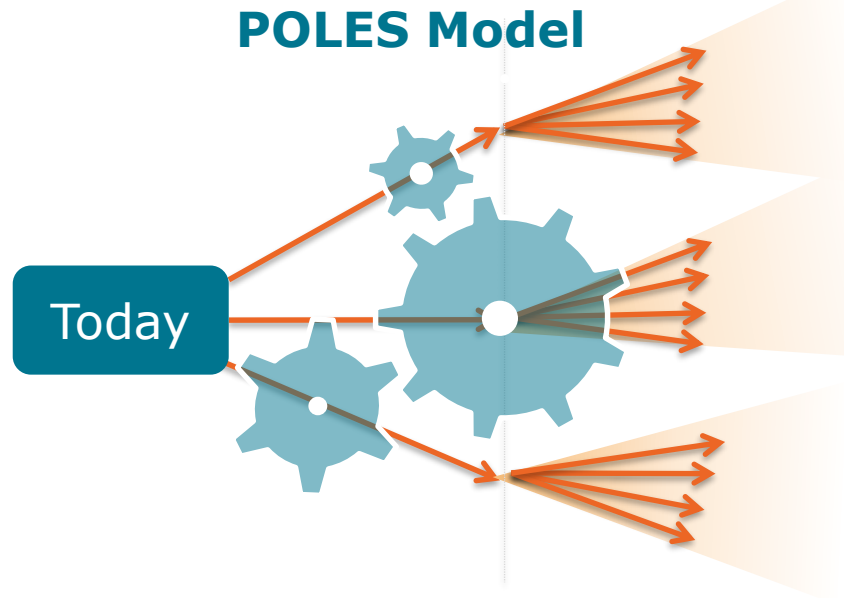
- Introduction
Methodology and scenarios overview
- Ener-Blue
INDCs based scenario
- Ener-Green
2°C max. increase scenario
- Supply
- Focus on China
- Focus on EU-28
- Conclusions

Methodology and scenarios overview

EnerFuture: global energy scenarios to 2040

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

*With identical macro-
economic hypothesis:
population,
GDP growth...*



2040 ?

<p>Demand <i>Global & regional dynamics, fuel mix, efficiency...</i></p>
<p>Supply & Prices <i>Availability, self-sufficiency, trade, bills ...</i></p>
<p>Sustainability <i>CO₂ emissions...</i></p>

... allows us to explore different pathways for energy markets

Description of the EnerFuture scenarios



Ener-Blue

Ener-Green



Ener-Brown



CLIMATE & ENERGY POLICIES

- | | | |
|--|---|---|
| <ul style="list-style-type: none"> ▪ 2030 INDCs targets achieved ▪ CO₂ emissions growth slow-down ▪ +3-4°C temperature increase | <ul style="list-style-type: none"> ▪ Reinforcement trend ▪ INDCs targets regularly reviewed upwards ▪ +1.5-2°C temperature increase | <ul style="list-style-type: none"> ▪ INDCs targets not reached ▪ Soaring CO₂ emissions ▪ +5-6°C temperature increase |
|--|---|---|

ENERGY DEMAND

- | | | |
|--|--|---|
| <ul style="list-style-type: none"> ▪ Increase in developing countries ▪ Stable in OECD ▪ Controlled through INDCs | <ul style="list-style-type: none"> ▪ Global stabilization ▪ Ambitious energy efficiency policies ▪ Regular updates of efficiency targets | <ul style="list-style-type: none"> ▪ Limited improvement on energy intensity ▪ High growth in developing countries ▪ Growth in OECD too |
|--|--|---|

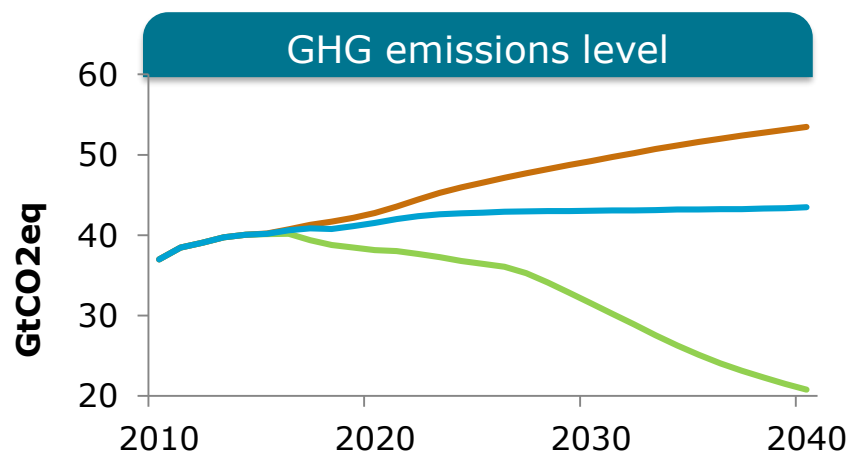
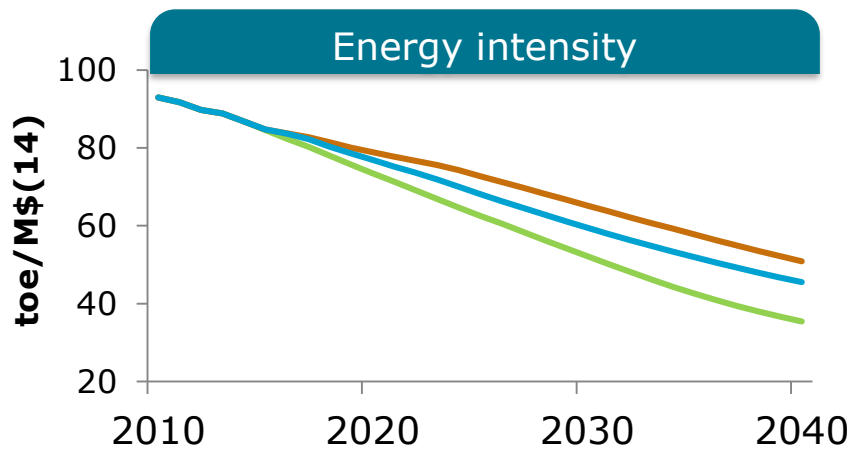
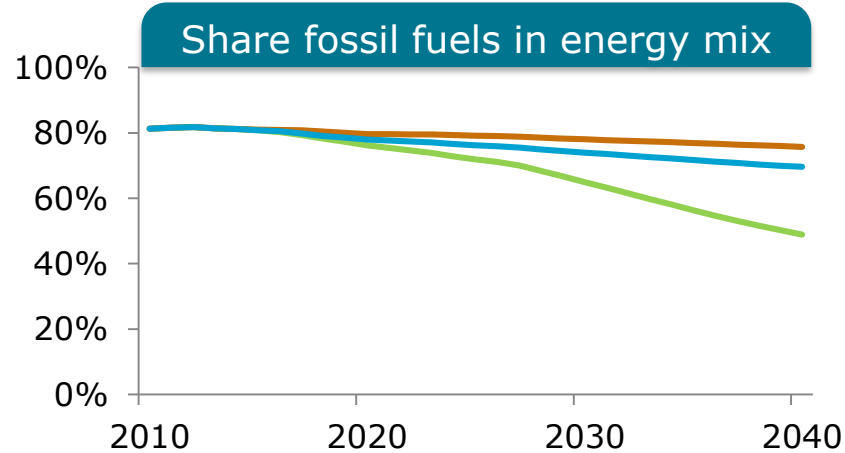
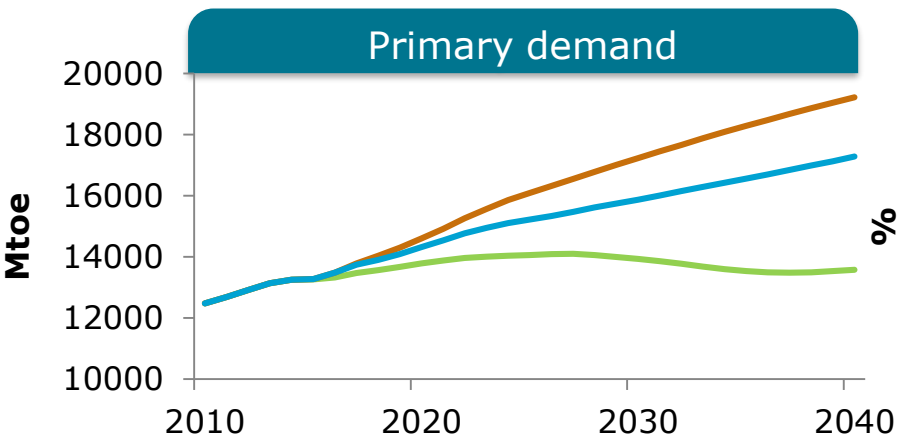
ENERGY SUPPLY & PRICES

- | | | |
|--|---|---|
| <ul style="list-style-type: none"> ▪ Tensions on available resources ▪ Increasing energy prices ▪ Diversification towards renewables | <ul style="list-style-type: none"> ▪ Fossil fuel subsidies phase-out ▪ Strong development of renewables ▪ Price increase reflect policies and CO₂ constraints | <ul style="list-style-type: none"> ▪ Fossil fuels renaissance ▪ Lower energy prices ▪ Strong fossil fuel technological improvement ▪ Continued efforts on renewables |
|--|---|---|



Key energy indicators by scenario

— Ener-Blue — Ener-Green — Ener-Brown



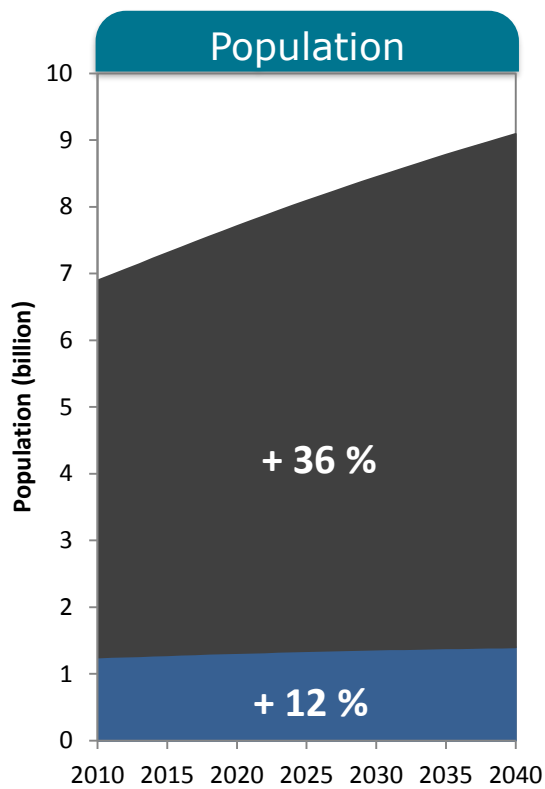
Source: EnerFuture

Ener-Blue: key outputs

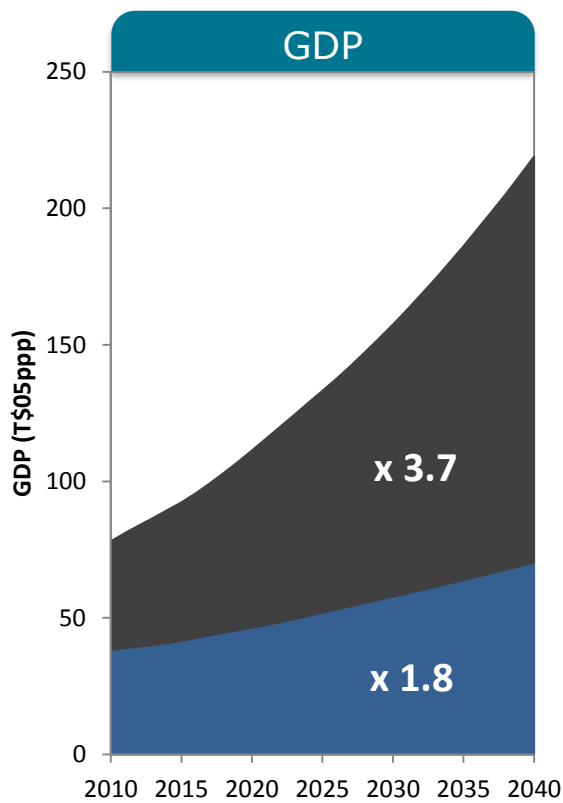
based on INDCs' targets achievement



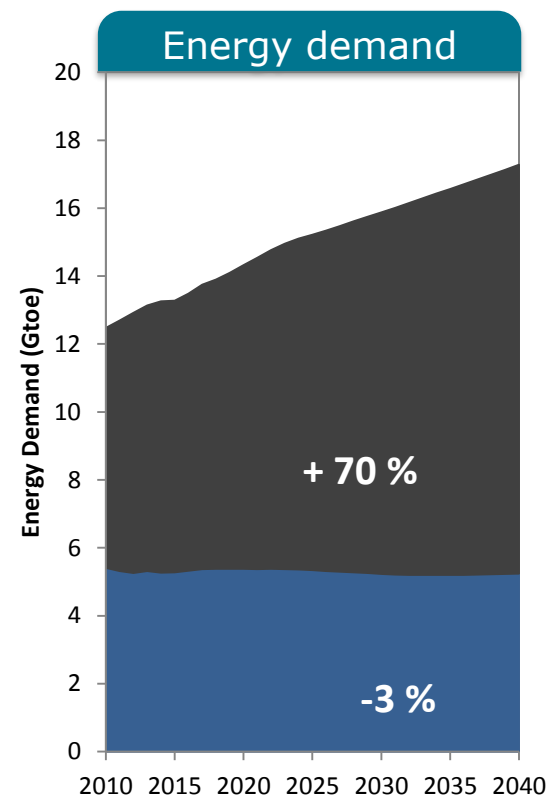
Expected economic recovery will drive up energy consumption...



Source: UN World Population Prospects (2015 Revision)



Source: IMF outlook (2014 - 2020) CEPII Baseline (2021 - 2040)



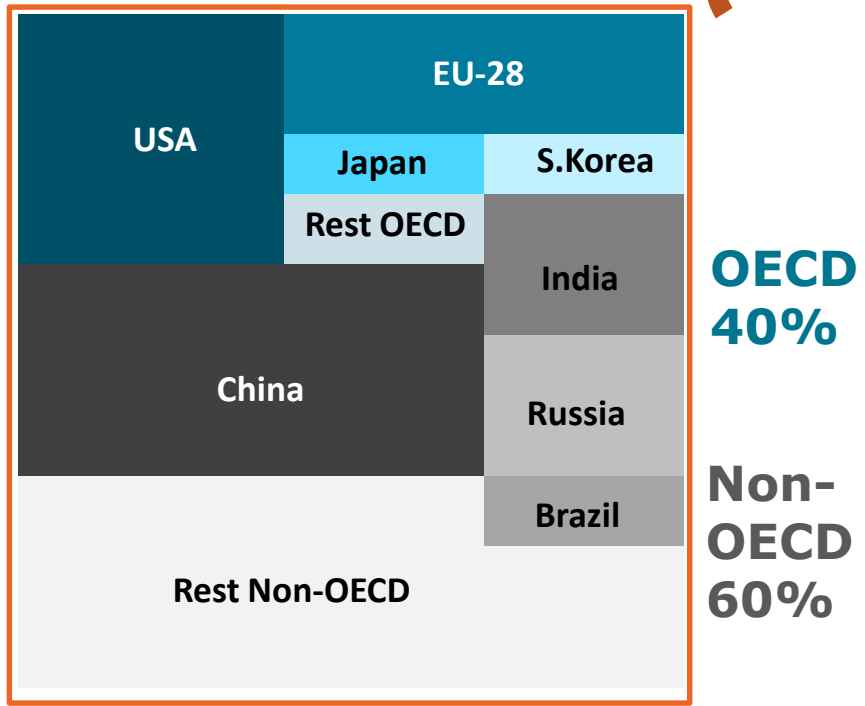
Source: EnerFuture Comparison base year: 2010

■ OECD ■ NOECD World CAGR (%)

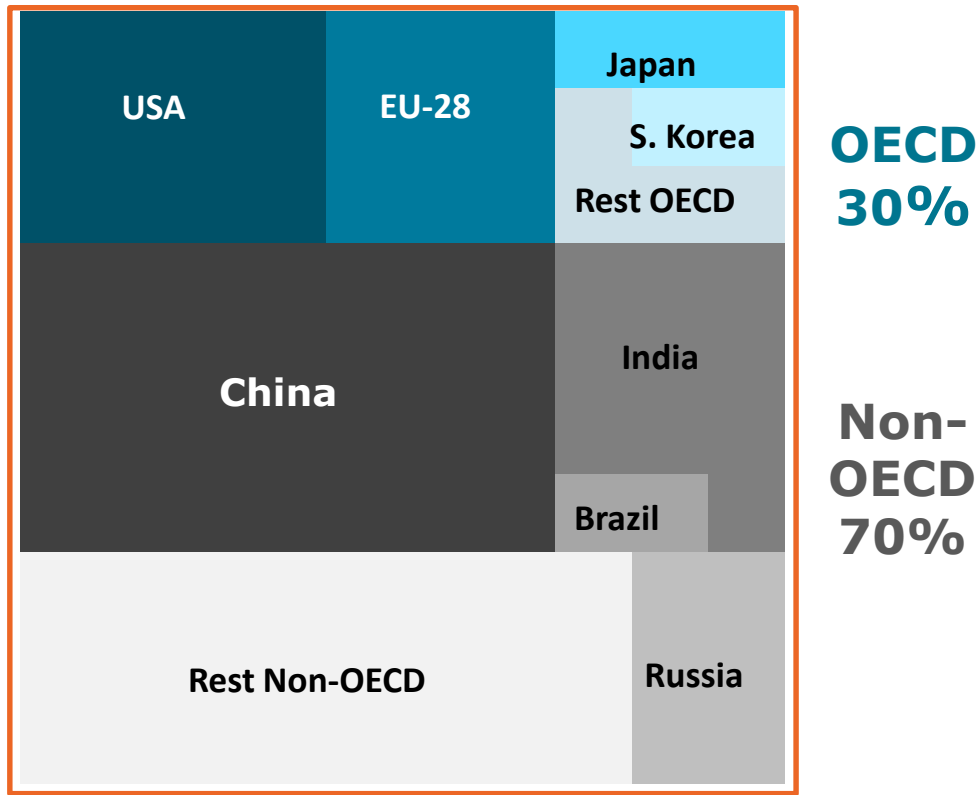


... pulled by developing countries, when OECD demand stabilizes.

**+4,0 Gtoe
(+30%)**



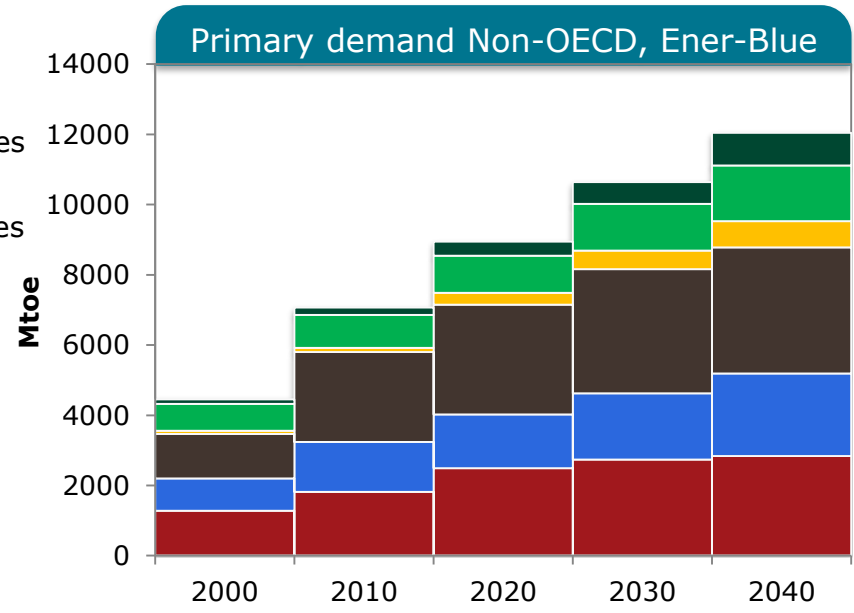
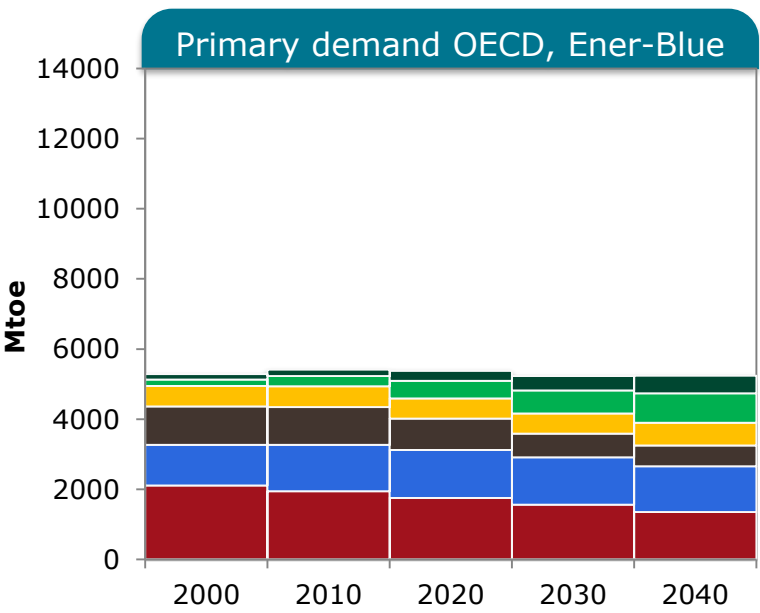
2014 (13.3 Gtoe)



2040 (17.3 Gtoe)



Fossil fuels' domination decreases from 80% to 70% of the mix...



Share fossil fuels

2000	2010	2020	2030	2040
83%	75%	62%		

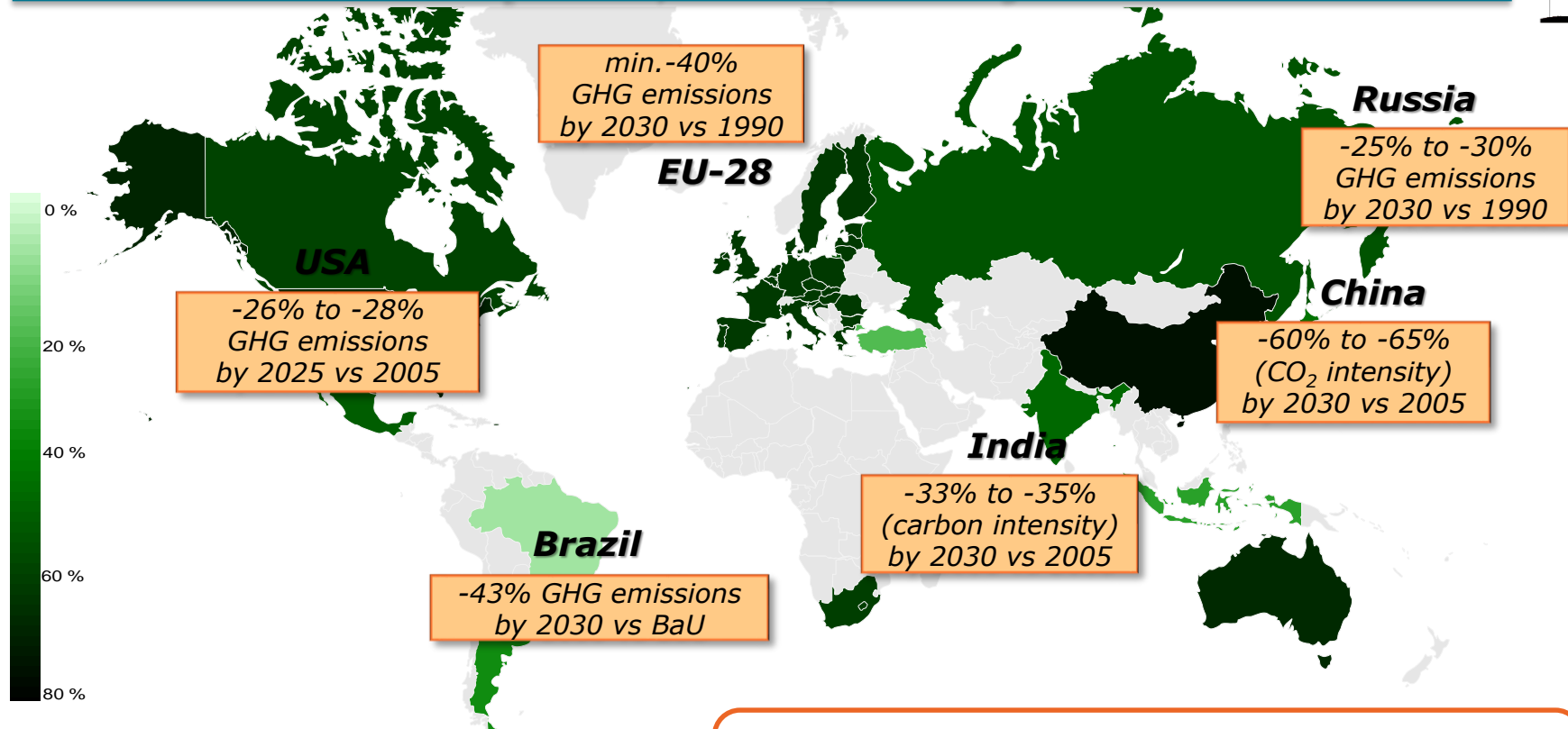
2000	2010	2020	2030	2040
78%	80%	73%		

... impacted by the high increase in renewables sources.



INDCs are key targets to ensure global GHG emissions reductions ...

Reduction efforts of CO₂ intensity* in G20, INDC target recalculated vs 1990



* CO₂ intensity of GDP: ratio of CO₂ emissions to GDP, excl. LULUCF

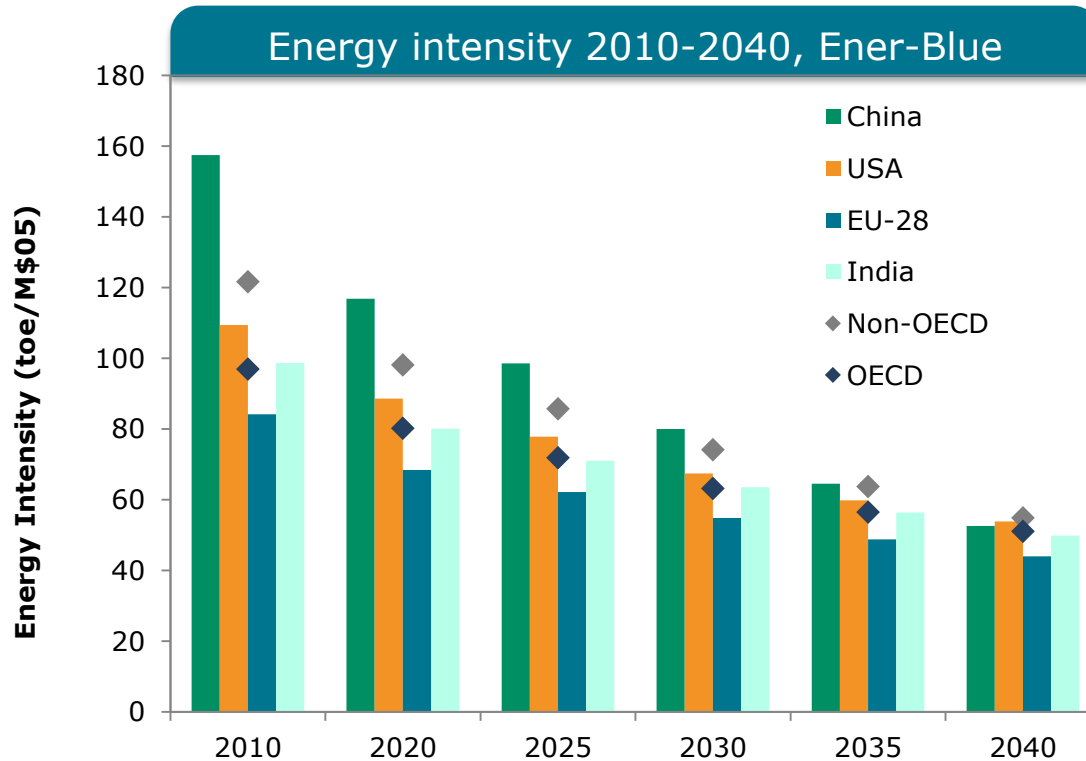
Source: UNFCCC, submitted INDCs

G20 represent ~85% of GHG global emissions

... but ambitions remain different depending on the countries.



In Non-OECD countries, energy intensity is more than halved over 2010-2040...

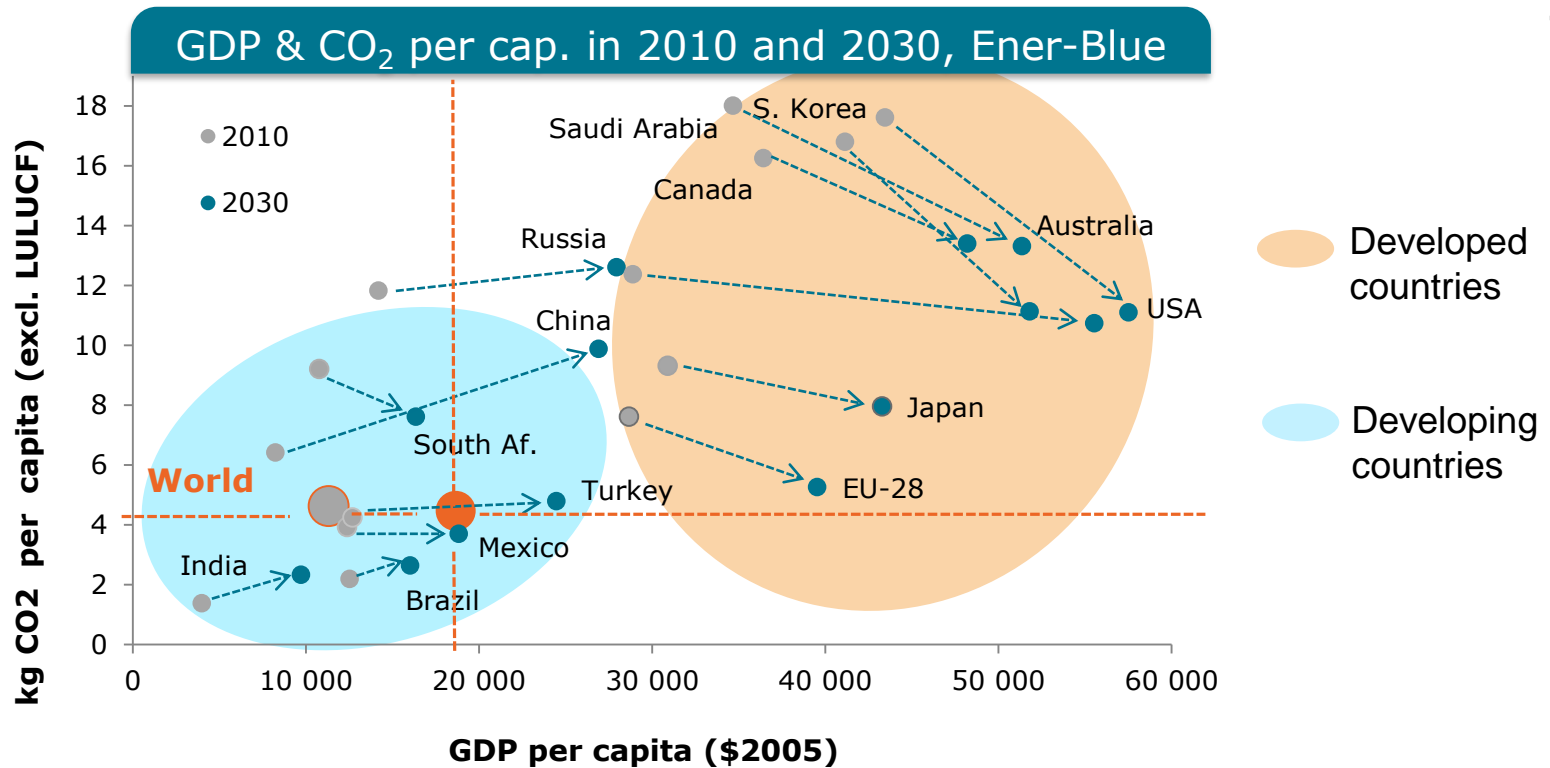


... and converges toward OECD countries' levels.

Source: EnerFuture, Ener-Blue scenario



INDCs lead to a growing decoupling between GHG emissions and GDP, mostly in OECD...



...however these improvements are not sufficient to cope with global climate challenges.

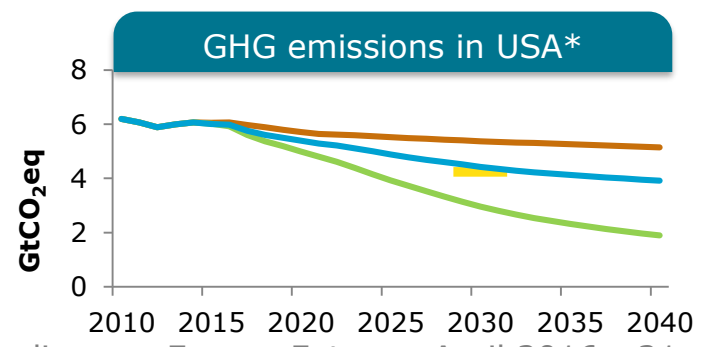
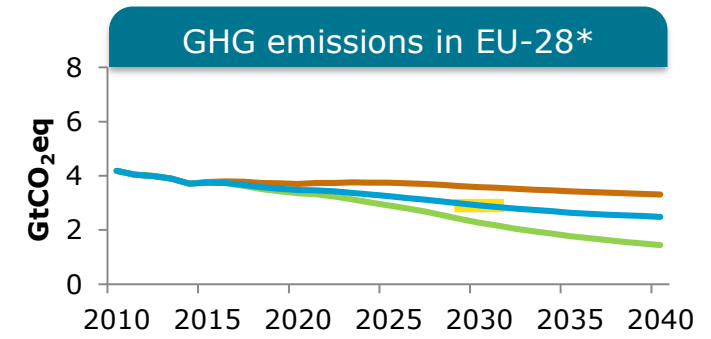
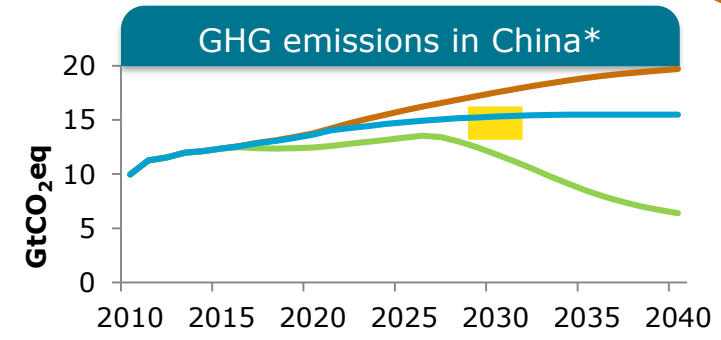
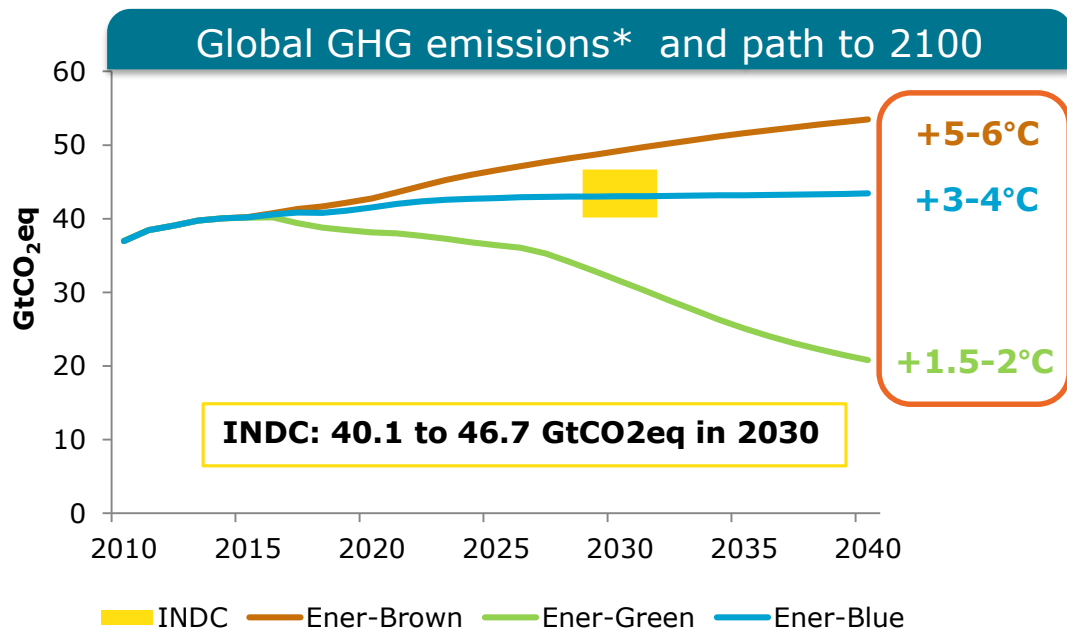
Source: EnerFuture, Ener-Blue scenario

Ener-Green key outputs

from COP21 INDCs to a 2°C ambition



GHG emissions reductions implied by INDCs are not sufficient to reach the 2°C target ...



Source: UNFCCC, submitted INDCs and EnerFuture

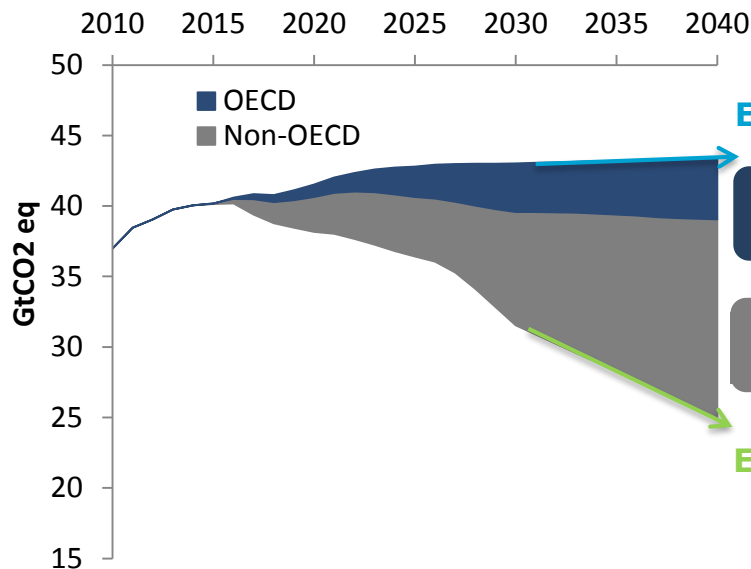
... Strengthened efforts and policies are necessary to ensure GHG emissions compatible with the UN 2°C goal.

* excl. LULUCF





70% of additional emissions reduction should come from Non-OECD



Source: EnerFuture, Ener-Blue and Ener-Green scenarios

% reduction, cum. 2010-2040

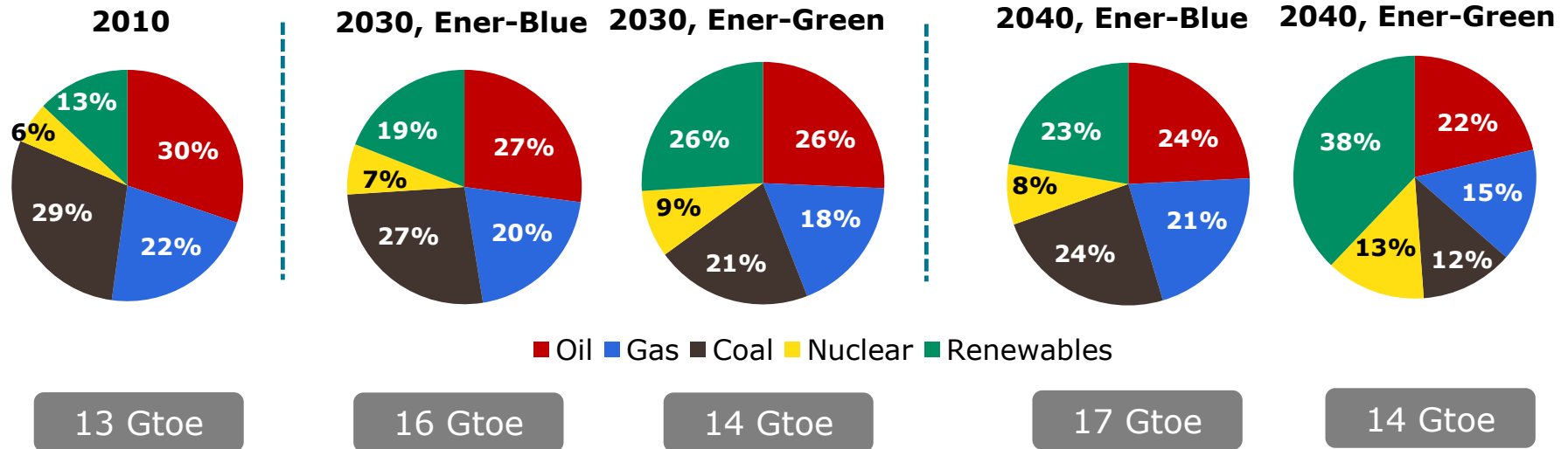
EU-28	11 GtCO₂eq	5%
USA	27 GtCO₂eq	12%
Rest OECD	26 GtCO₂eq	11%
Brazil	3 GtCO₂eq	1%
India	22 GtCO₂eq	9%
Rest Non-OECD	70 GtCO₂eq	30%
China	75 GtCO₂eq	32%

... and China would represent ~1/3 of the global additional efforts to be made to reach the +2°C objective.



Reaching the 2°C target leads to an important shift in the energy mix...

World primary energy mix, Ener-Blue vs Ener-Green



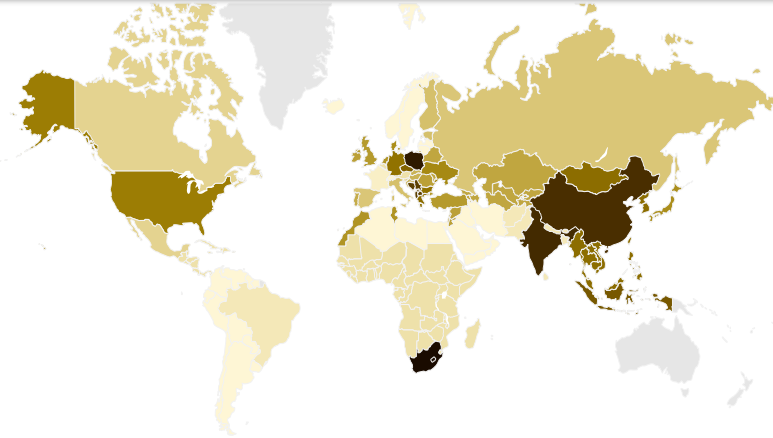
- Very high growth of RES (+ nuclear development)
- While coal production would dramatically decrease.

Source: EnerFuture, Ener-Blue & Ener-Green scenarios



To reach the 2°C objective, the coal share in power would decrease dramatically...

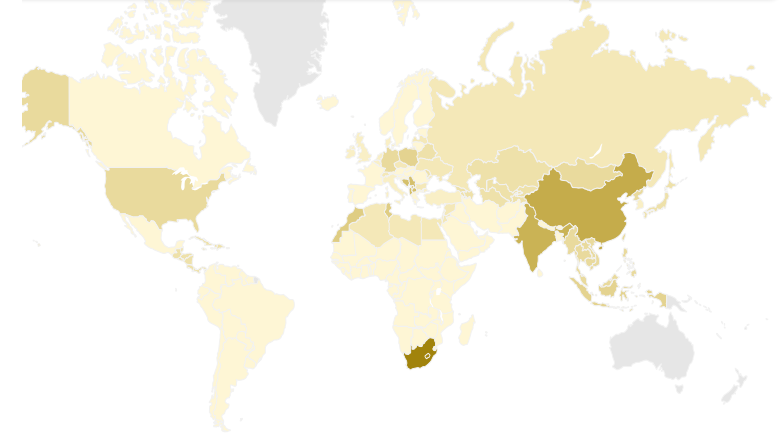
% of Coal in Power Gen., 2014



41%

9 738 TWh

% of Coal in Power Gen., Ener-Green, 2040



13%

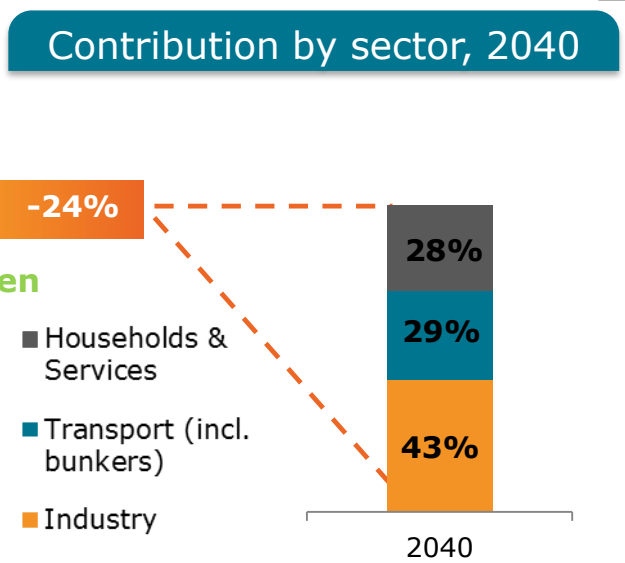
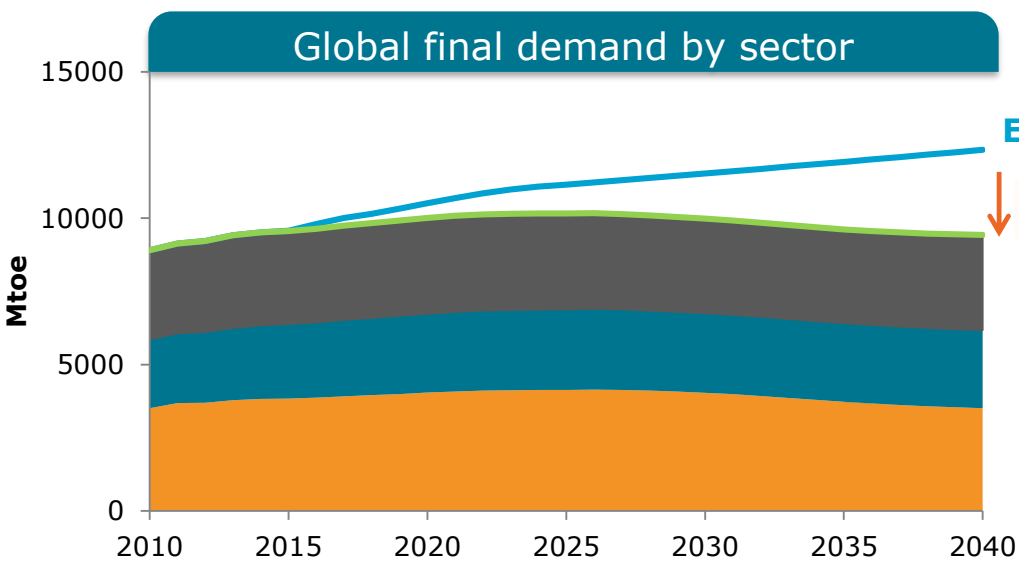
5 025 TWh

... despite the deployment of carbon capture and storage technology which would reach 20% of coal installed capacities in 2040

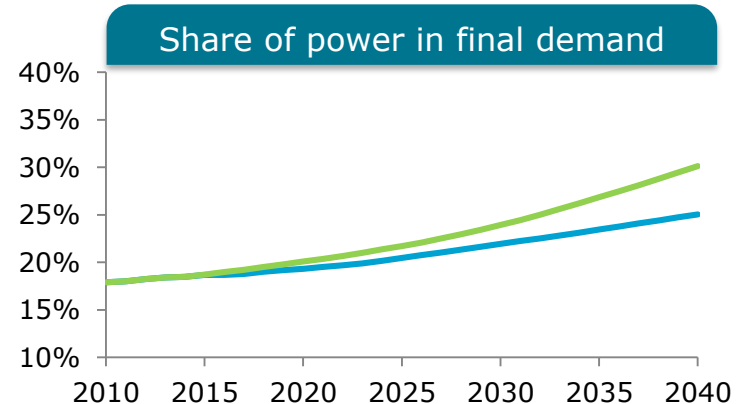
Source: EnerFuture, Ener-Green scenarios



All sectors should contribute to the necessary energy demand stabilisation...



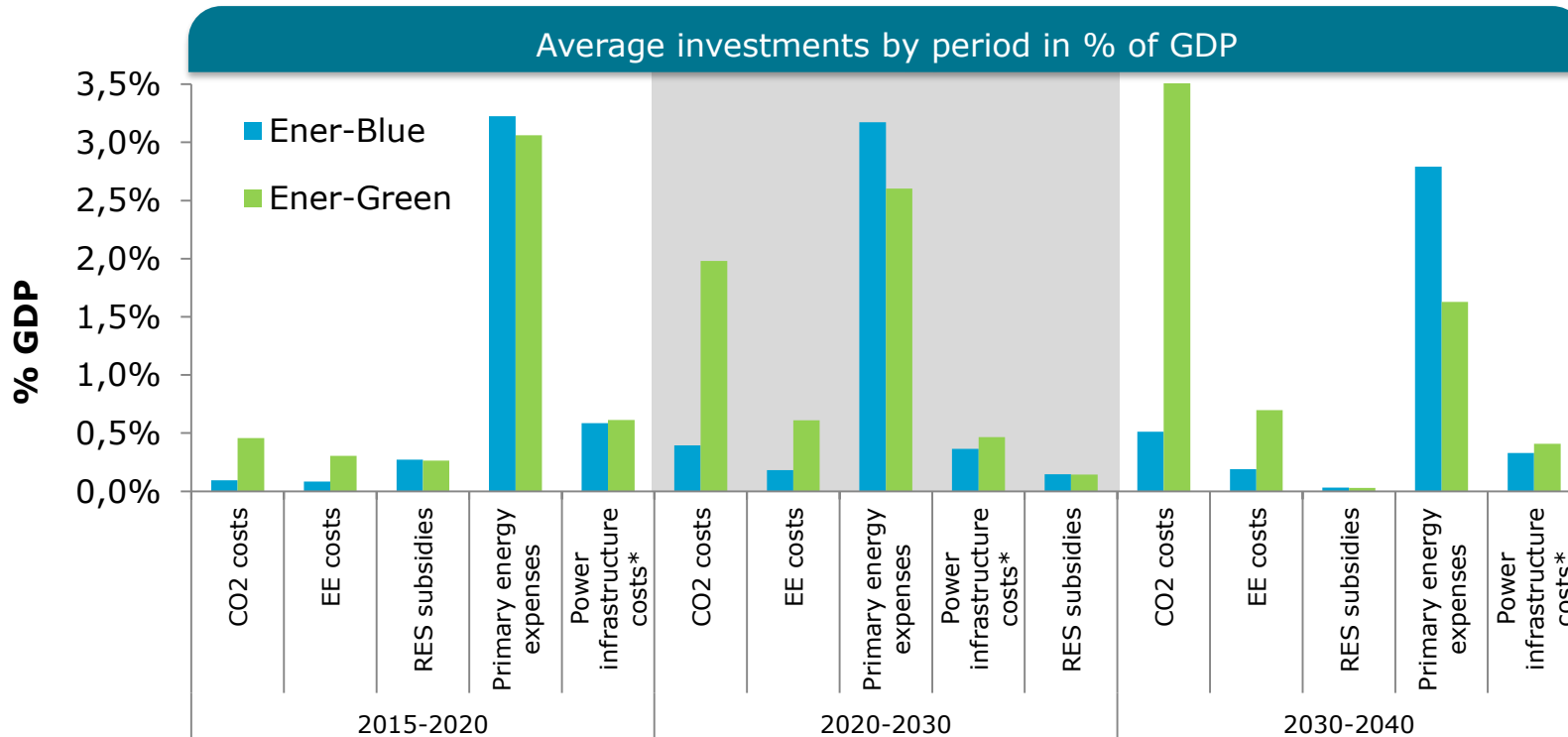
... accompanied by an increased electrification.



Source: EnerFuture, Ener-Blue and Ener-Green scenarios
 Understanding our Energy Future - April 2016 26



Additional costs and investments will be needed to reach the 2°C target...



* Excluding subsidies.

... on the other hand, climate and energy policies should enable to decrease significantly the energy import costs.

Source: EnerFuture, Ener-Blue and Ener-Green scenarios

EnerBlue – EnerGreen – EnerBrown

Focus on supply

oil

gas

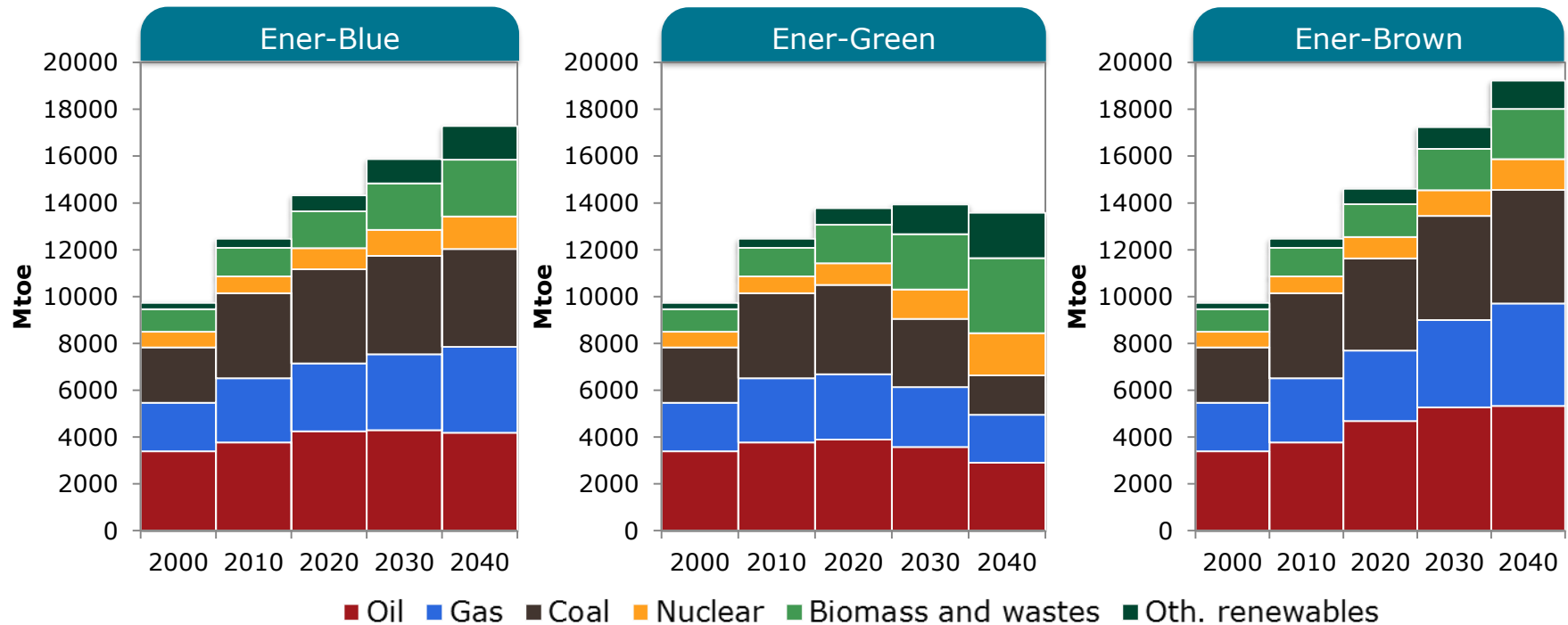
coal

nuclear

renewables



Primary Energy mix evolution by scenario

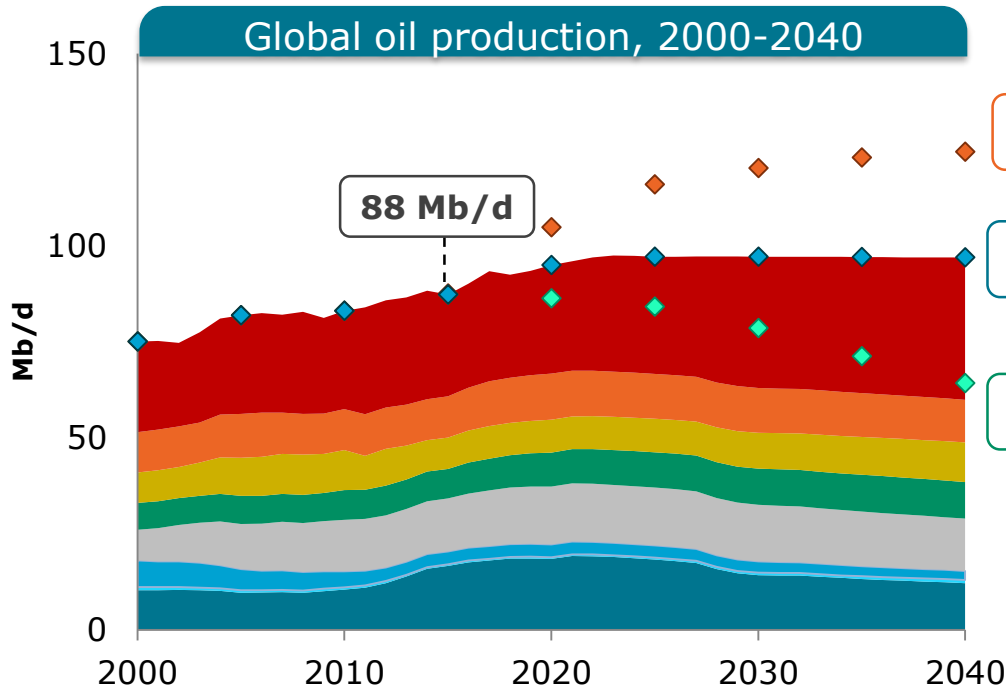


- Fossil fuels stay at 76% in Ener-Brown and 70% in Ener-Blue, but fall down to 50% in Ener-Green.
- RES + Nuclear vary from 24% (Ener-Brown) to 50% (Ener-Green).

Source: EnerFuture



Global oil demand is strongly impacted by climate and energy policies

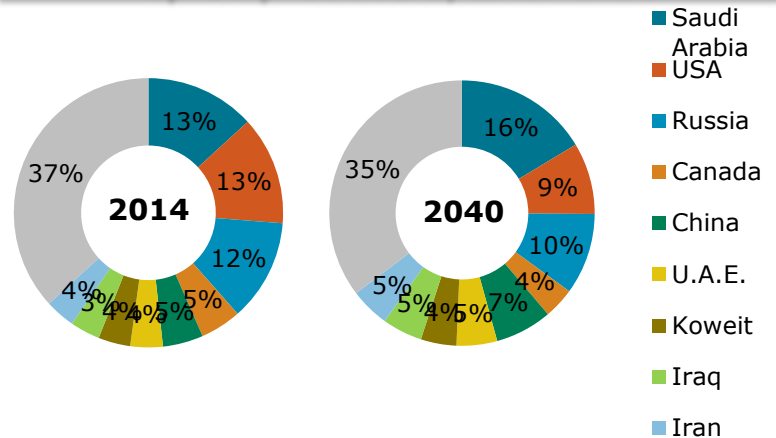


Source: EnerFuture

China becomes the biggest oil consumer around 2020, followed by the USA and India.

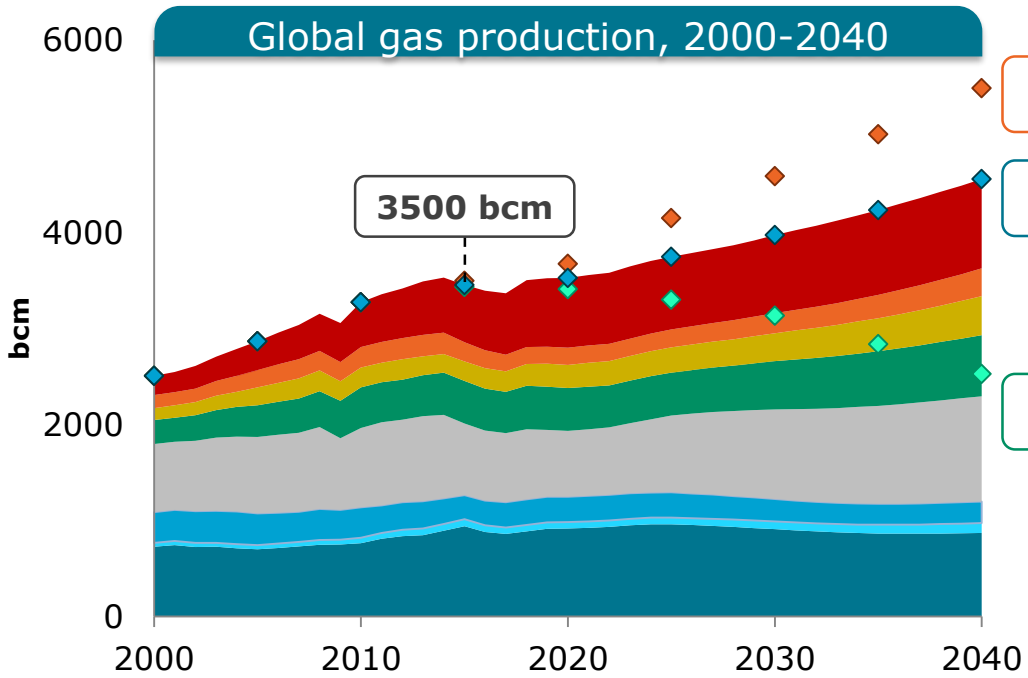
- North America
- Oceania
- Europe
- CIS
- Asia
- North Africa and Sub-Saharan Africa
- Central & South America
- Middle East
- ◆ Ener-Green
- ◆ Ener-Brown
- ◆ Ener-Blue

Top oil producers, Ener-Blue



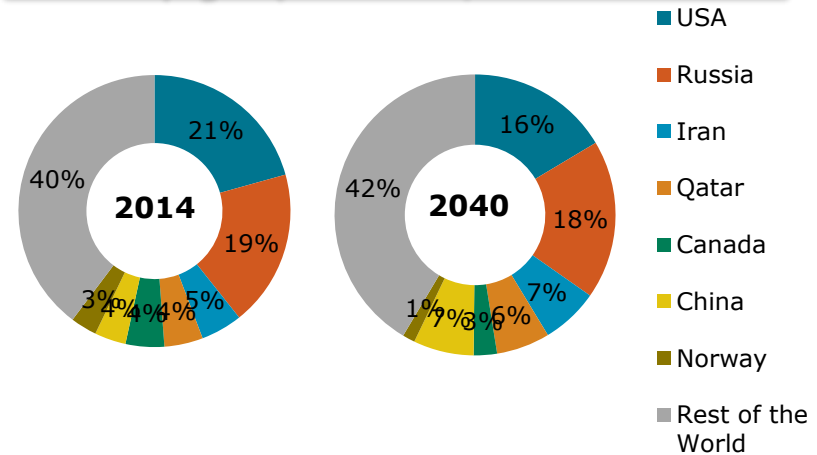


Global gas consumption continues to increase excepted in Ener-Green



- North America
- Oceania
- Europe
- CIS
- Asia
- North Africa and Sub-Saharan Africa
- Central & South America
- Middle East
- ◆ Ener-Green
- ◆ Ener-Brown
- ◆ Ener-Blue

Top gas producers, Ener-Blue



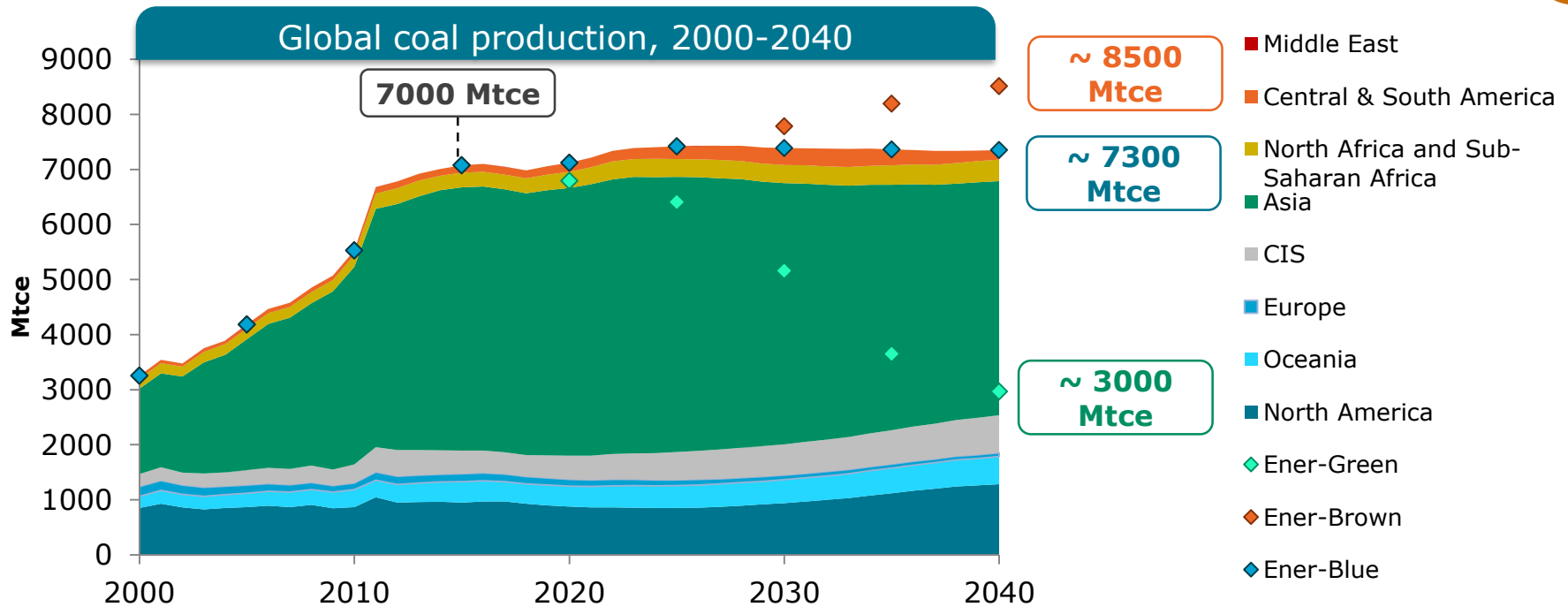
7 countries concentrate ~60% of the global production.

Source: EnerFuture





Global coal production decreases only in Ener-Green, but sharply

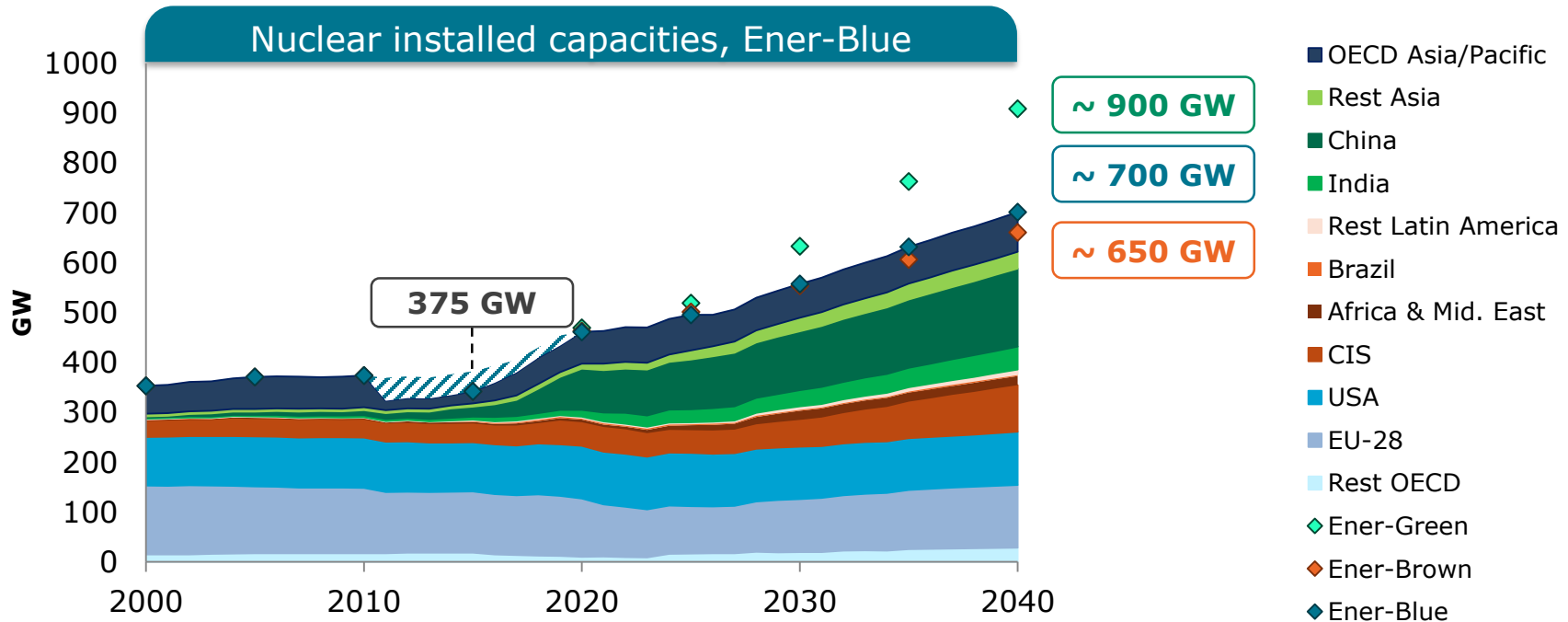


China remains the biggest coal consumer (~75% of the Asian demand in 2040 in Ener-Blue), followed by India and the USA.

Source: EnerFuture



Nuclear development participates to climate and energy policies, especially in Asia...

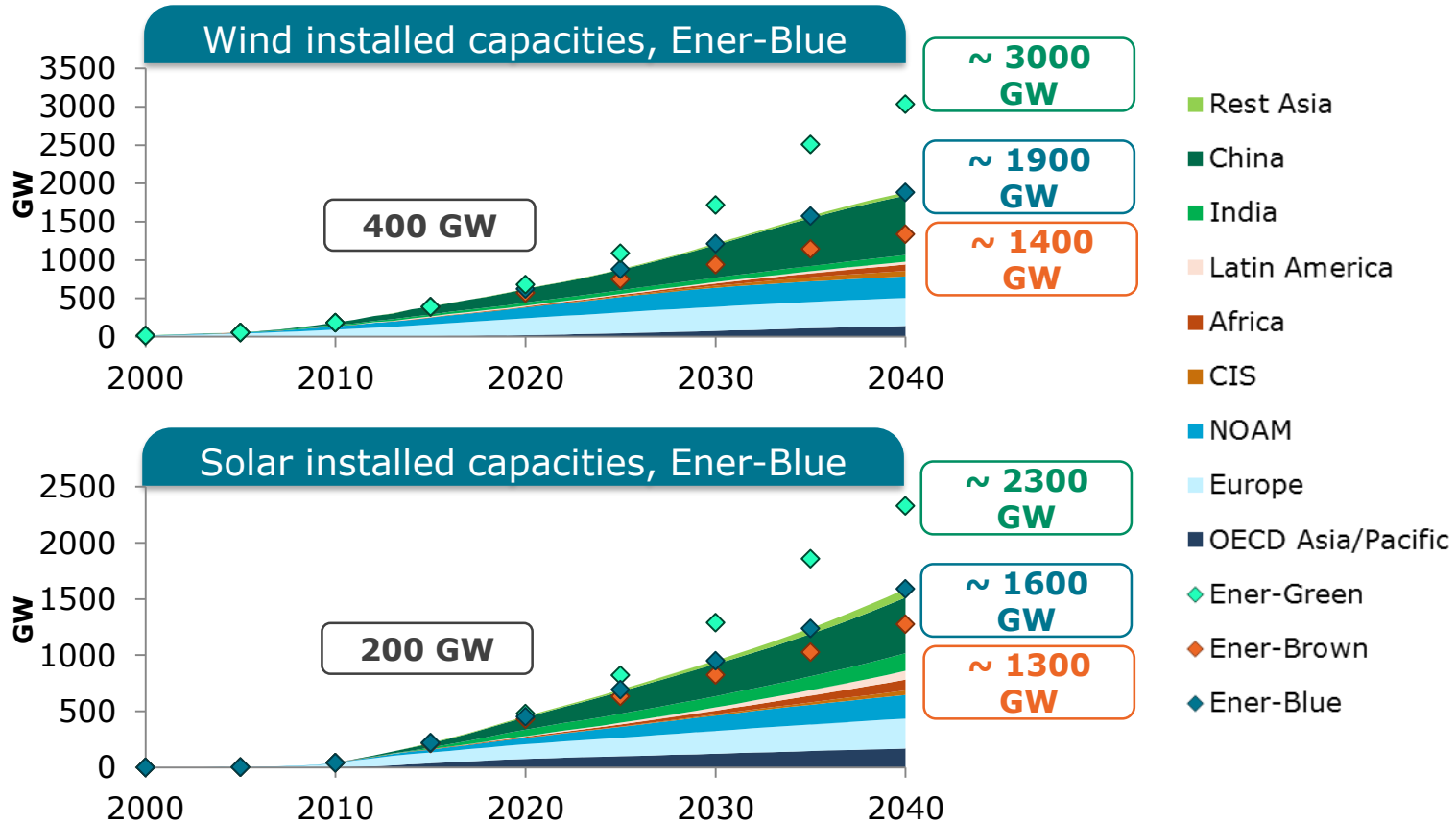


- China : 22% of the total installed capacities
- Japan restarts, India + rest of Asia grow, CIS too...
- Germany completes its phase-out

Source: EnerFuture, Ener-Blue scenario



Renewables will continue to develop strongly in all regions of the world...



... and China will represent more than 40% and 30% of the total installed wind and solar capacities respectively.

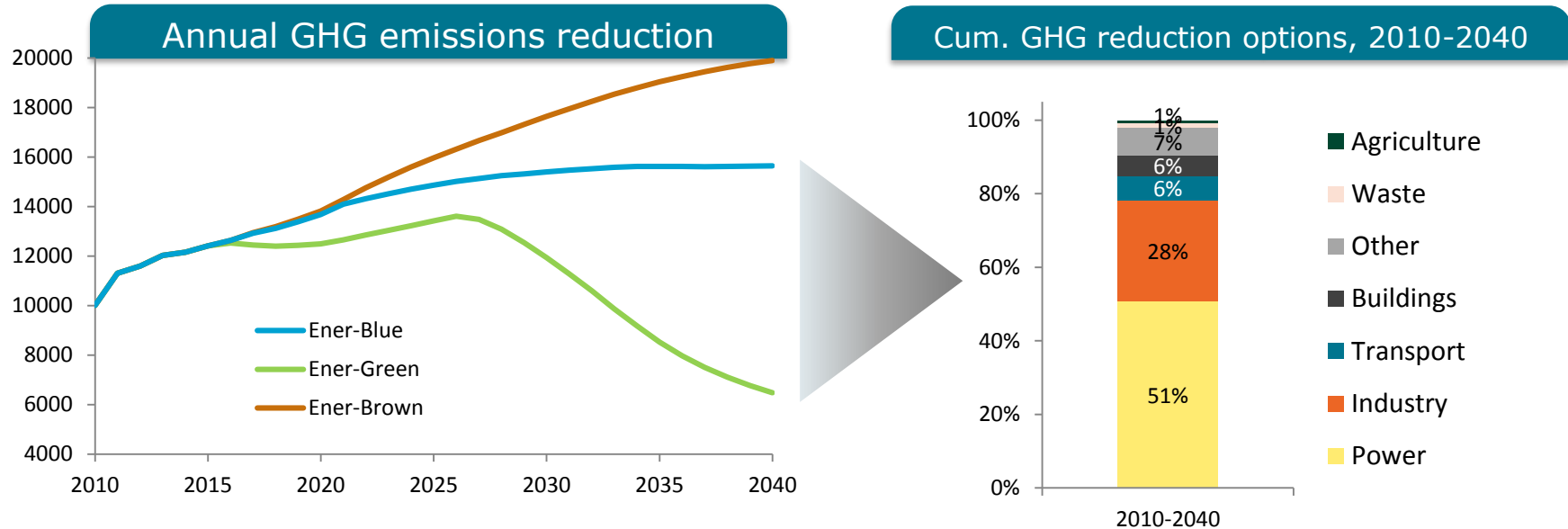
Source: EnerFuture, Ener-Blue scenario



Regional focus: China



In China, huge additional efforts will be required to enable the global 2°C target...



... with long-term GHG reduction mainly driven by power and industry.

Source: EnerFuture



RES in China: around 40% of total installed capacities in 2030 (Ener-Blue)...

New installed capacities in China, Ener-Blue

Installed capacities, Ener-Blue	Average annual new capacities (GW/year)		
	2000-2014	2014-2020	2020-2030
Renewables (GW)	13	41	92
of which wind (GW)	8	21	52
of which solar (GW)	0	10	29
Fossil (GW)	66	110	57
of which oil (GW)	1	0	0
of which gas (GW)	2	17	11
of which coal (GW)	63	93	45
Nuclear	1	10	6

Official targets and indicators, Ener-Blue

	Target 2020	2014-2030	
		Capacities	Production
Wind	200 GW	x4	x6
Solar	100 GW	x10	x19
Nuclear	85 GW	x6	x7

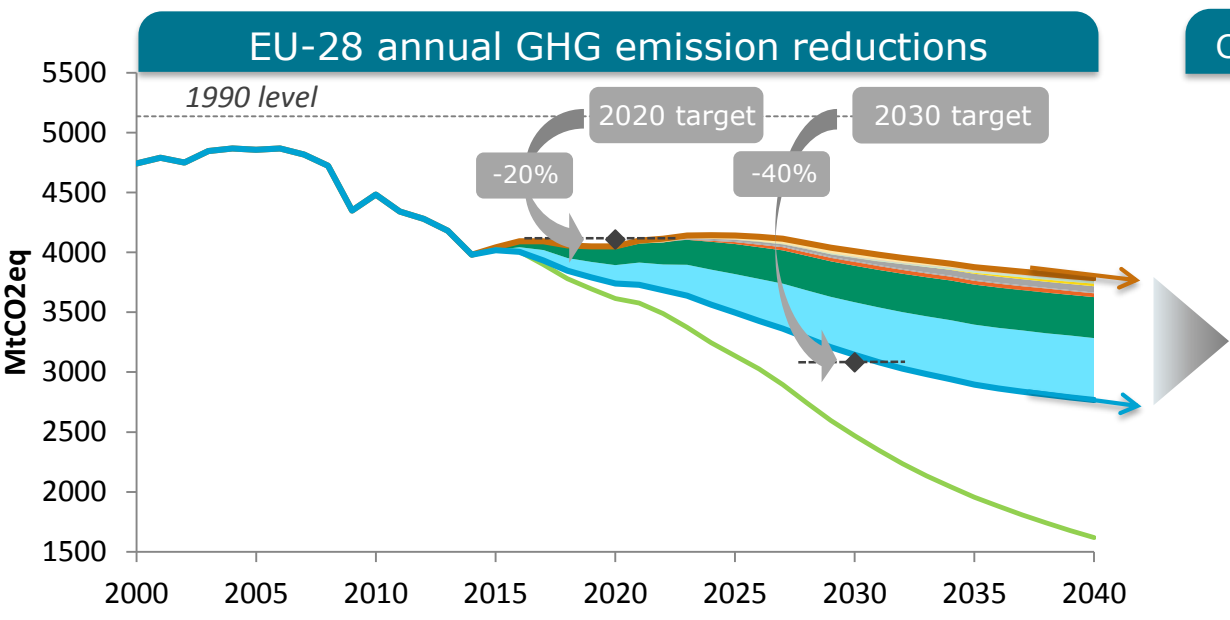
... and more than 50% of additional capacities after 2025.

Source: EnerFuture, Ener-Blue, scenario

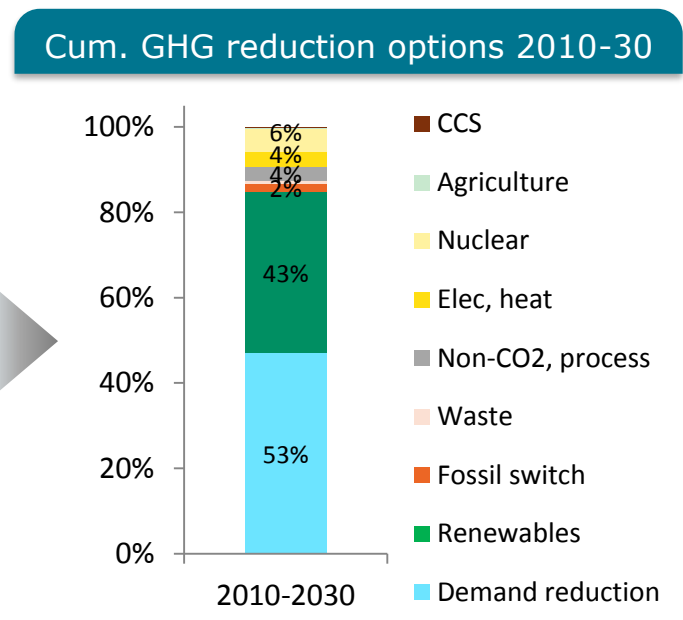
Regional focus: European Union



EU's 2030 target on emissions mainly reached via the deployment of renewables & efficiency



Source: EnerFuture

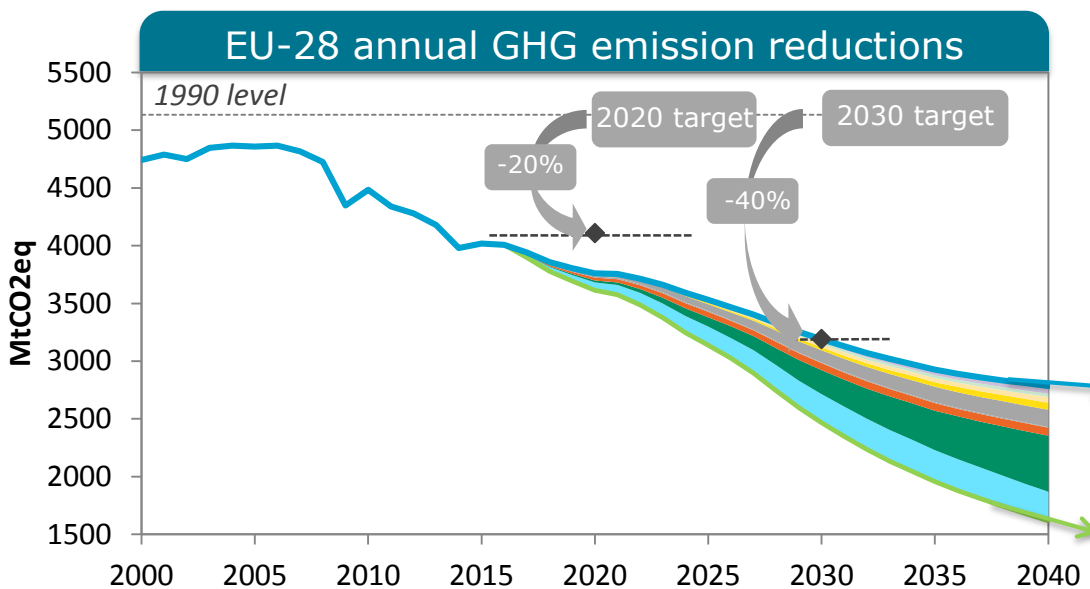


Source: EnerFuture, Ener-Blue and Ener-Brown scenarios

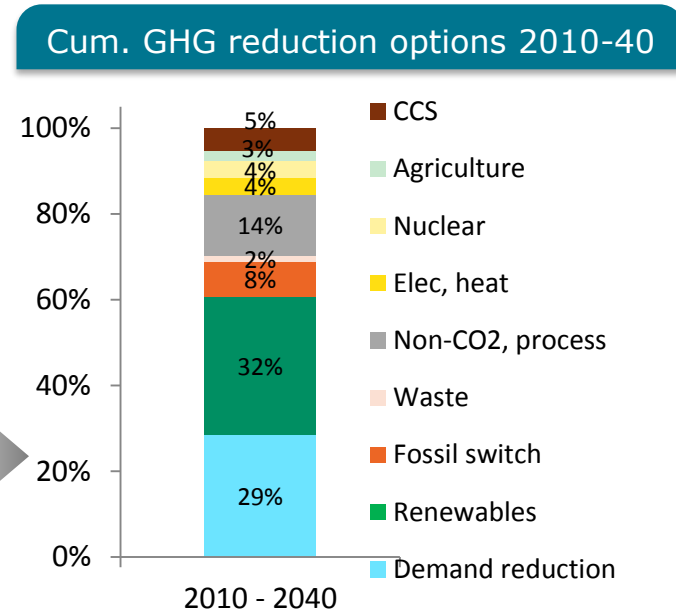
... with a decarbonisation principally achieved in the power and transport sectors.



Enabling the 2°C target will heavily depend on demand reduction and renewables...



Source: EnerFuture

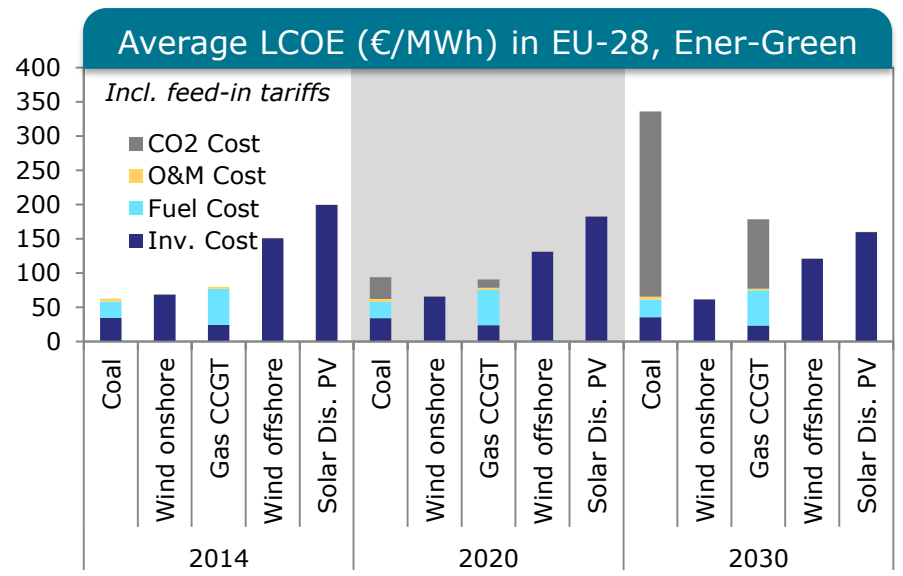
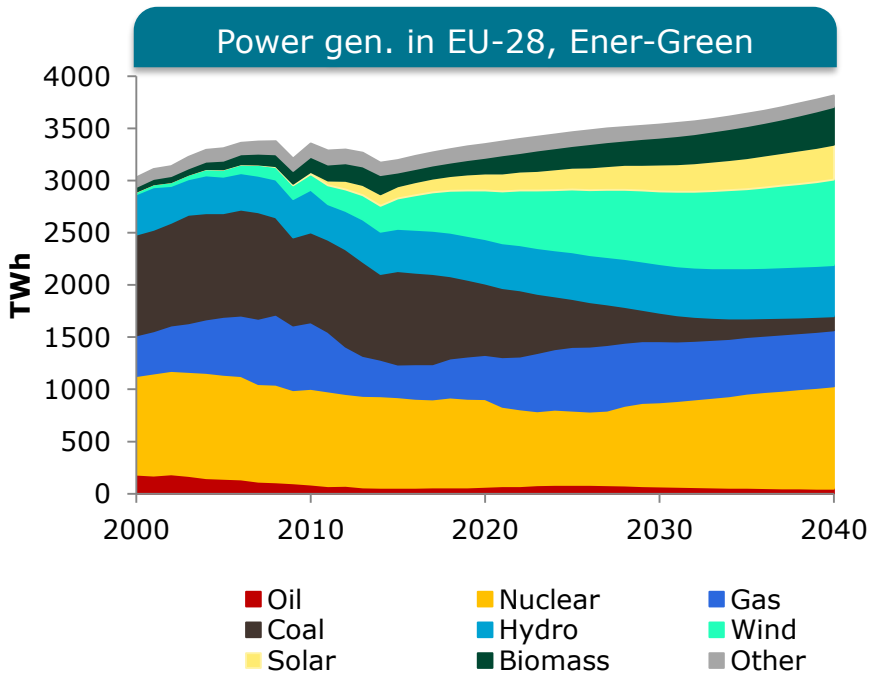


Source: EnerFuture, Ener-Blue and Ener-Green scenarios

... but options will also include fossil fuel switch (coal to gas) and processes improvement.



In the power sector, EU's climate policies mainly affect coal generation costs, benefiting gas...



LCOE: Levelised cost of electricity is the average generation cost for a given technology, expressed in present value equivalent. Direct renewable support is included.

... but its attractiveness is eventually reduced as renewables become a very competitive option.

Conclusions

EnerFuture scenarios – wrap up



Ener-Blue



Ener-Green



Ener-Brown

POLICIES & OBJECTIVES

- | | | |
|---|--|---|
| <ul style="list-style-type: none"> 2030 INDCs targets achieved CO₂ emissions growth slow-down <p>+3-4°C temperature increase</p> | <ul style="list-style-type: none"> Reinforcement trend INDCs targets regularly reviewed upwards <p>+1.5-2°C temperature increase</p> | <ul style="list-style-type: none"> INDCs objectives not reached Soaring CO₂ emissions <p>+5-6°C temperature increase</p> |
|---|--|---|

KEY OUTPUTS

- | | | |
|---|---|---|
| <ul style="list-style-type: none"> Demand: +30% over 2014-40, up to +50% in Non-OECD Energy mix transformation : less fossil (70% in 2040), RES share >20% by 2040 Energy intensity divided by 2 over 2014-2040 GHG emissions stabilization around 44 GtCO₂eq, thanks to RES and Energy Efficiency CO₂ shadow price ~30€/tCO₂ in 2040 (~70€/tCO₂ in the EU) | <ul style="list-style-type: none"> Global demand stabilization below 14 Gtoe Fossil fuels share <50% by 2040- big coal decrease RES + nuclear development: 70% of power capacities (2040) GHG emissions reach ~21 GtCO₂eq; 70% of reduction efforts in Non-OECD countries Add. costs + investments (CO₂ shadow price >400€/tCO₂) balanced partially by lower fuel costs | <ul style="list-style-type: none"> Demand continuous growth: +45% over 2014-2040 Fossil fuels stay at 75% and grow in volume, with gas gaining market share 40% of global natural gas supply will come from shale gas in 2040 RES power production also grows: x2.3 over 2014-2040 GHG emissions growth: +33% over 2014-2040, reaching 53 GtCO₂eq |
|---|---|---|

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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.

www.enerdata.net



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