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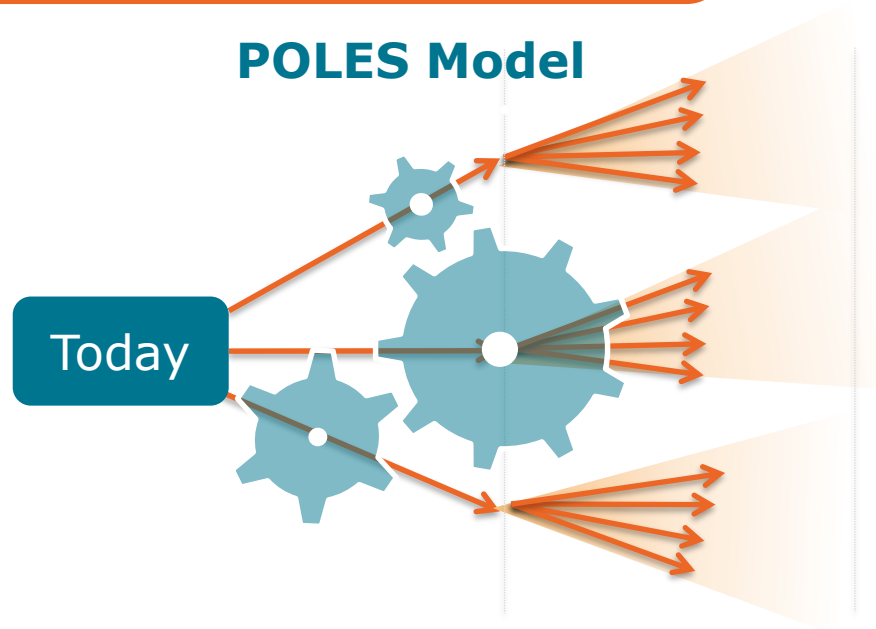
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Methodology and scenarios overview

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 ?

Demand

*Global &
regional
dynamics, fuel
mix, efficiency...*

Supply & Prices




*Availability,
self-sufficiency,
trade, bills ...*

Sustainability

CO₂ emissions...

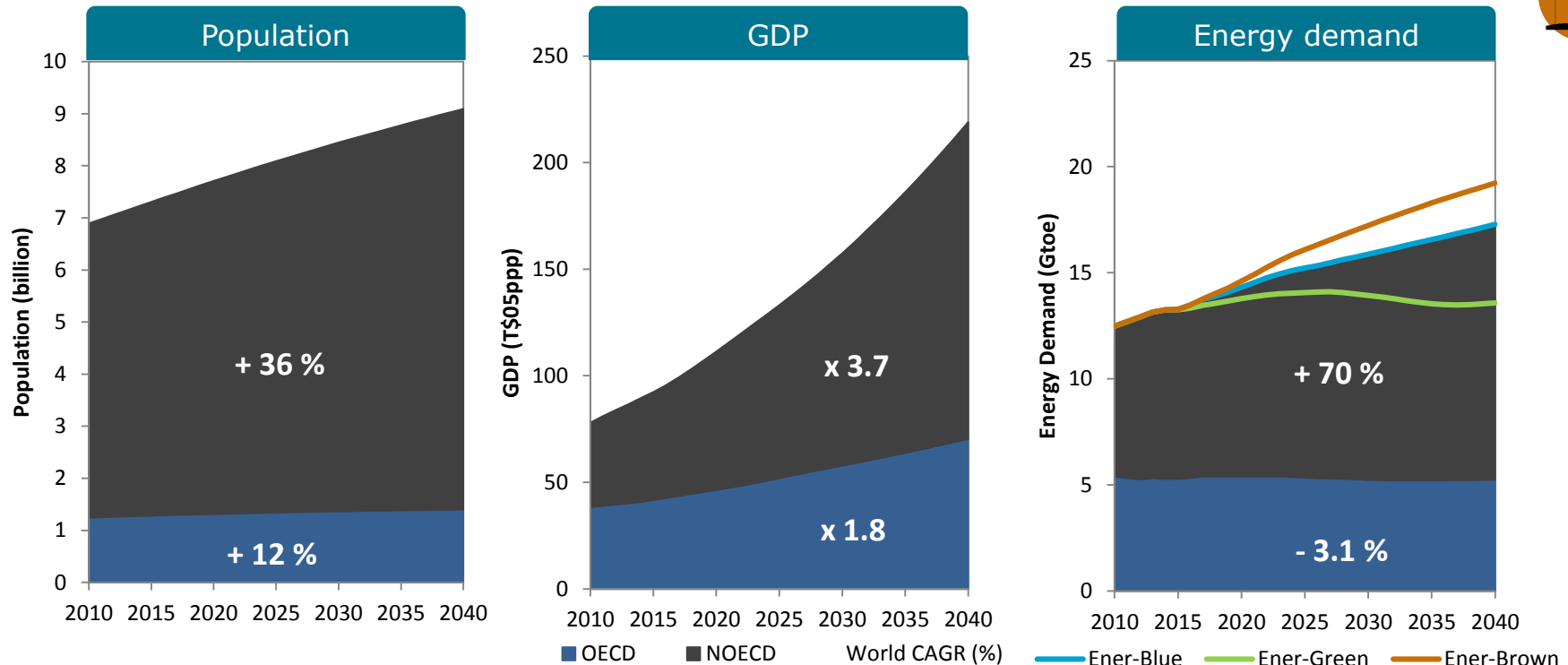
*... allows us to explore different
pathways for energy markets*

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



Identical macro-economic assumptions lead to very different energy demand trends



Source: UN World Population Prospects (2015 Revision)

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

Source: EnerFuture
Comparison base year: 2010

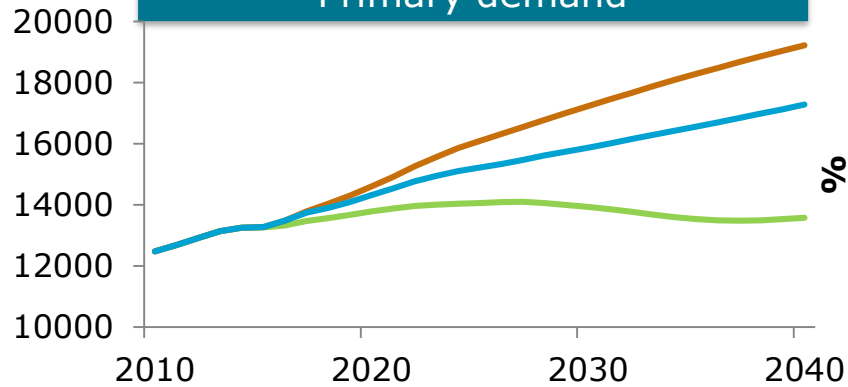
Only ambitious climate and energy policies implemented in Ener-Green scenario will stabilize energy needs in the long term.



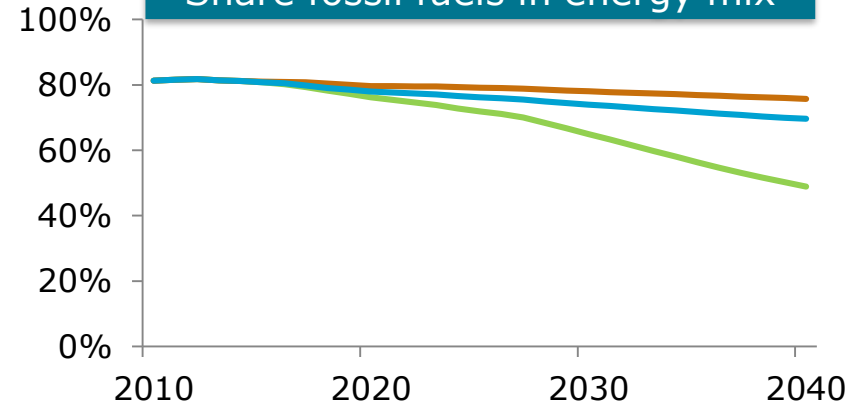
Key energy indicators by scenario

— Ener-Blue — Ener-Green — Ener-Brown

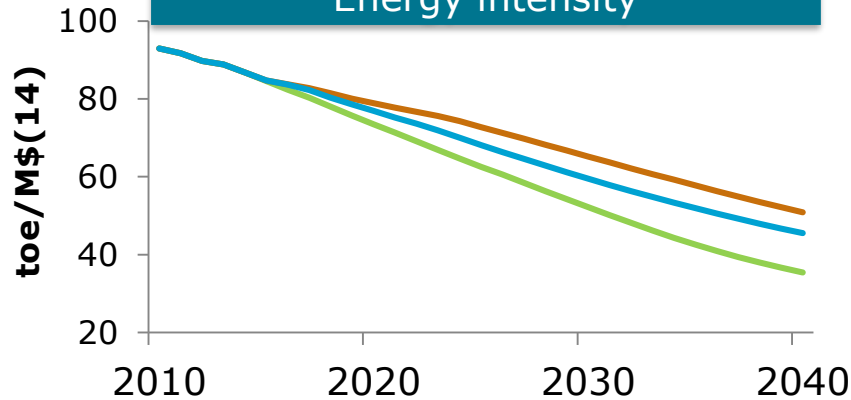
Primary demand



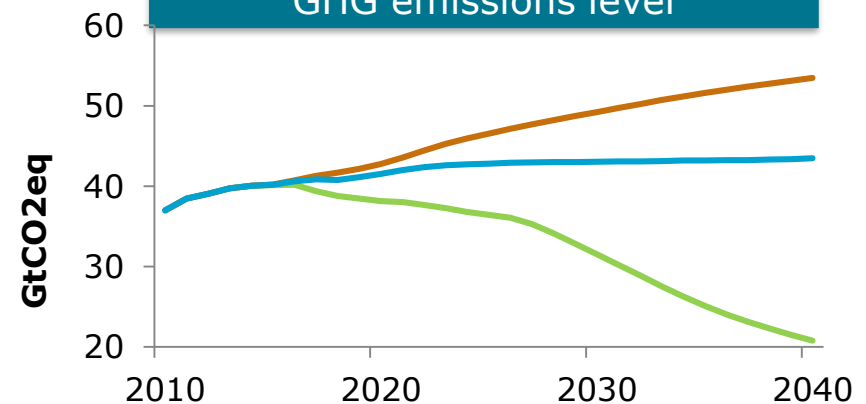
Share fossil fuels in energy mix



Energy intensity



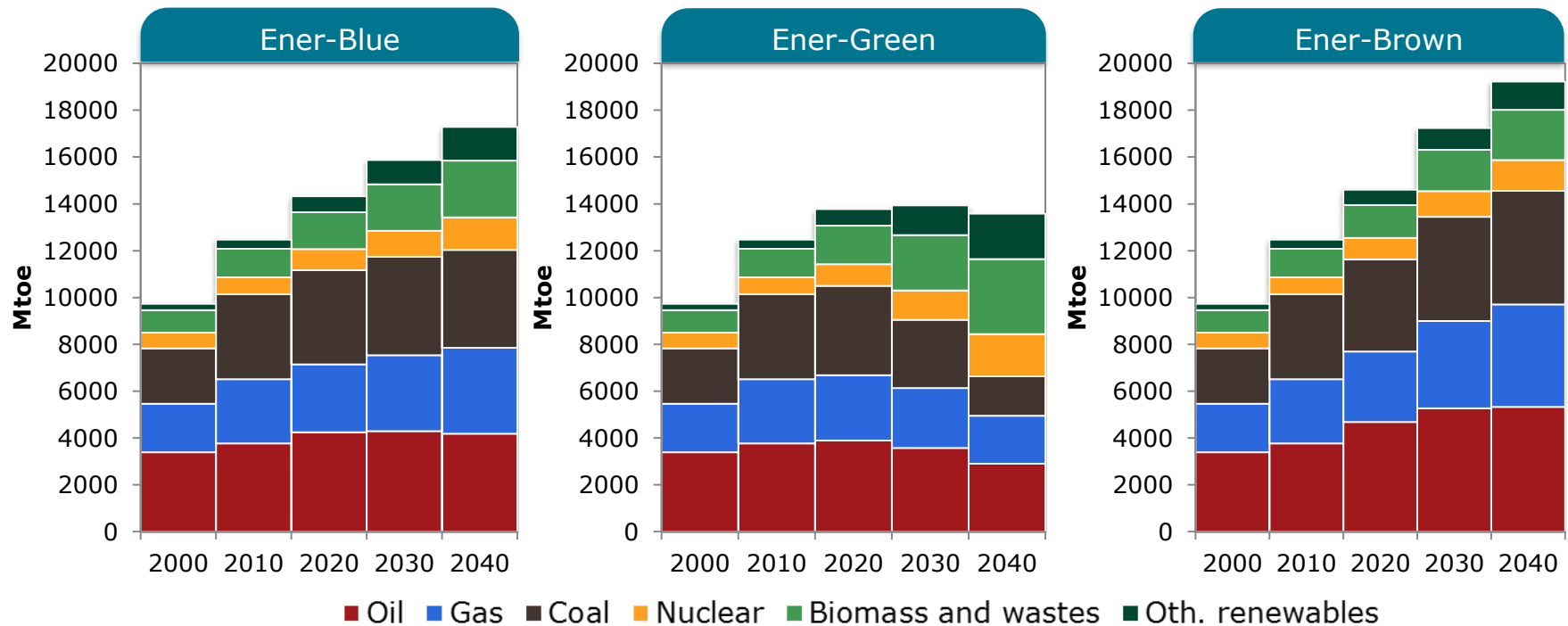
GHG emissions level



Source: EnerFuture



Primary Energy mix evolution by scenario

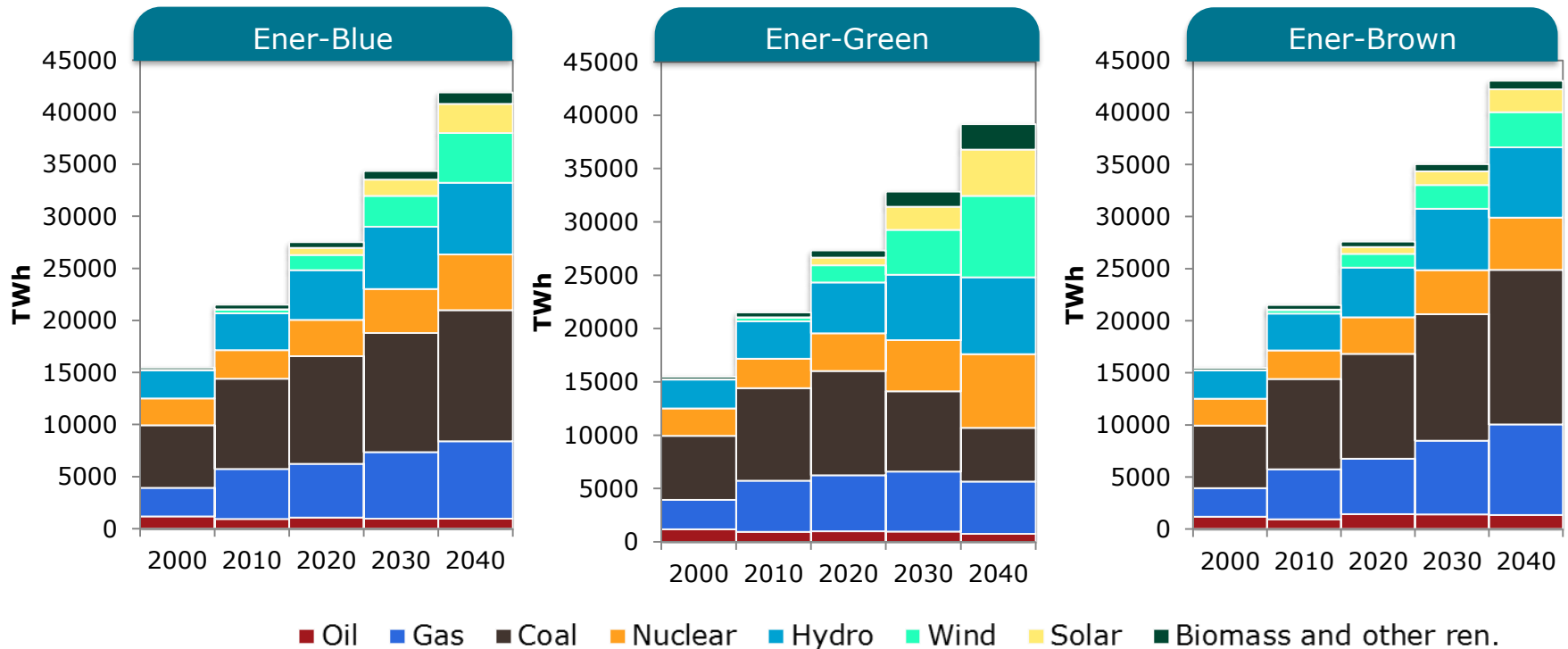


- Fossil fuels stay at 76% in Ener-Brown and 70% in Ener-Blue, but fall down to 50% in Ener-Green.
- RES + Nuclear vary from 24% (Ener-Brown) to 50% (Ener-Green).

Source: EnerFuture



Power mix evolution by scenario



Carbon intensity in power production varies dramatically :

- RES + Nuclear represent resp. 55% and 18% of the mix (Ener-Green)
- Compared with 37%/13% (Ener-Blue) and 31%/12% (Ener-Brown)

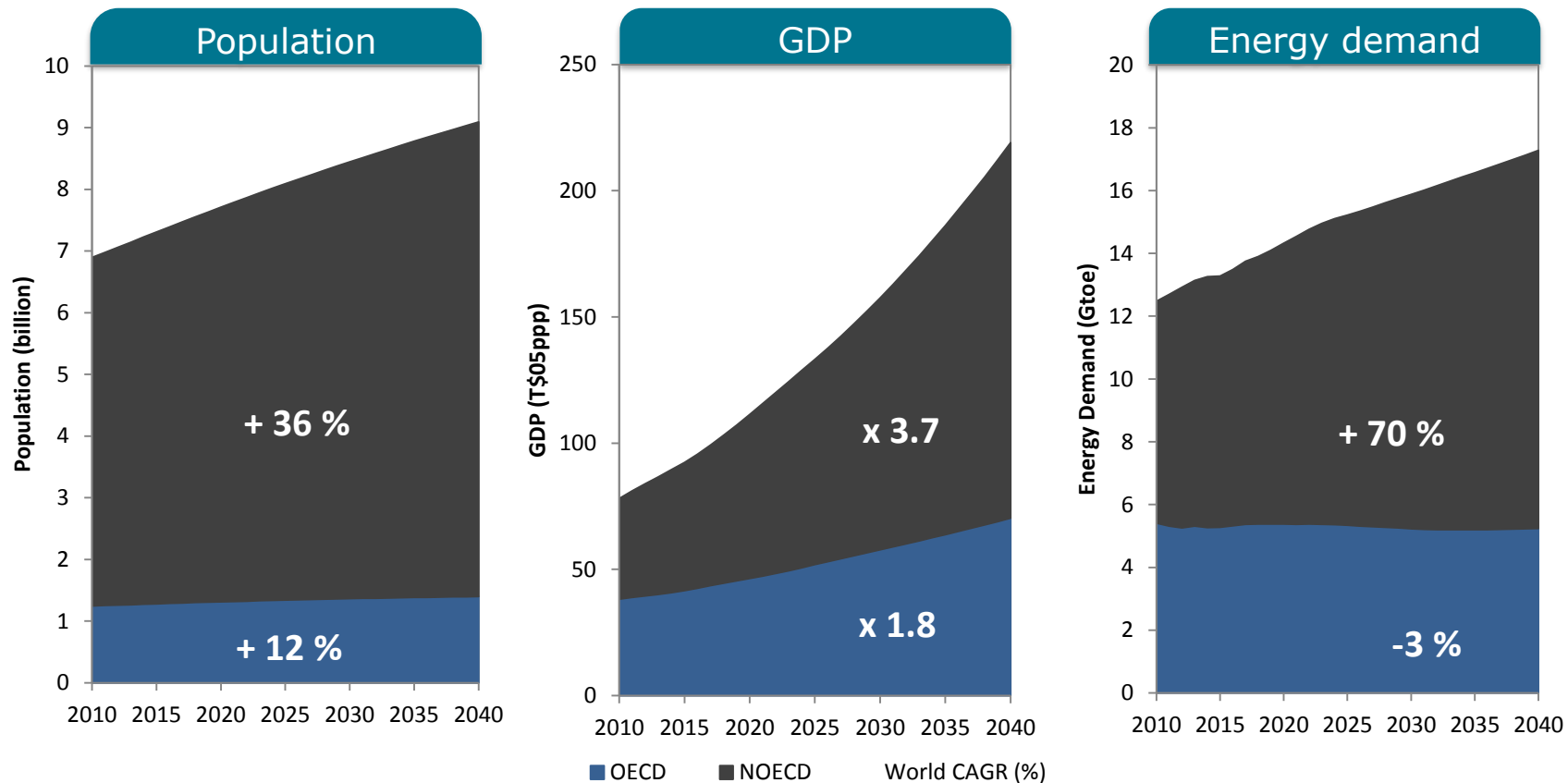
Source: EnerFuture

Ener-Blue: key outputs

based on INDCs' targets achievement



Expected economic recovery will drive up energy consumption...



Source: UN World Population Prospects (2015 Revision)

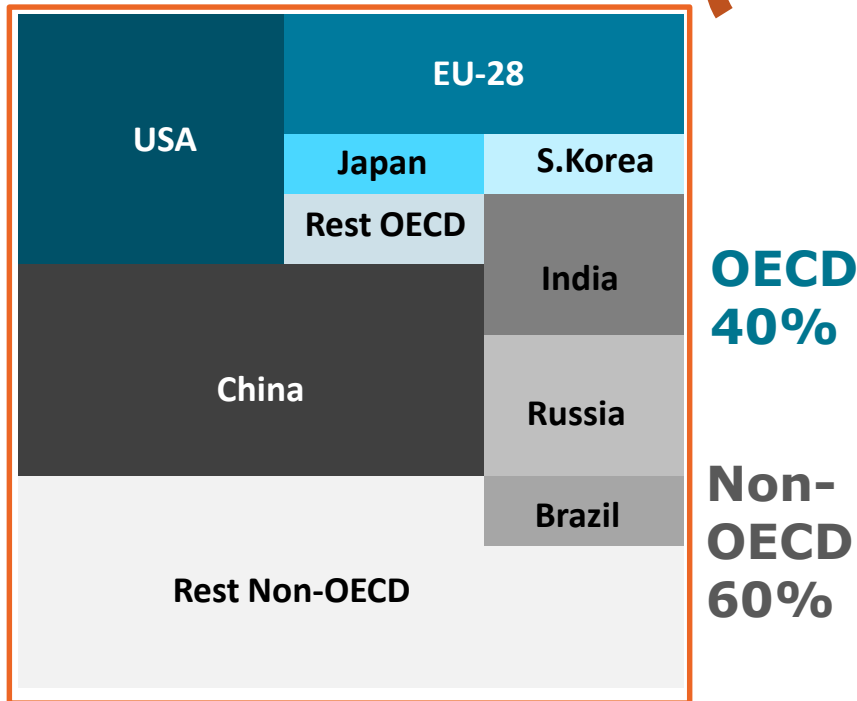
Source: IMF outlook (2014 – 2020)
CEPII Baseline (2021 – 2040)

Source: EnerFuture
Comparison base year: 2010

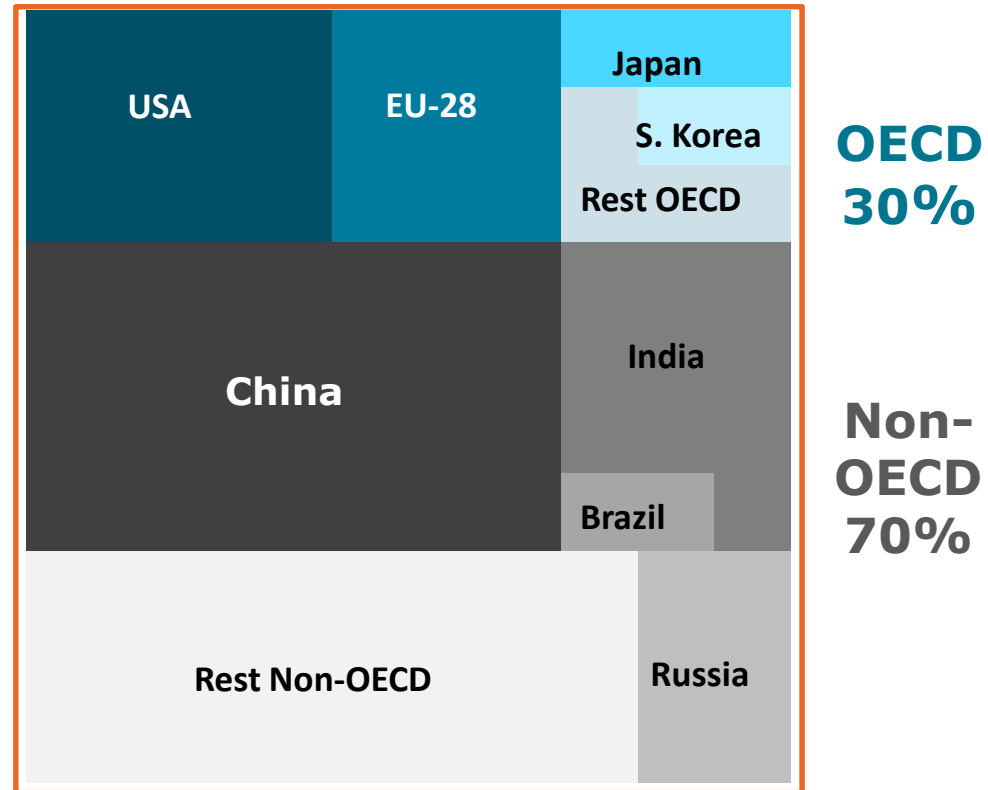


... pulled by developing countries, when OECD demand stabilizes.

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



2014 (13.3 Gtoe)

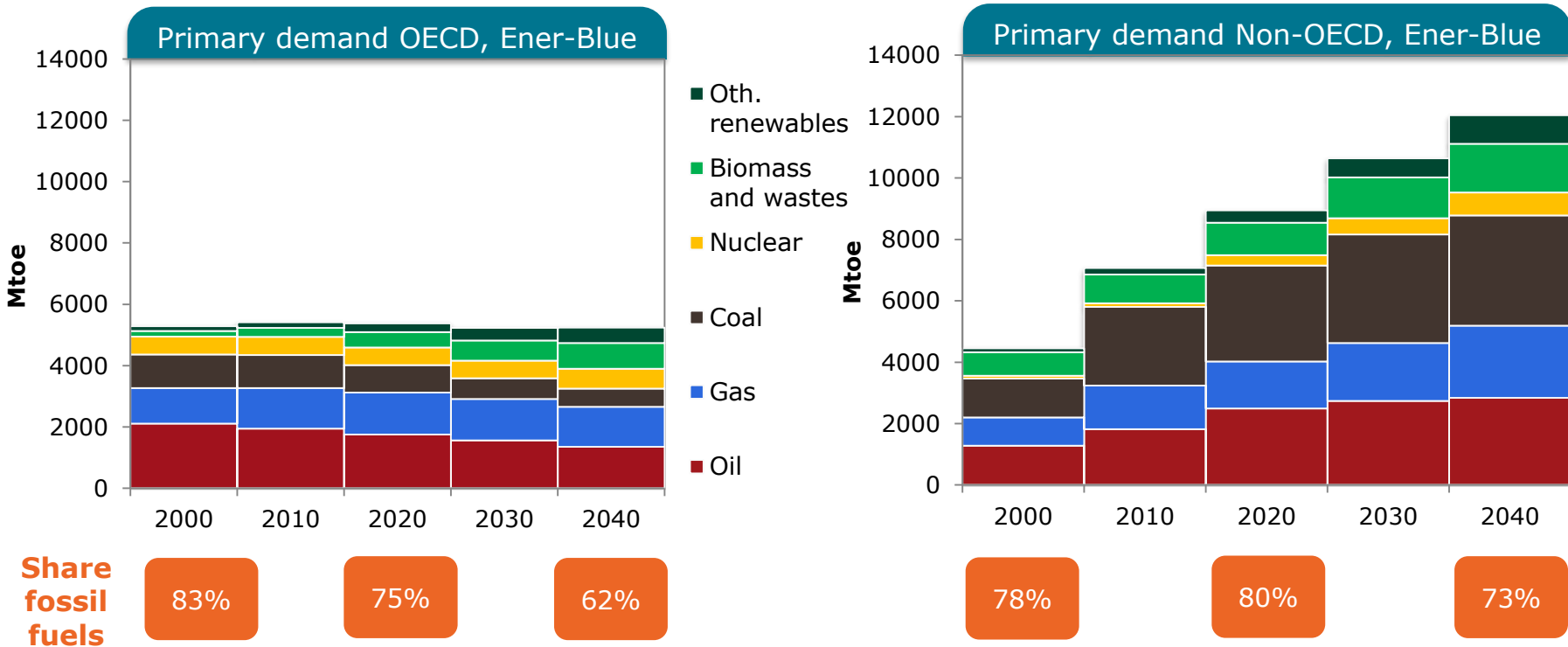


2040 (17.3 Gtoe)

Source: EnerFuture, Ener-Blue scenario



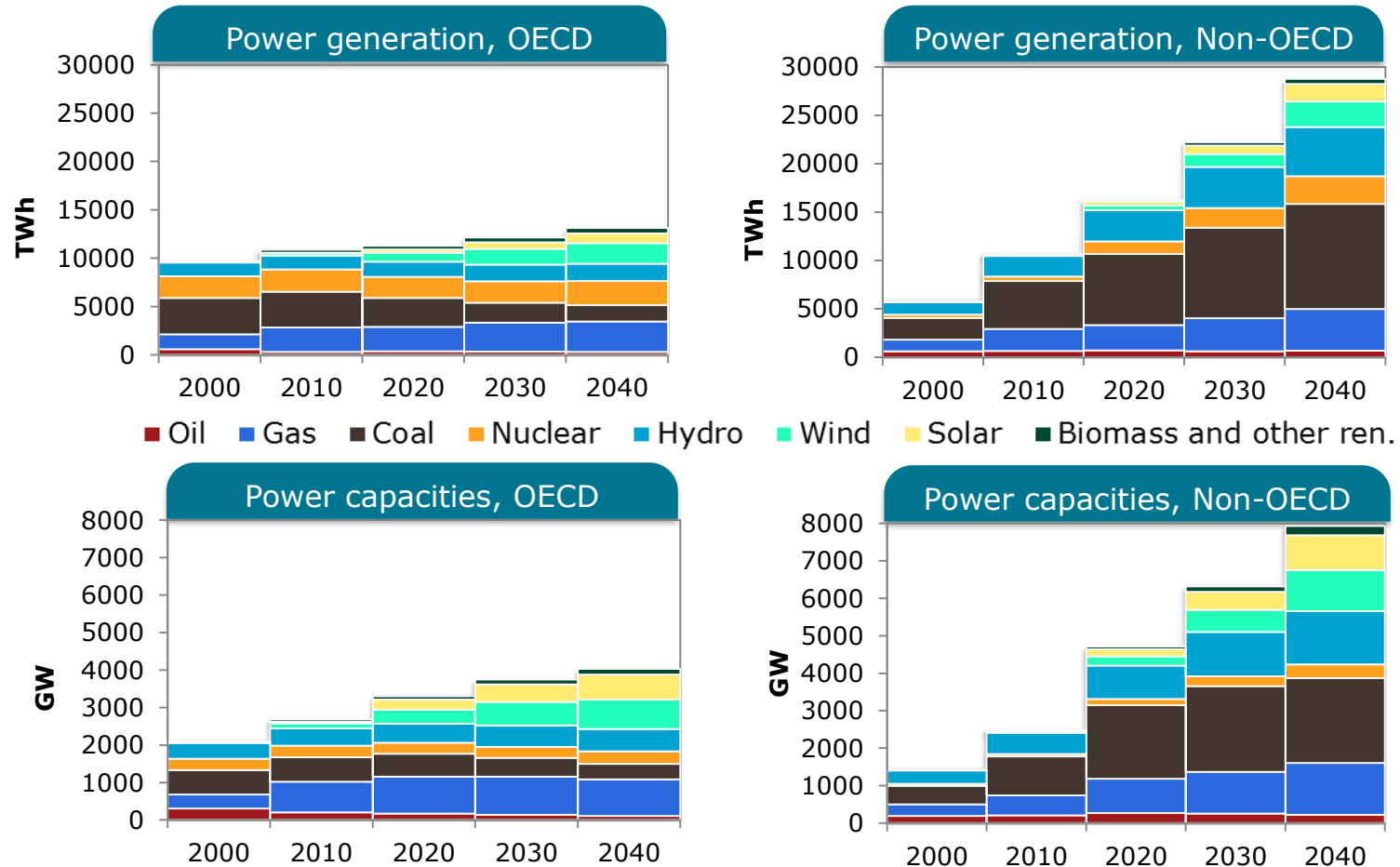
Fossil fuels' domination decreases from 80% to 70% of the mix...



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



In the power sector, the share of RES increases everywhere...



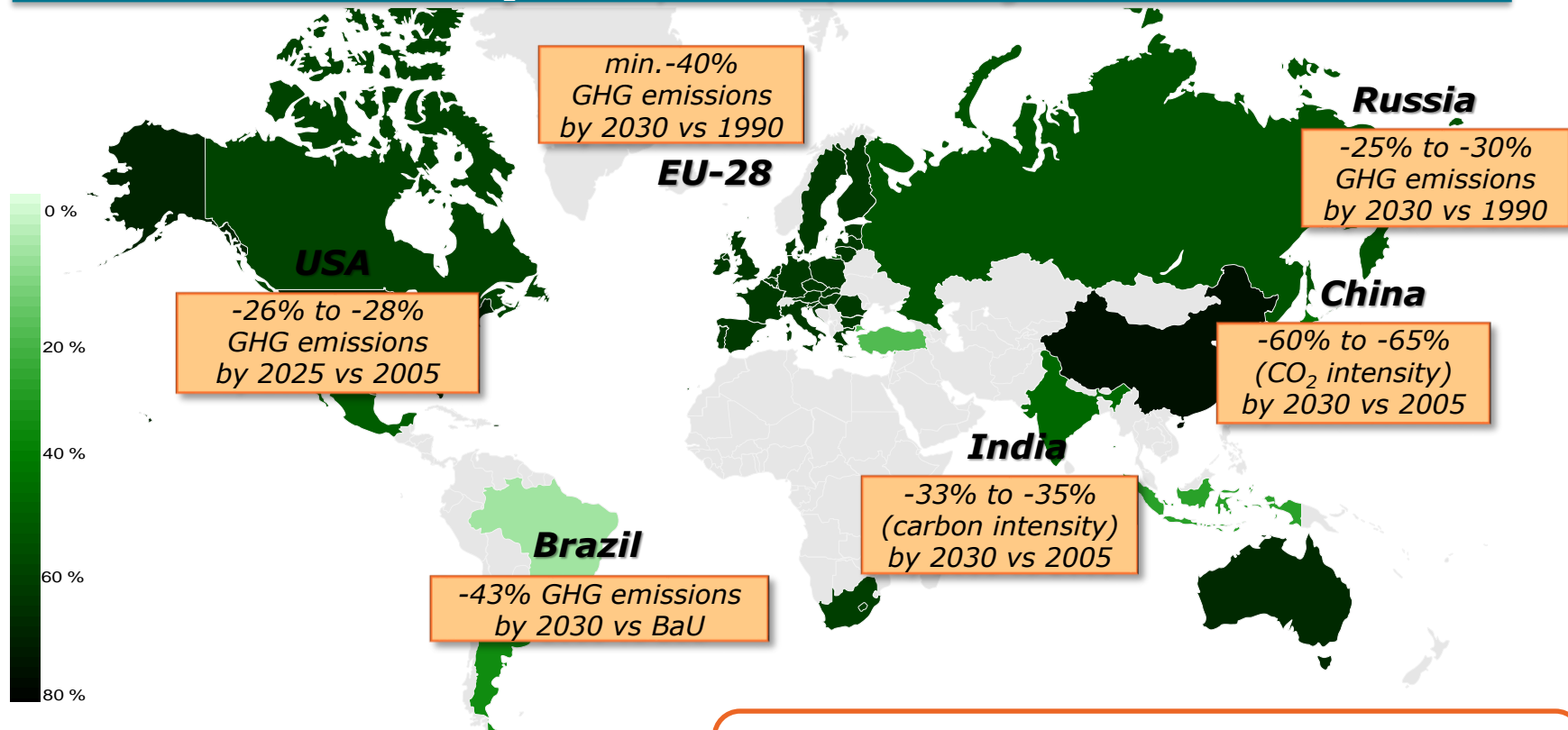
... but in non-OECD, fossil fuels capacities also increase to meet the growing demand.

Source: EnerFuture, Ener-Blue scenario



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

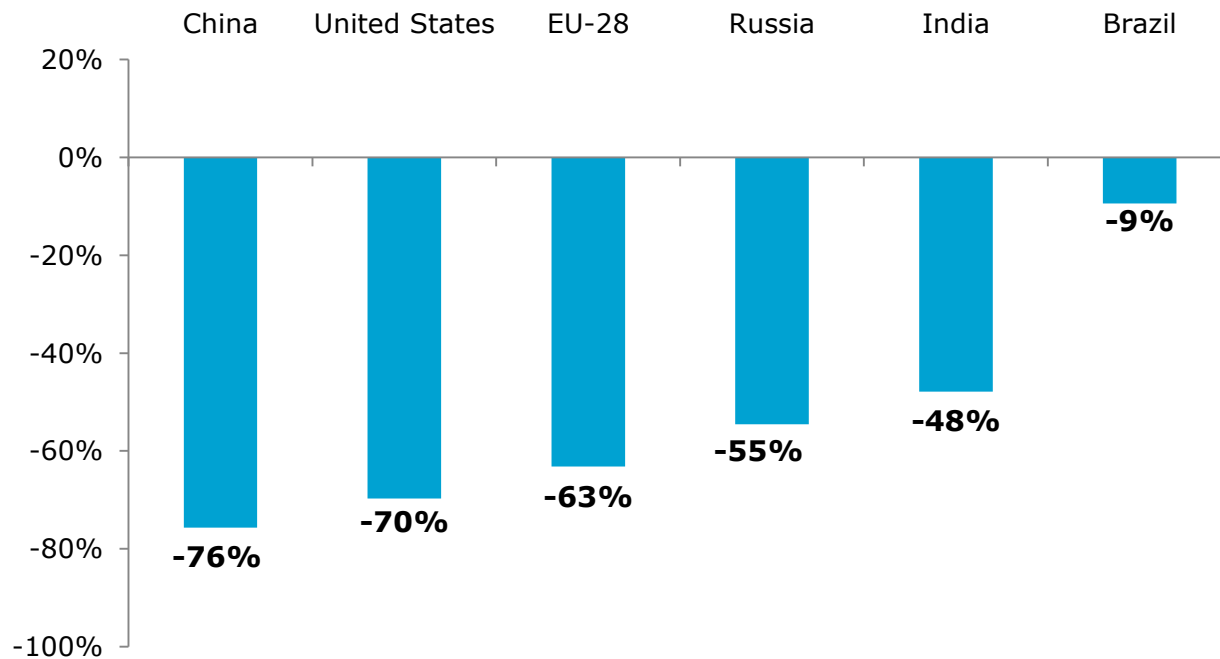
G20 represent ~85% of GHG global emissions

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



INDCs show different ambitions

CO₂ intensity* reduction, 2030 INDC target recalculated vs 1990

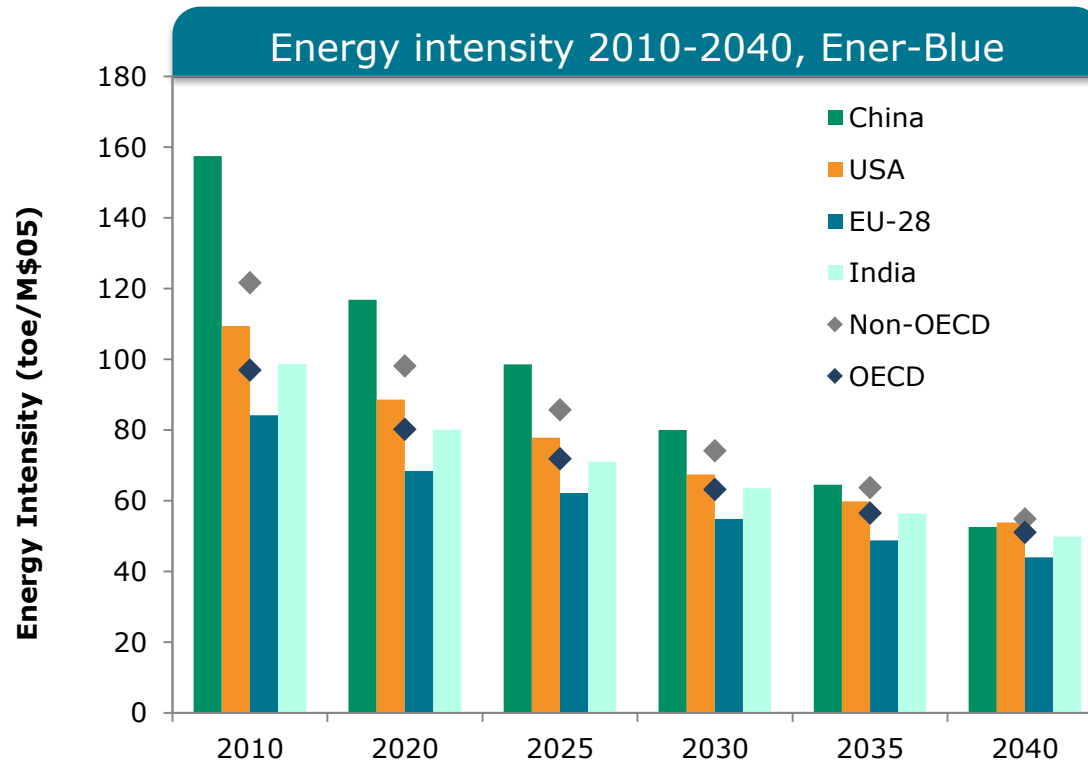


* CO₂ intensity of GDP: ratio of CO₂ emissions to GDP, excl. LULUCF

Source: EnerFuture, Ener-Blue scenario



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

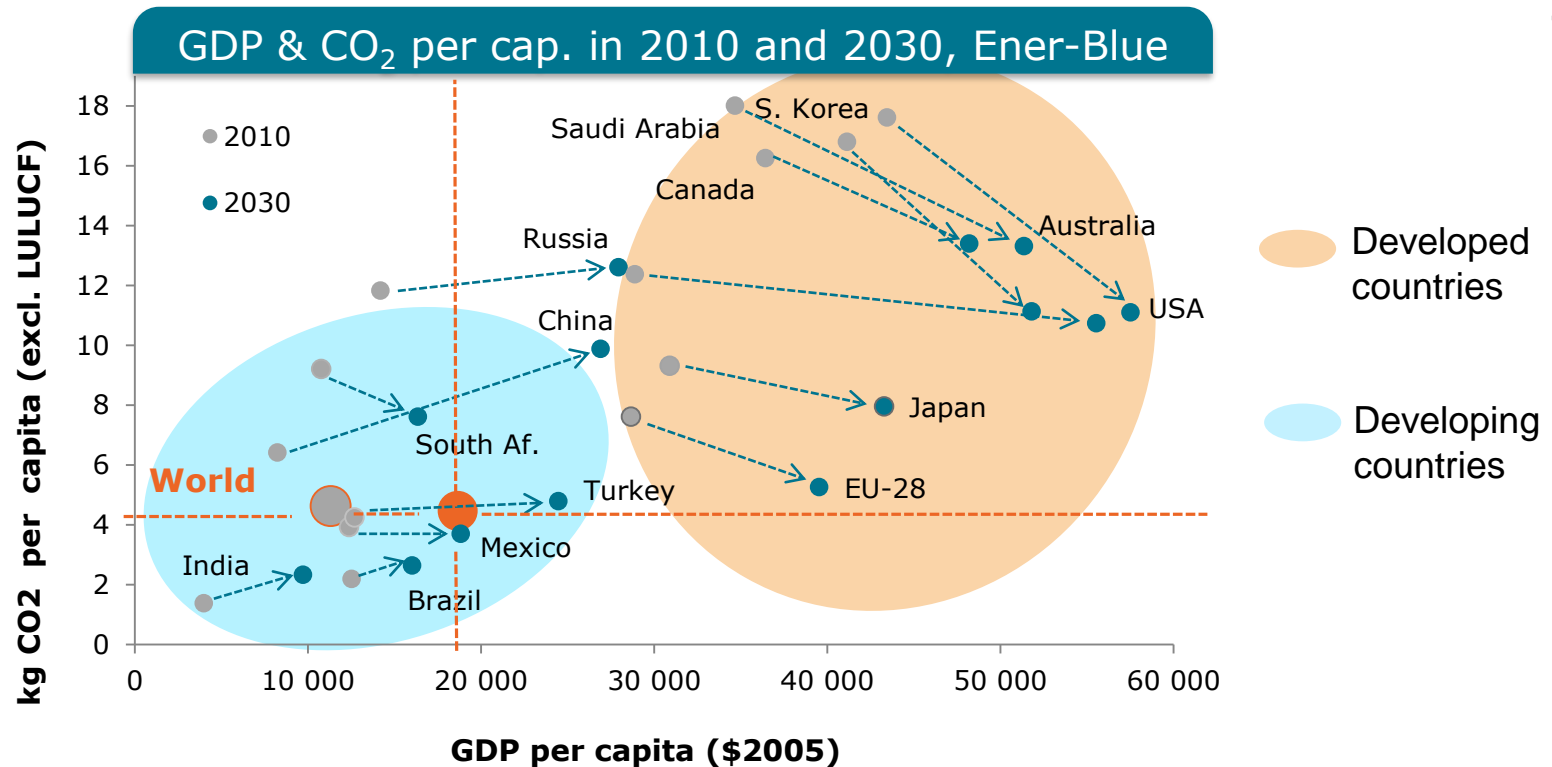


... and converges toward OECD countries' levels.

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.

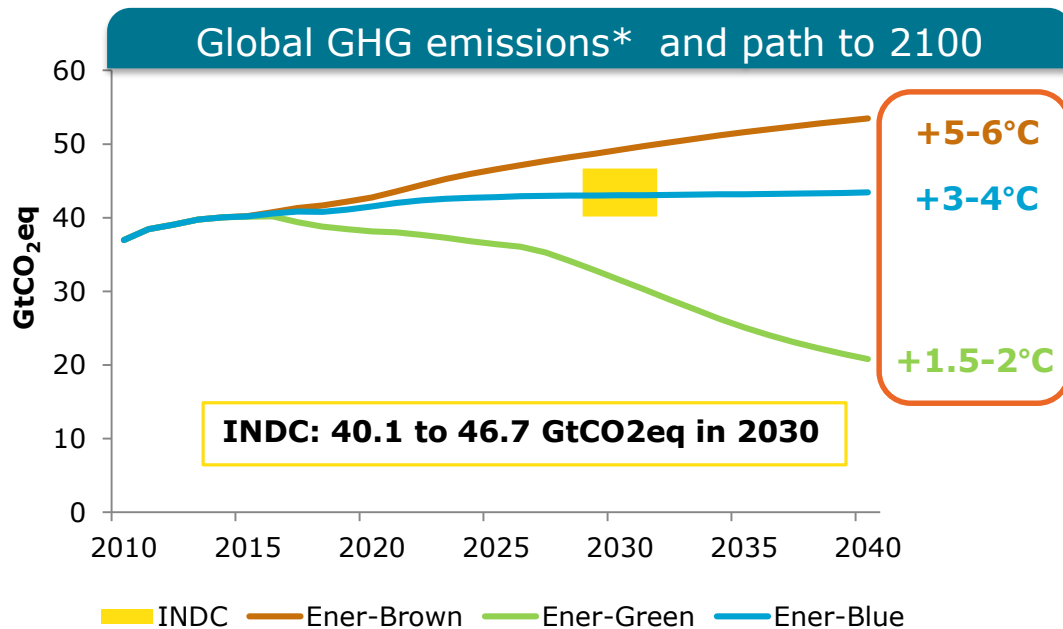
Source: EnerFuture, Ener-Blue scenario

Ener-Green key outputs

from COP21 INDCs to a 2°C ambition

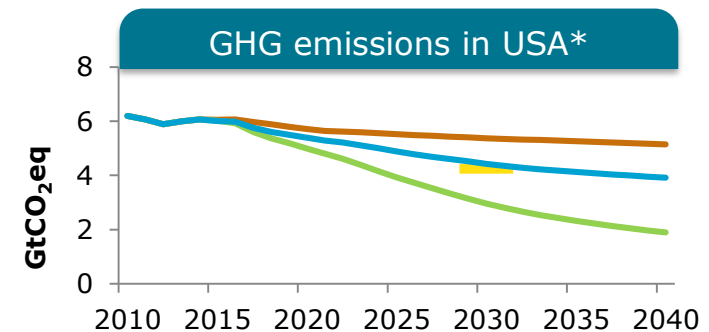
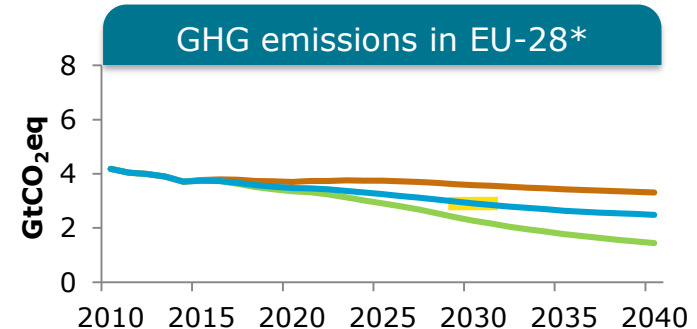
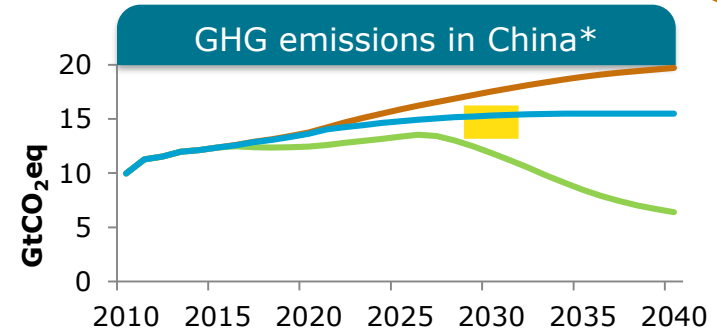


GHG emissions reductions implied by INDCs are not sufficient to reach the 2°C target ...



Source: UNFCCC, submitted INDCs and EnerFuture

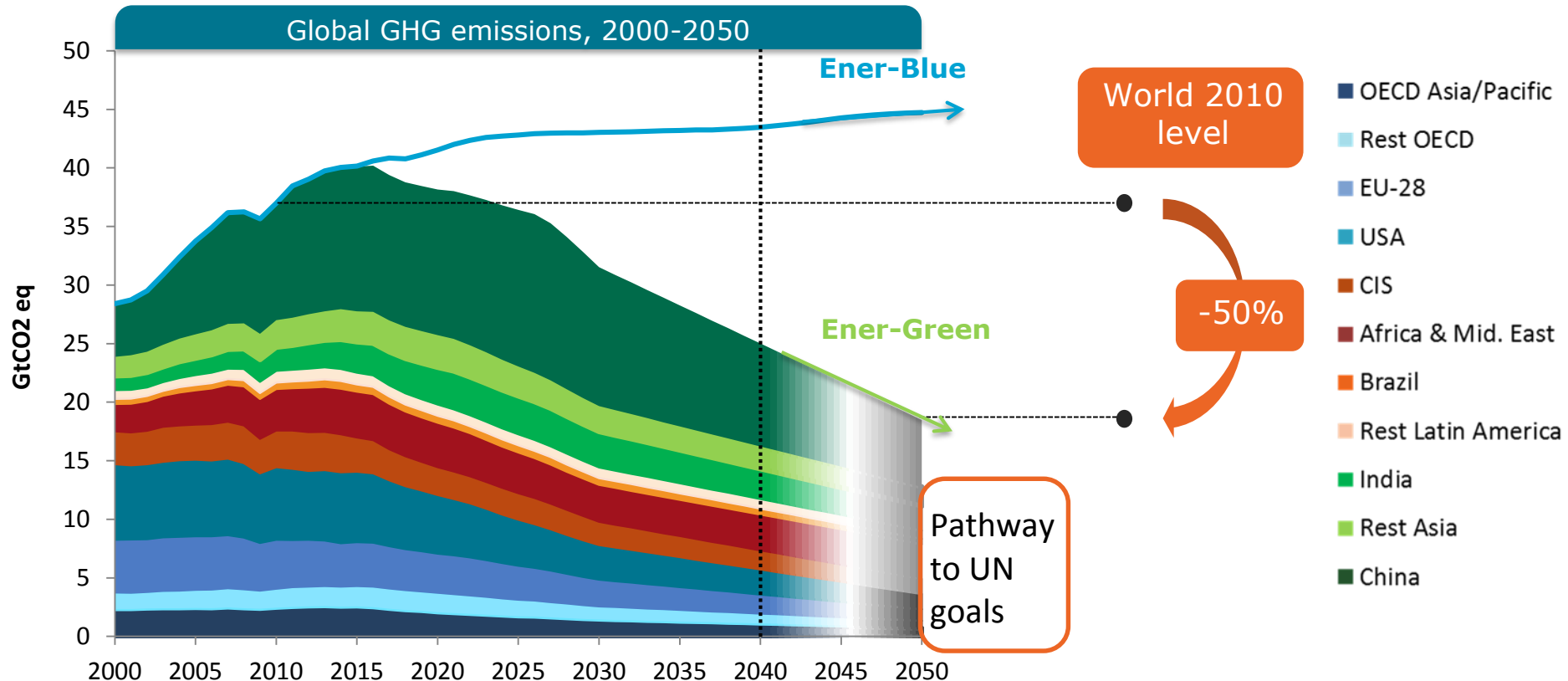
... Strengthened efforts and policies are necessary to ensure GHG emissions compatible with the UN 2°C goal.



* excl. LULUCF



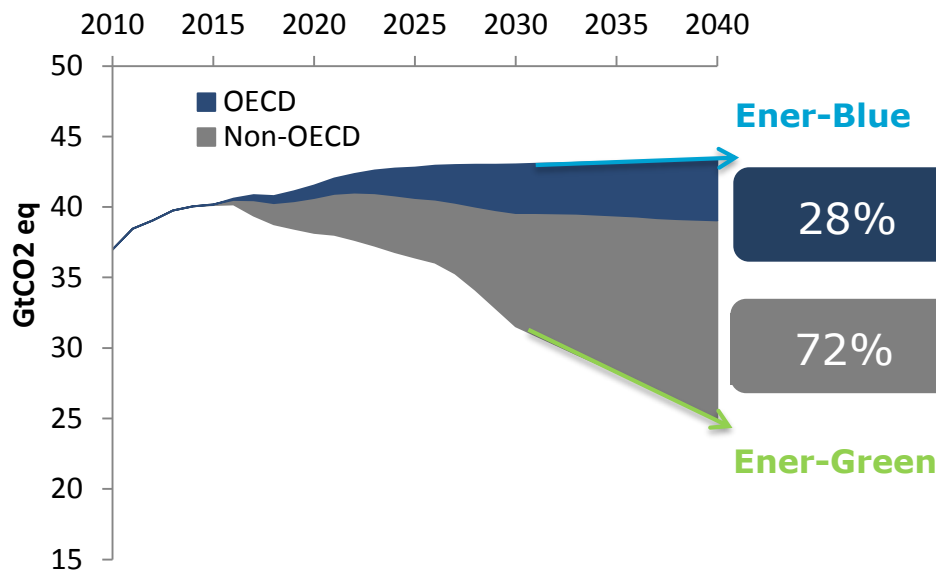
From INDCs to 2°C: a big gap to close !



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



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



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

% reduction, cum. 2010-2040

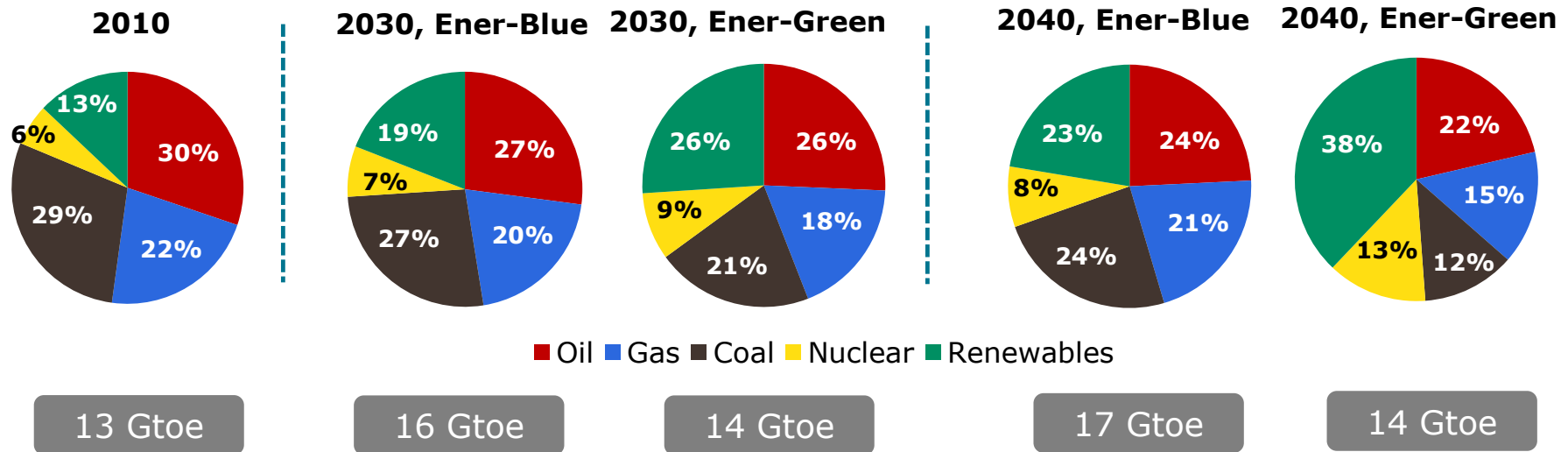
EU-28	11 GtCO₂eq	5%
USA	27 GtCO₂eq	12%
Rest OECD	26 GtCO₂eq	11%
Brazil	3 GtCO₂eq	1%
India	22 GtCO₂eq	9%
Rest Non-OECD	70 GtCO₂eq	30%
China	75 GtCO₂eq	32%

... 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



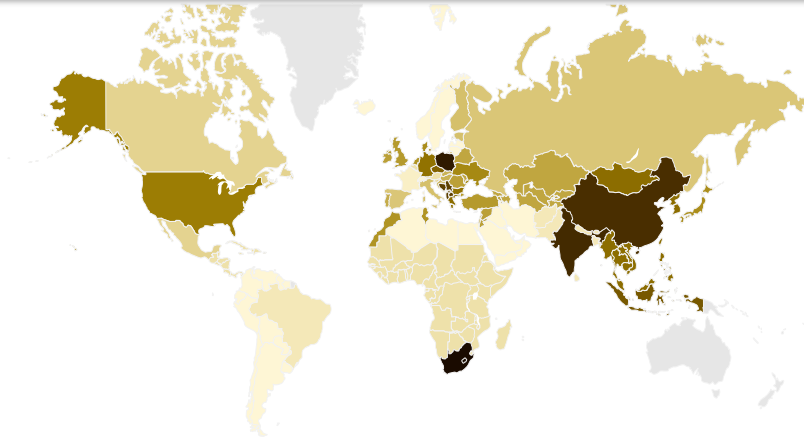
- Very high growth of RES (+ nuclear development)
- While coal production would dramatically decrease.

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



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

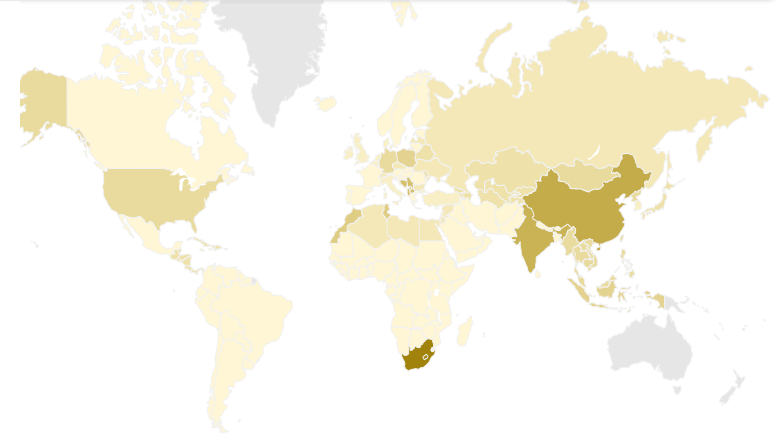
% of Coal in Power Gen., 2014



41%

9 738 TWh

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



13%

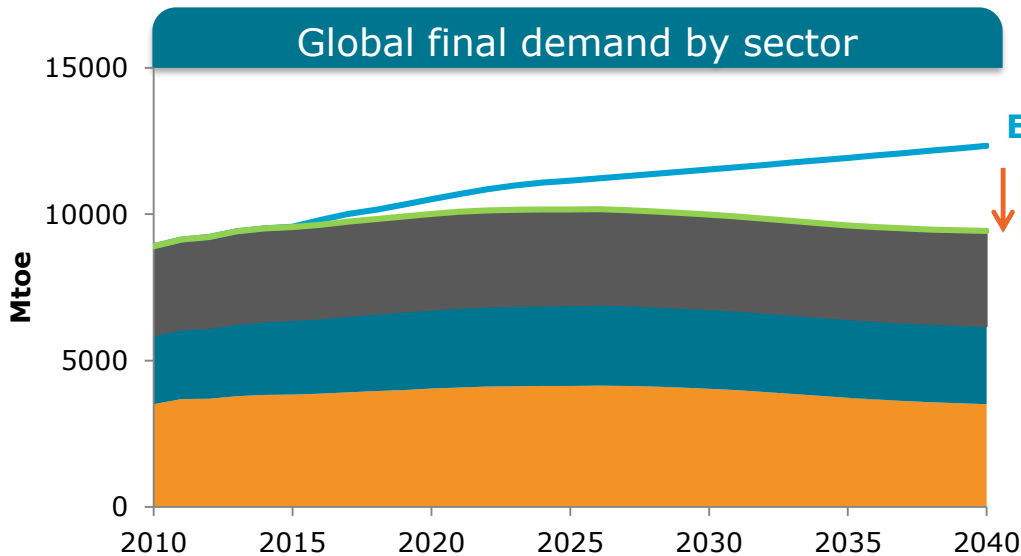
5 025 TWh

... 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.

Contribution by sector, 2040

Ener-Blue

-24%

Ener-Green

- Households & Services
- Transport (incl. bunkers)
- Industry

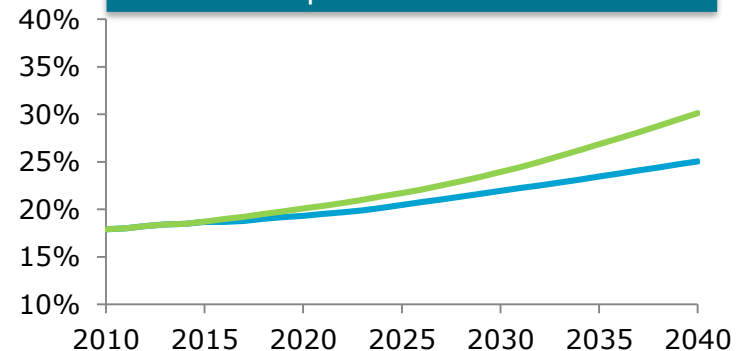
28%

29%

43%

2040

Share of power in final demand

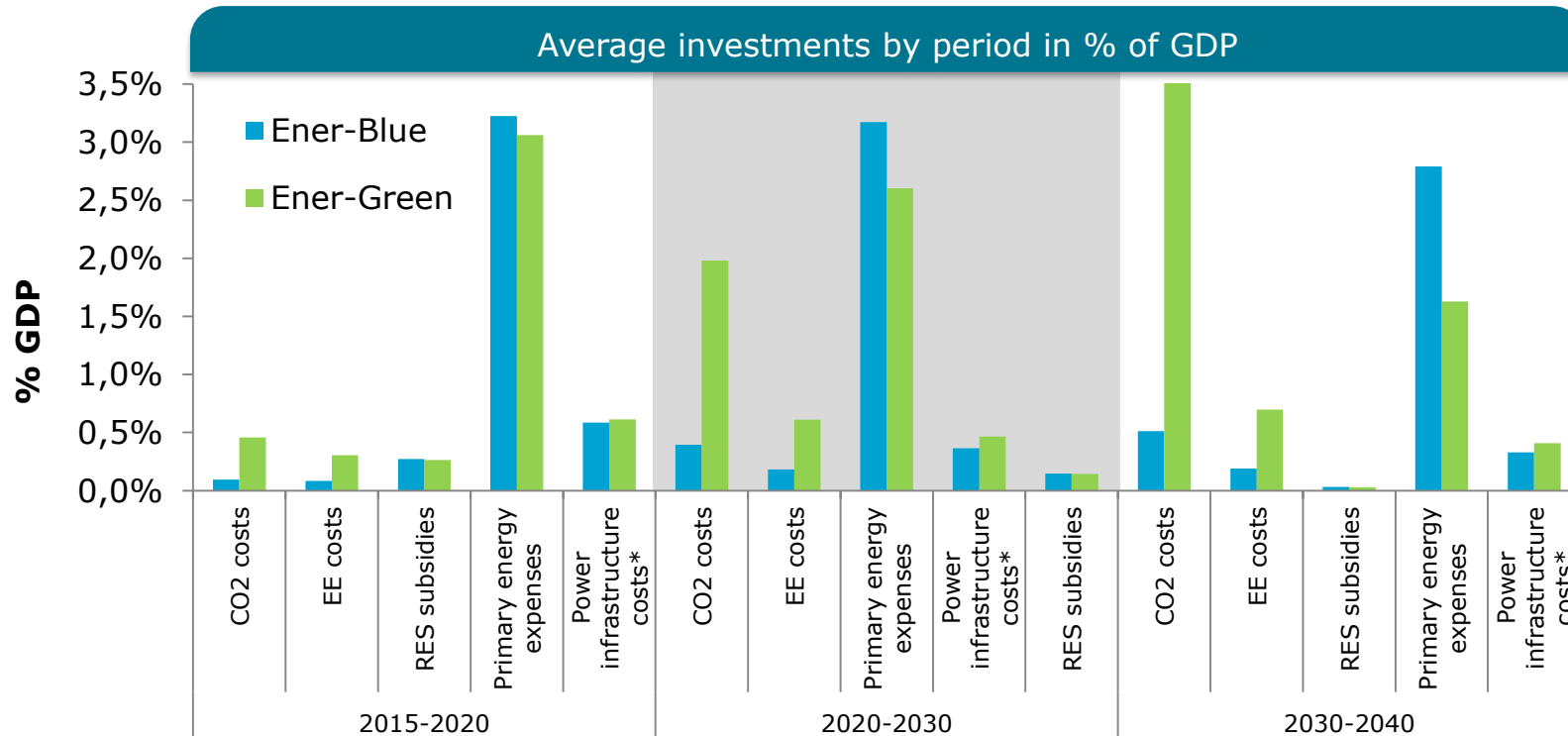


Source: EnerFuture, Ener-Blue and Ener-Green scenarios

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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

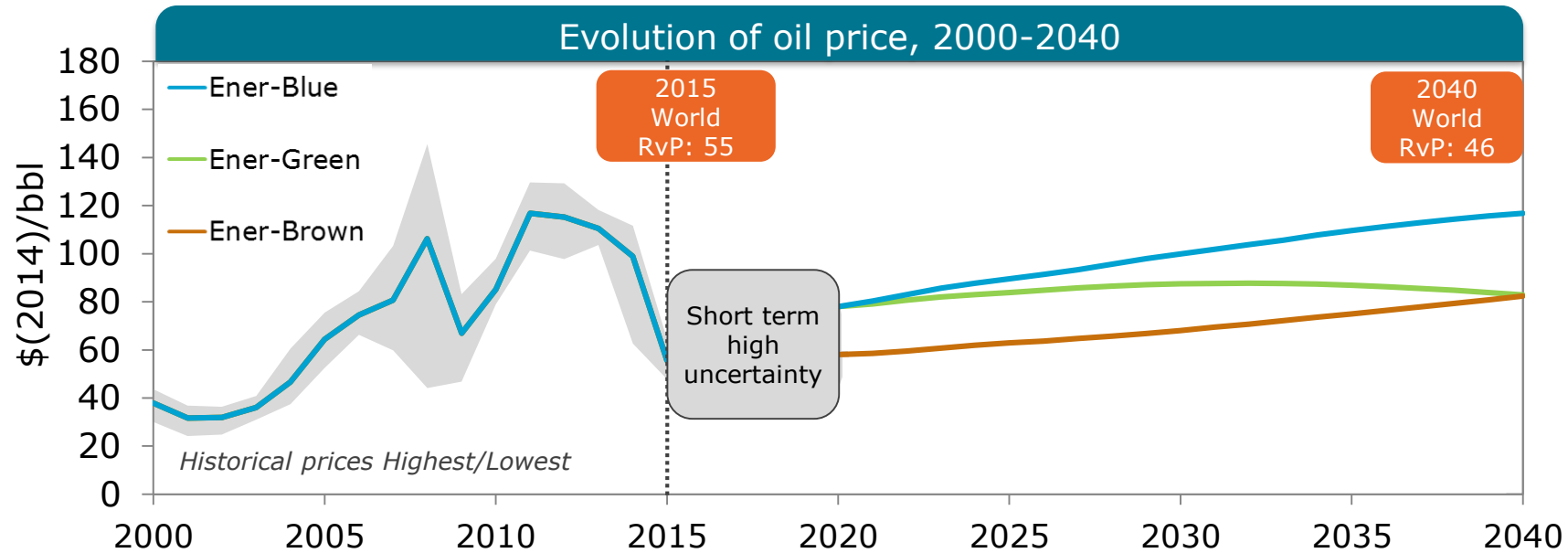
coal

nuclear

renewables



Based on supply-demand fundamentals, long-term oil prices should move in a range of 60-80\$/bbl...

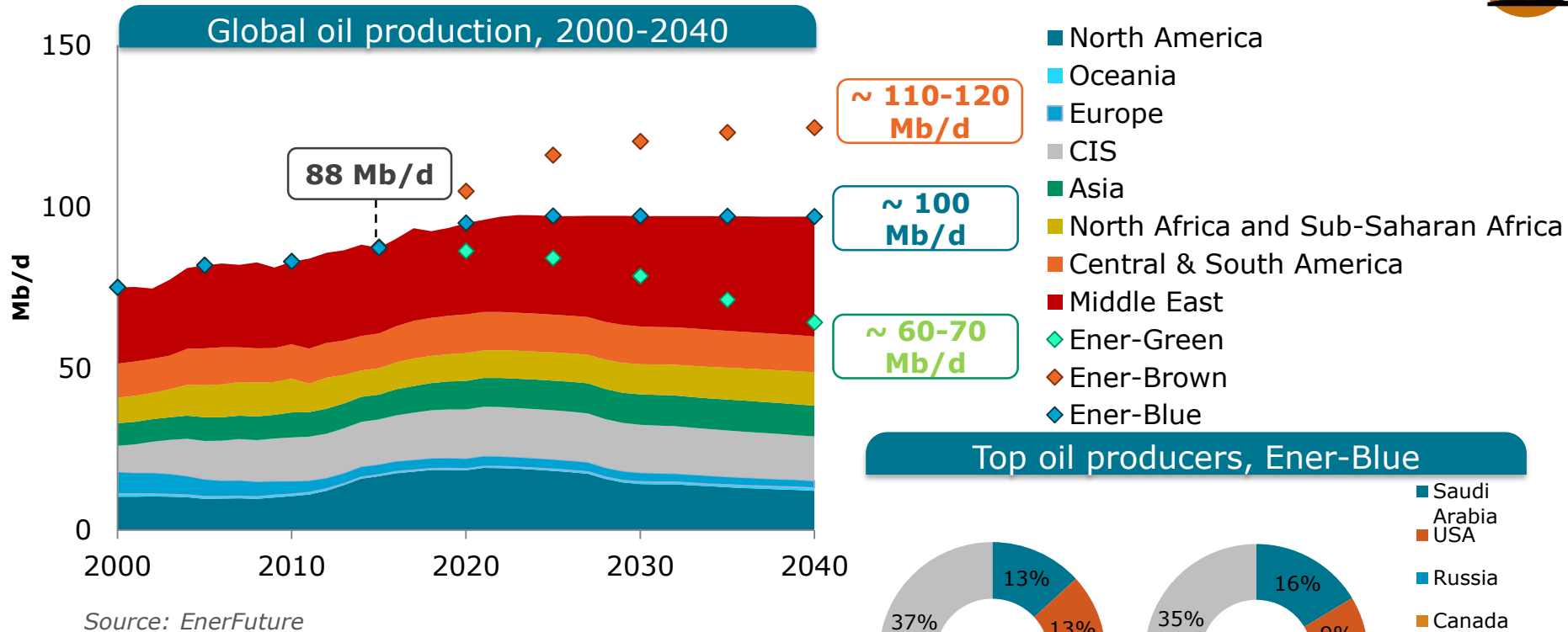


... but with a higher tension on oil markets in Ener-Blue, prices would recover faster and reach 100-120\$/bbl.

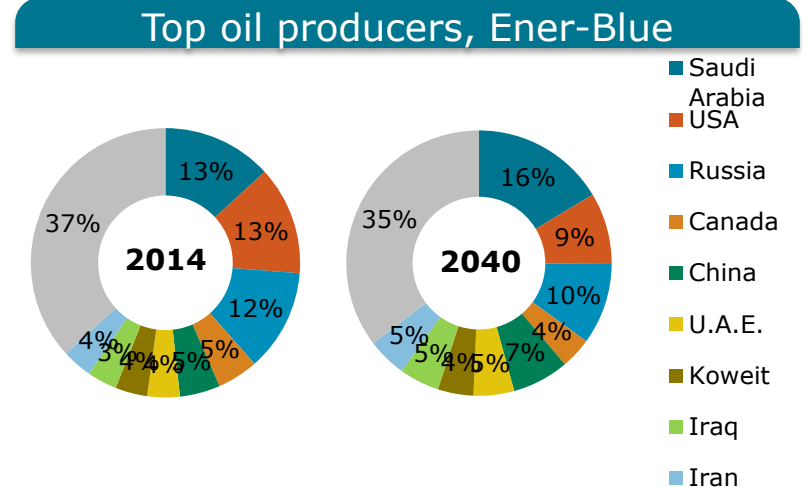
Source: EnerFuture



Global oil demand is strongly impacted by climate and energy policies

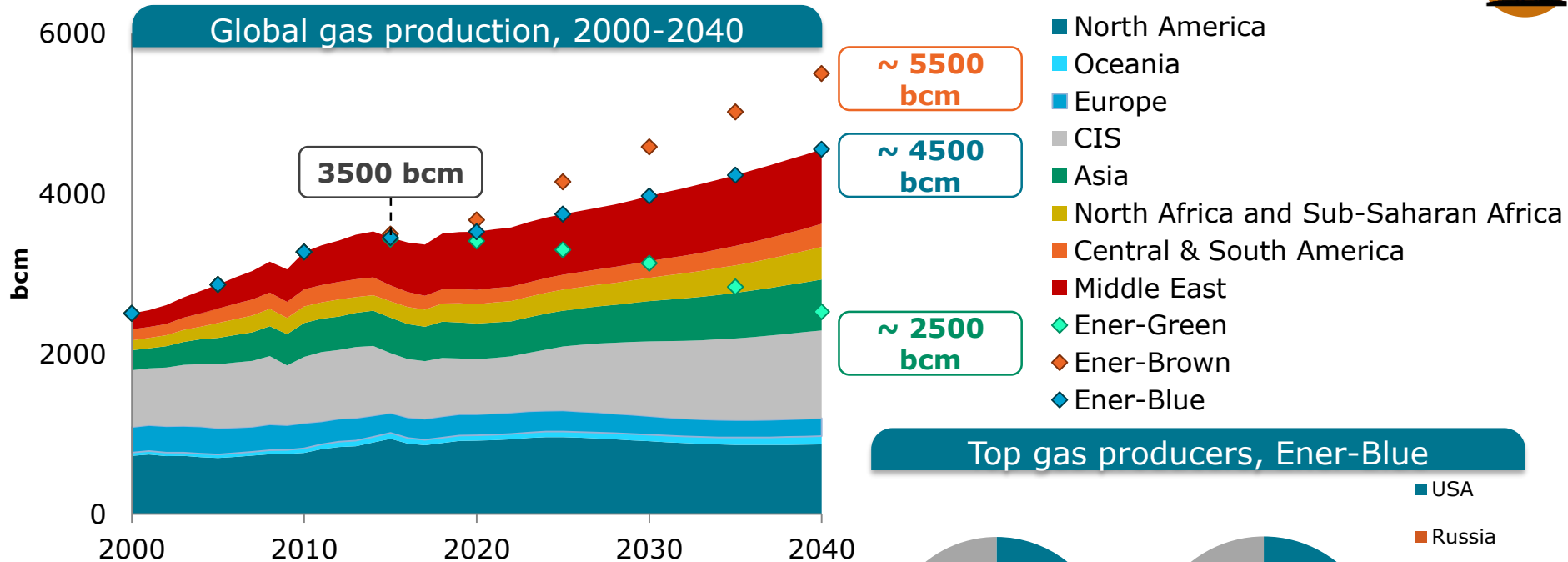


China becomes the biggest oil consumer around 2020, followed by the USA and India.



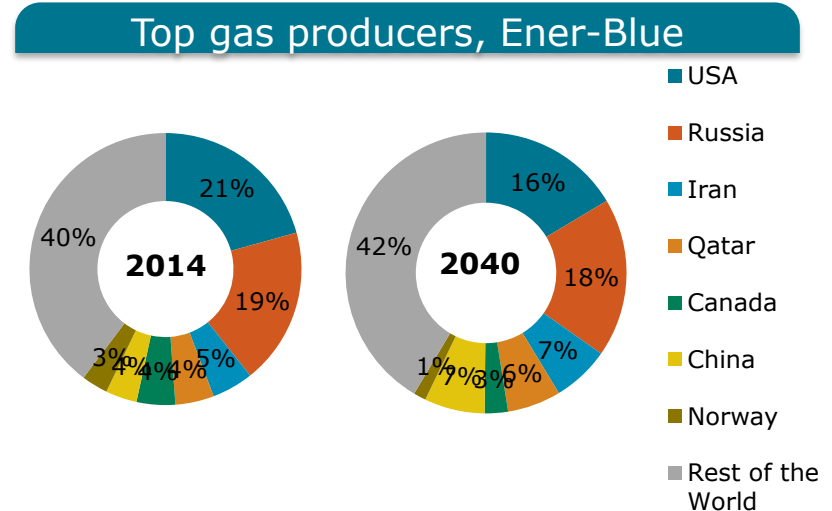


Global gas consumption continues to increase excepted in Ener-Green



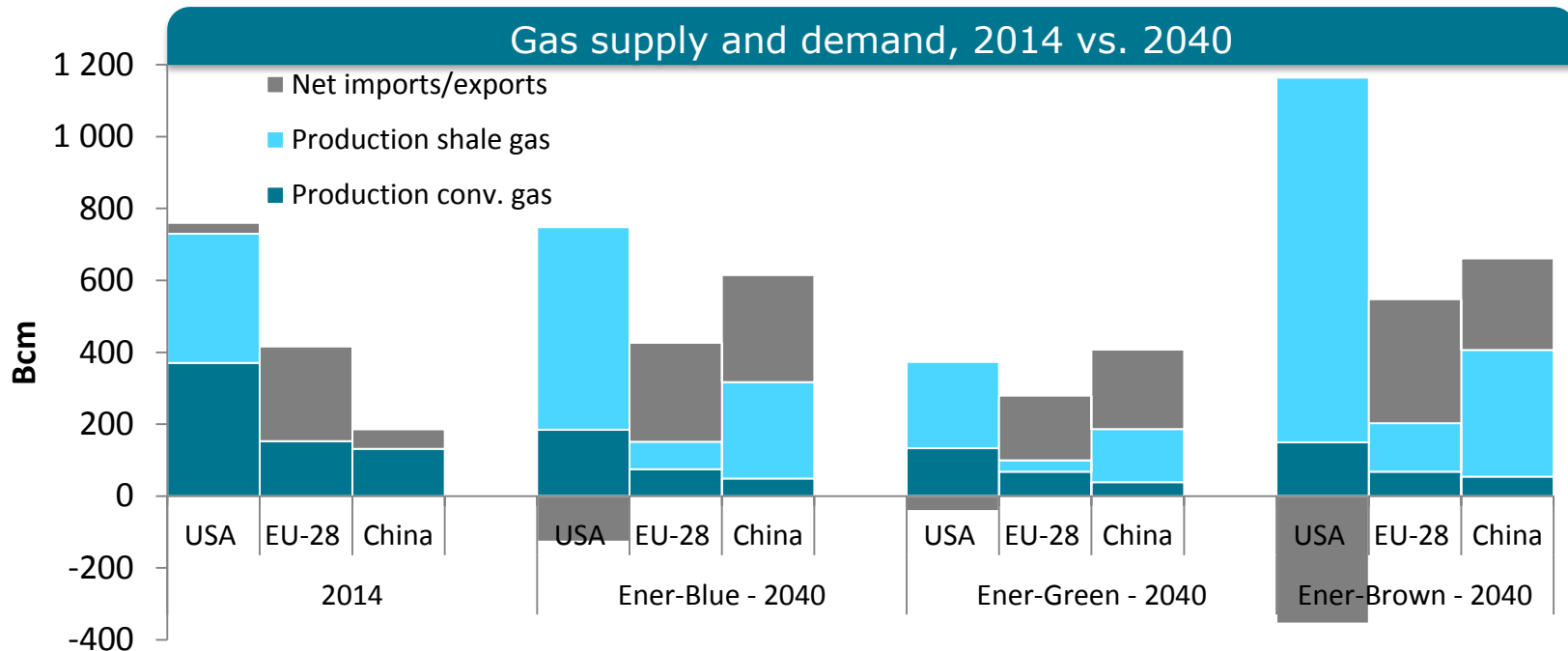
Source: EnerFuture

7 countries concentrate ~60% of the global production.





In Ener-Brown, optimistic shale gas development would boost gas supply

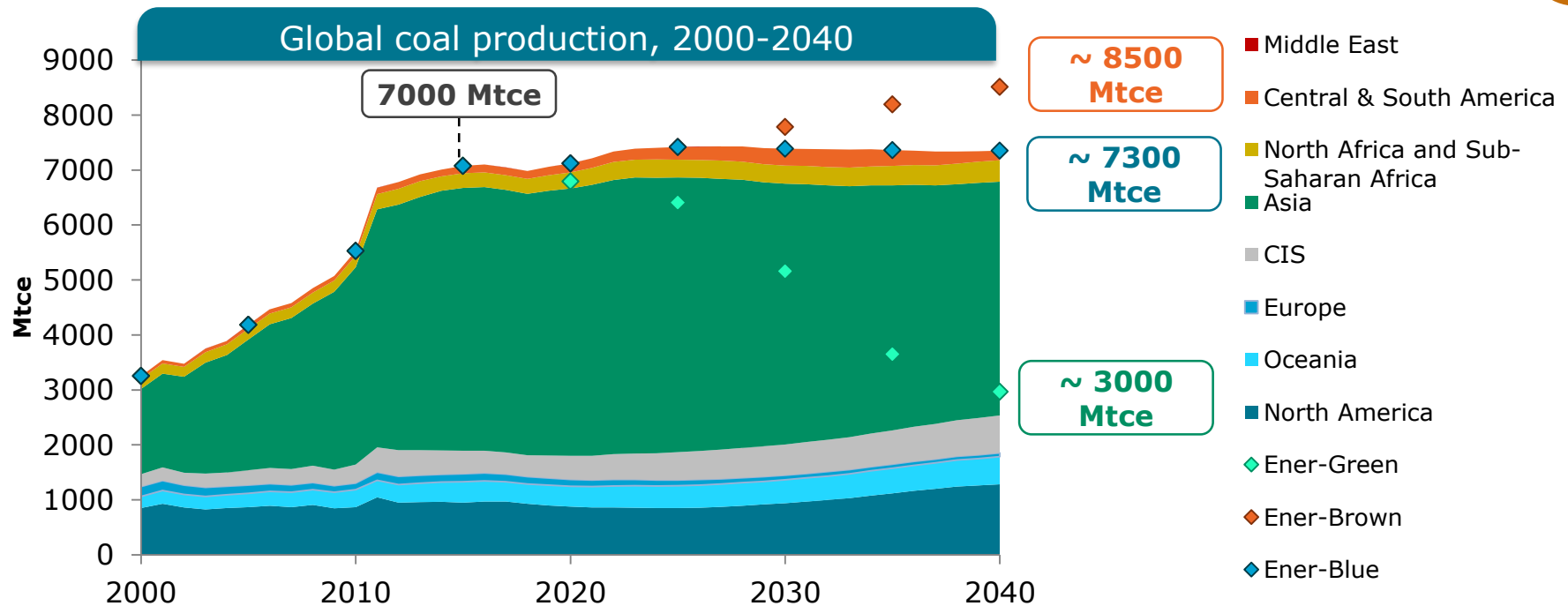


By 2040, 30% to 40% (resp. Ener-Blue and Ener-Brown) of gas supply will come from shale gas, mainly concentrated in North America.

Source: EnerFuture



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



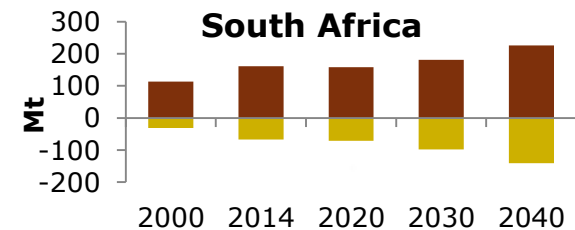
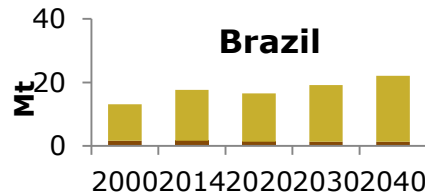
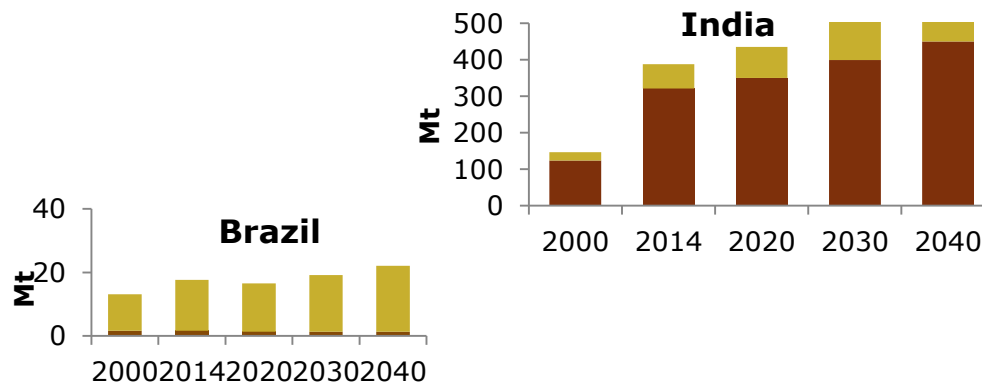
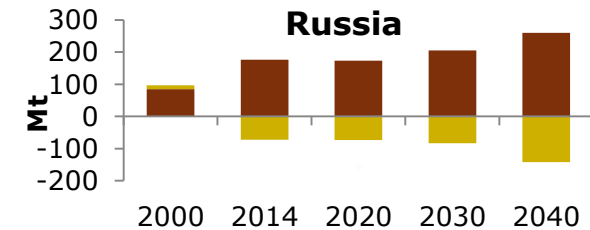
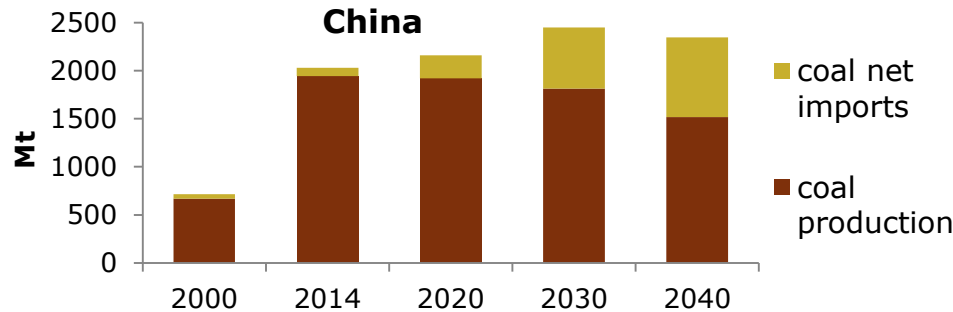
China remains the biggest coal consumer (~75% of the Asian demand in 2040 in Ener-Blue), followed by India and the USA.

Source: EnerFuture



The coal market is more diversified as Non-OECD countries, especially in Asia, increase their imports

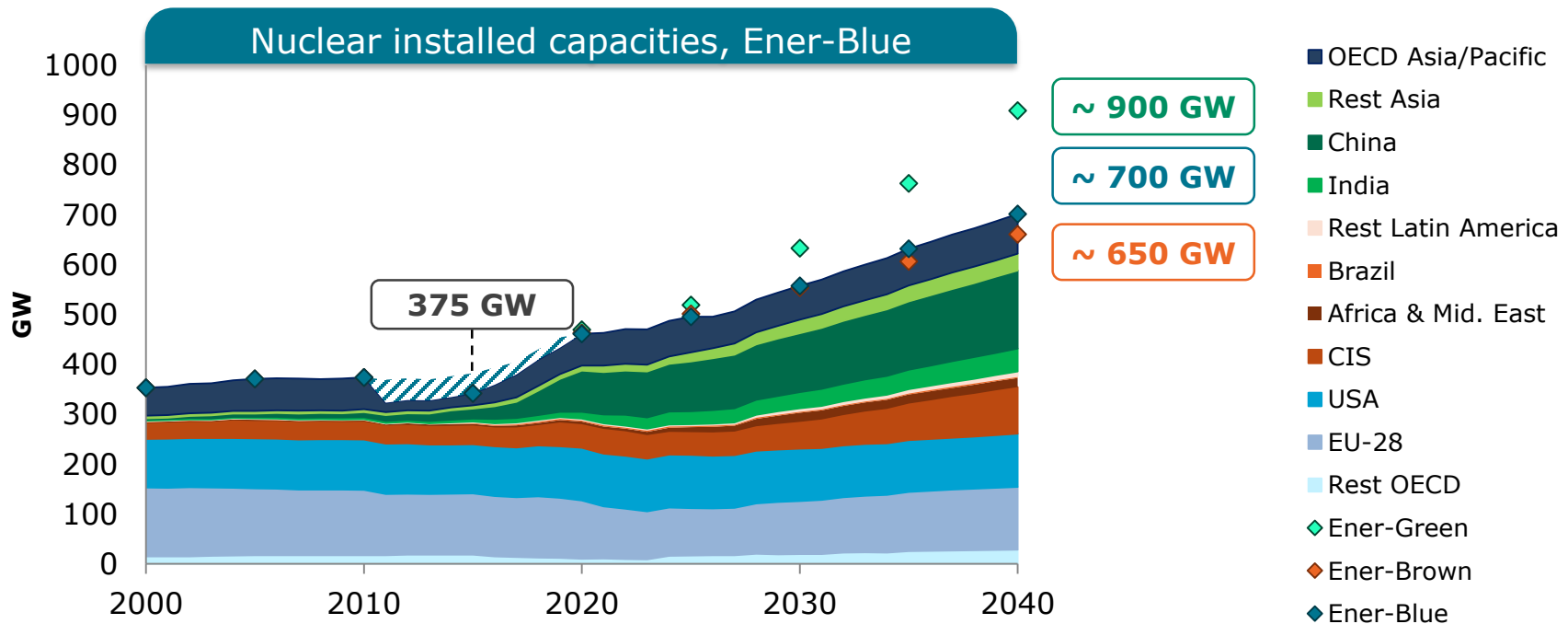
Coal primary demand vs production and net imports, 2014-2040



Source: EnerFuture, Ener-Blue scenario



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



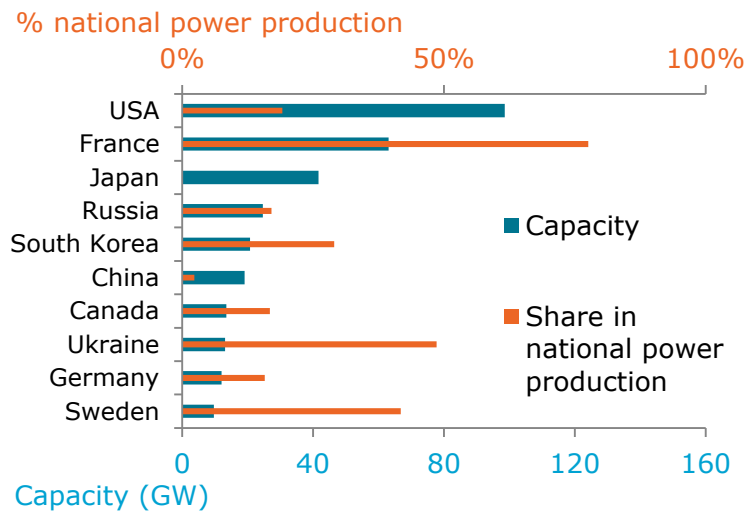
- China : 22% of the total installed capacities
- Japan restarts, India + rest of Asia grow, CIS too...
- Germany completes its phase-out

Source: EnerFuture, Ener-Blue scenario

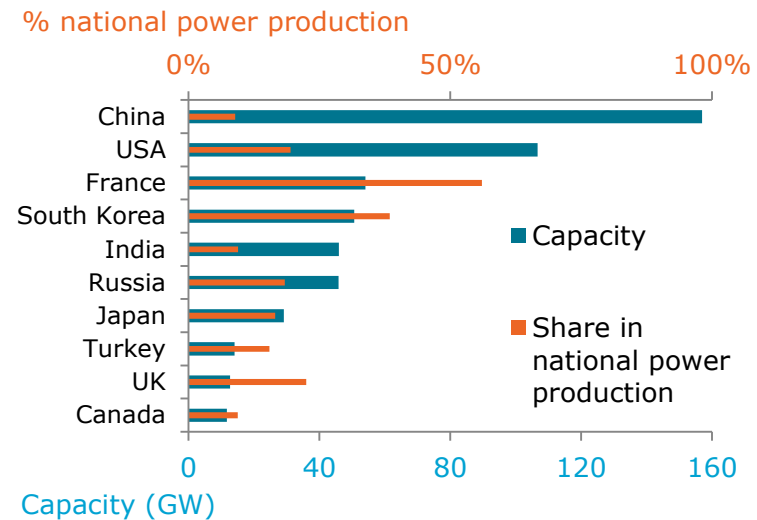


Top 10 nuclear countries represent 85% of the global nuclear installed capacities ...

Top 10 nuclear countries, 2014



Top 10 nuclear countries, 2040

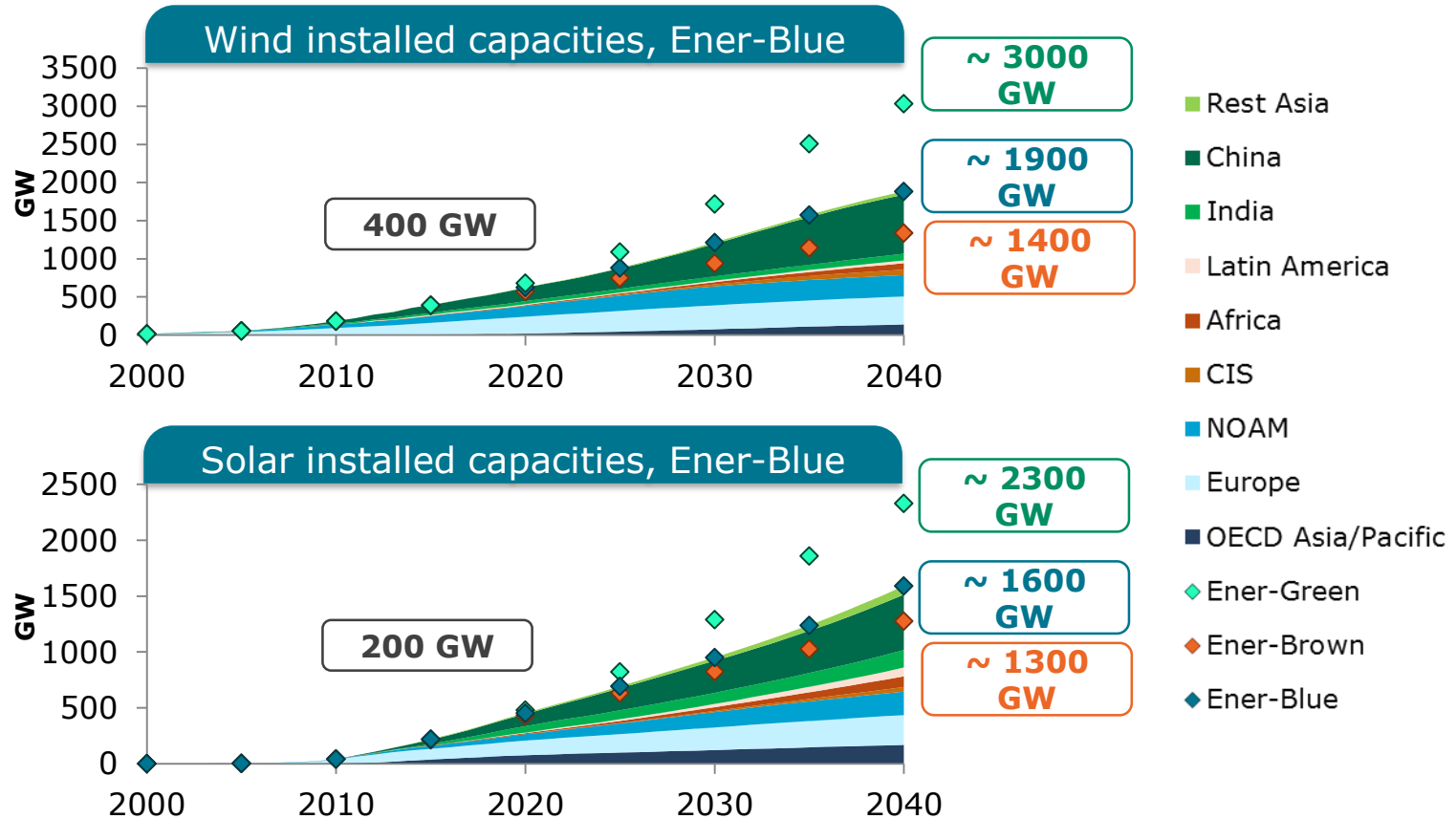


... and will produce about 4 500 TWh from nuclear (i.e. >10% of total global power production) at the horizon 2040.

Source: EnerFuture, Ener-Blue scenario



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



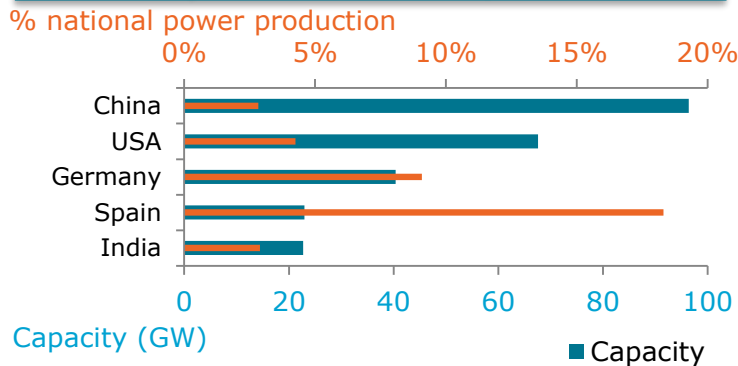
... and China will represent more than 40% and 30% of the total installed wind and solar capacities respectively.

Source: EnerFuture, Ener-Blue scenario

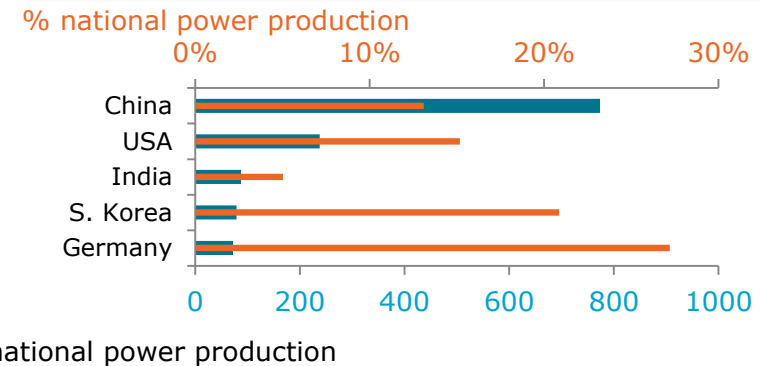


5 countries concentrate 2/3 of the global wind and solar installed capacities ...

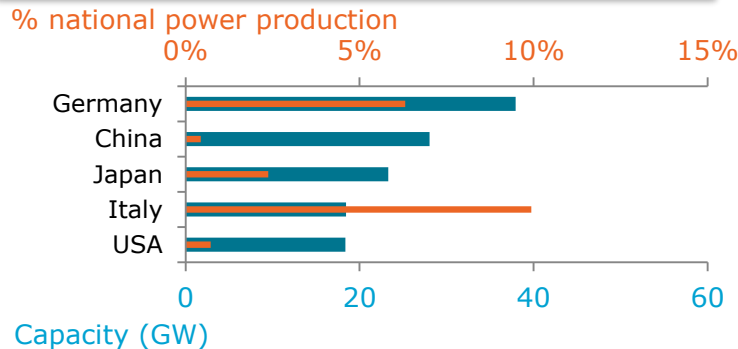
Top 5 wind countries, 2014



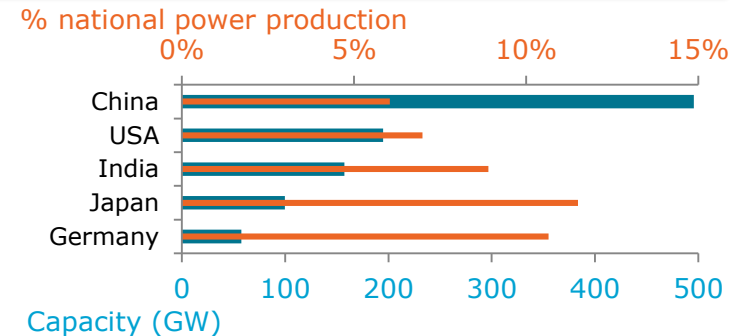
Top 5 wind countries, 2040



Top 5 solar countries, 2014



Top 5 solar countries, 2040

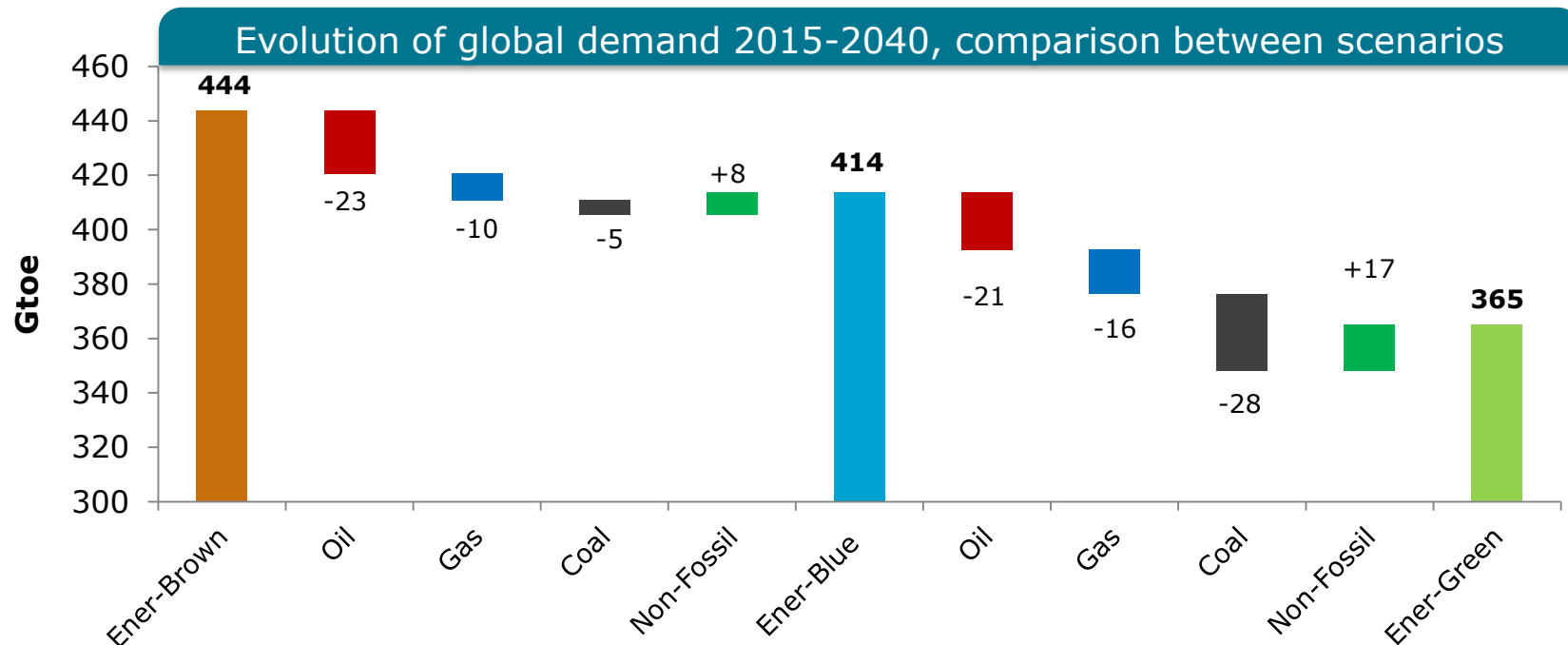


Source: EnerFuture, Ener-Blue scenario

- Boom in China, with ~20% of the national production in 2040
- Wind only would represent ~30% in Germany in 2040.



Energy policies and energy demand decrease impact strongly all fossil fuels ...



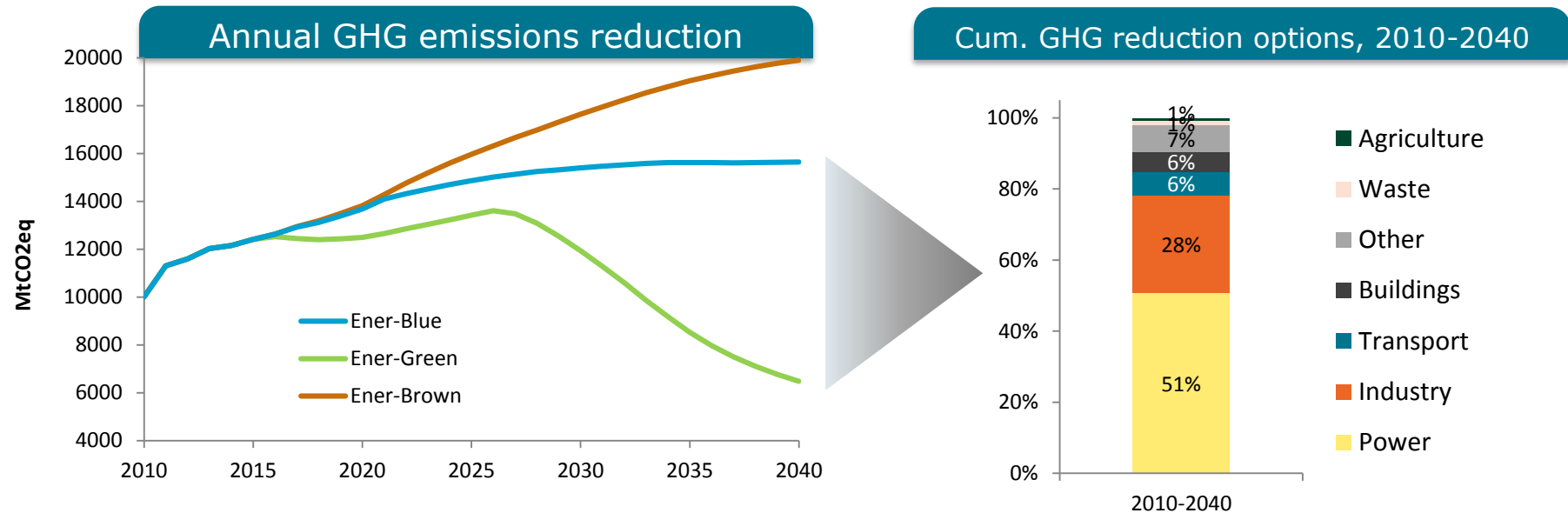
... but the 2°C target will be reached with a significant reduction of coal production.

Source: EnerFuture

Regional focus: China



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

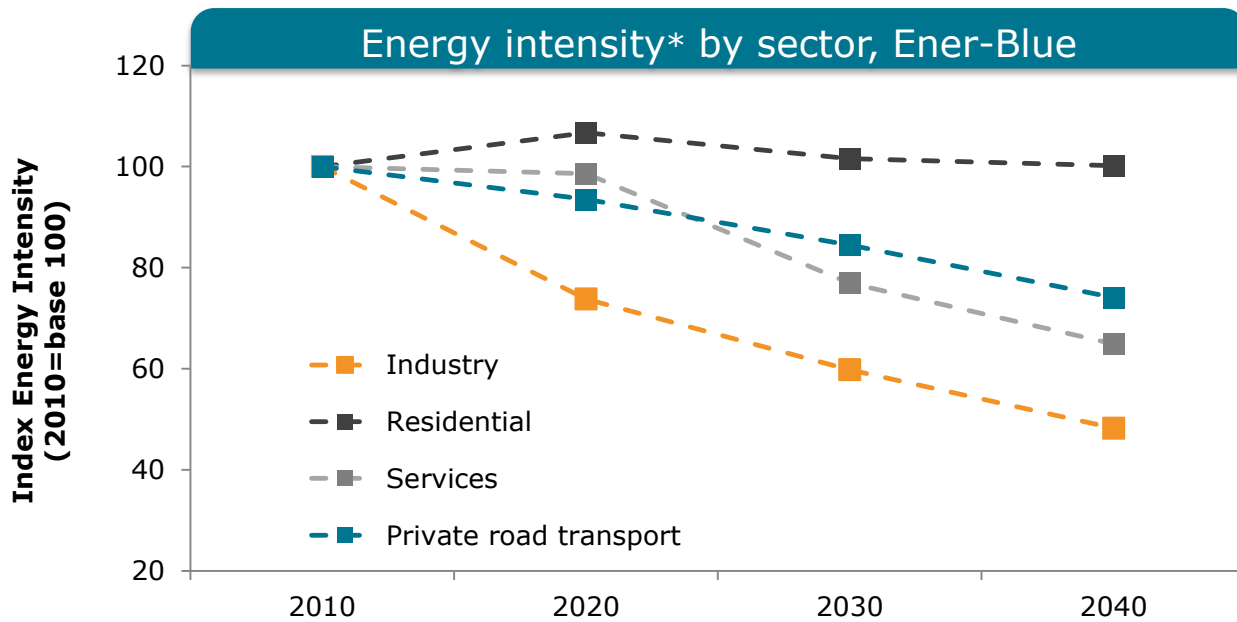


... with long-term GHG reduction mainly driven by power and industry.

Source: EnerFuture



China's INDC implies significant energy efficiency improvement



* Energy intensity calculation based on Value-Added for Industry and Services, on dwellings for Residential and on cars consumption in l/100km for Transport.

In the industry sector, energy intensity would decrease by 2.4%/y over 2010-2040.

Source: EnerFuture, Ener-Blue scenario



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

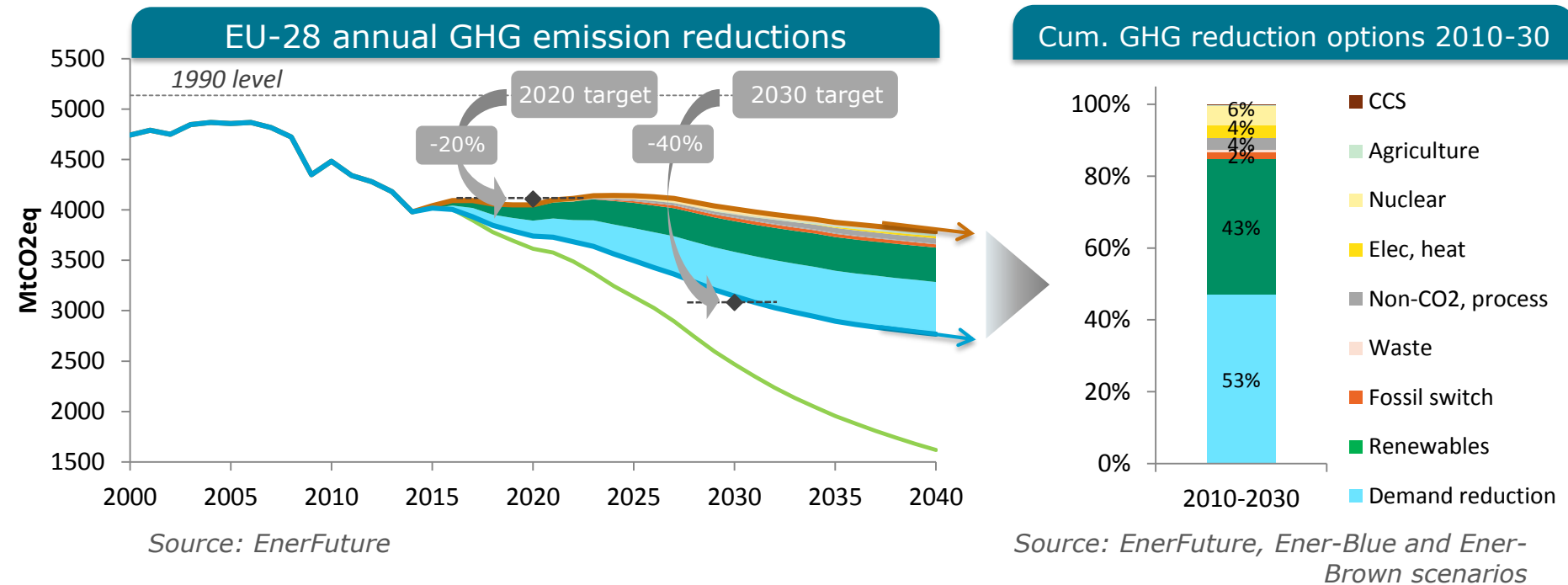
... and more than 50% of additional capacities after 2025.

Source: EnerFuture, Ener-Blue, scenario

Regional focus: European Union



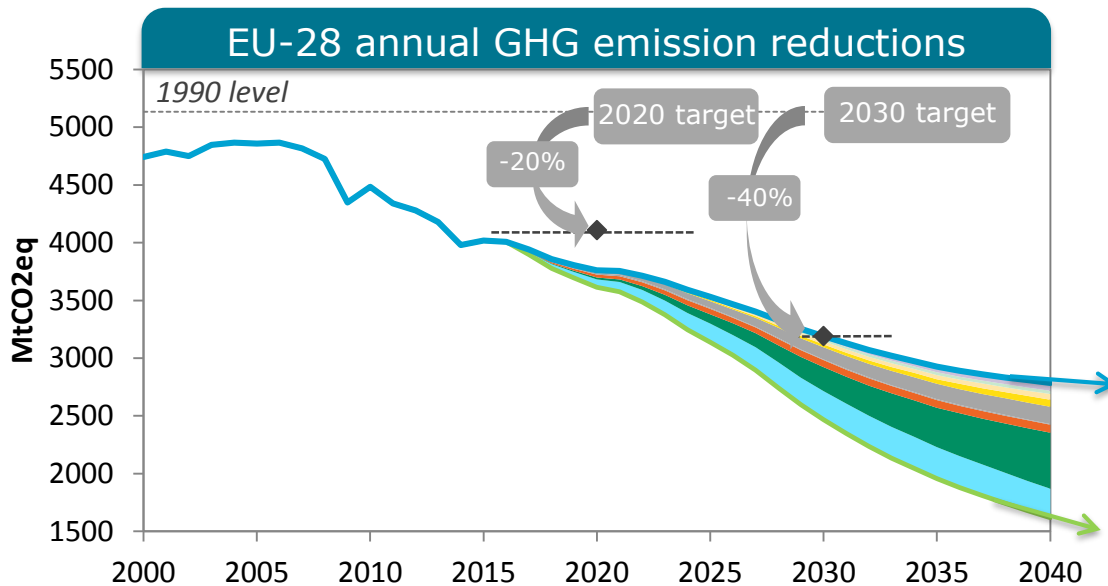
EU's 2030 target on emissions mainly reached via the deployment of renewables & efficiency



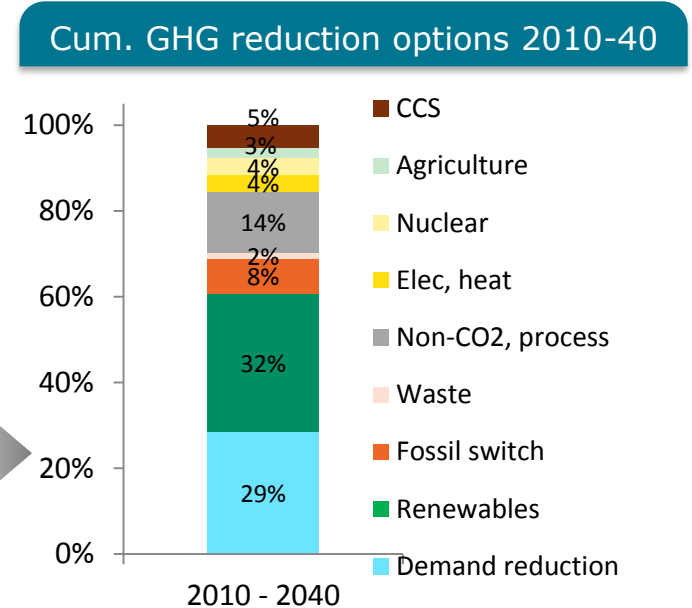
... with a decarbonisation principally achieved in the power and transport sectors.



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



Source: EnerFuture

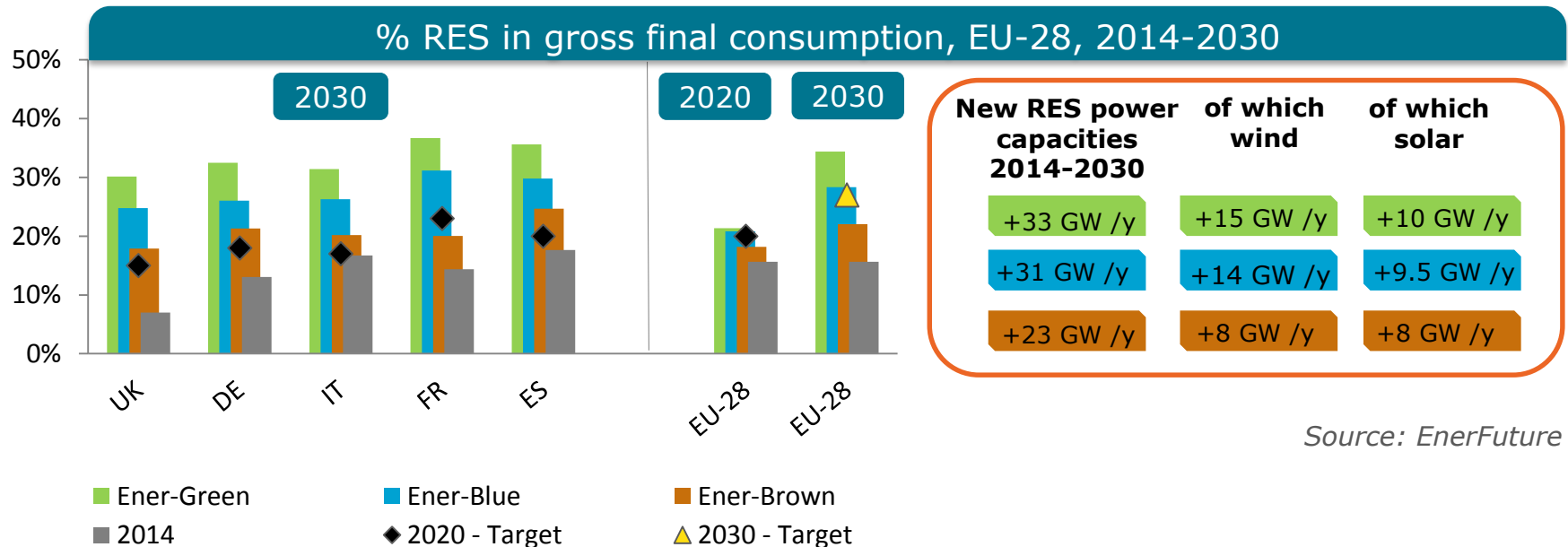


Source: EnerFuture, Ener-Blue and Ener-Green scenarios

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



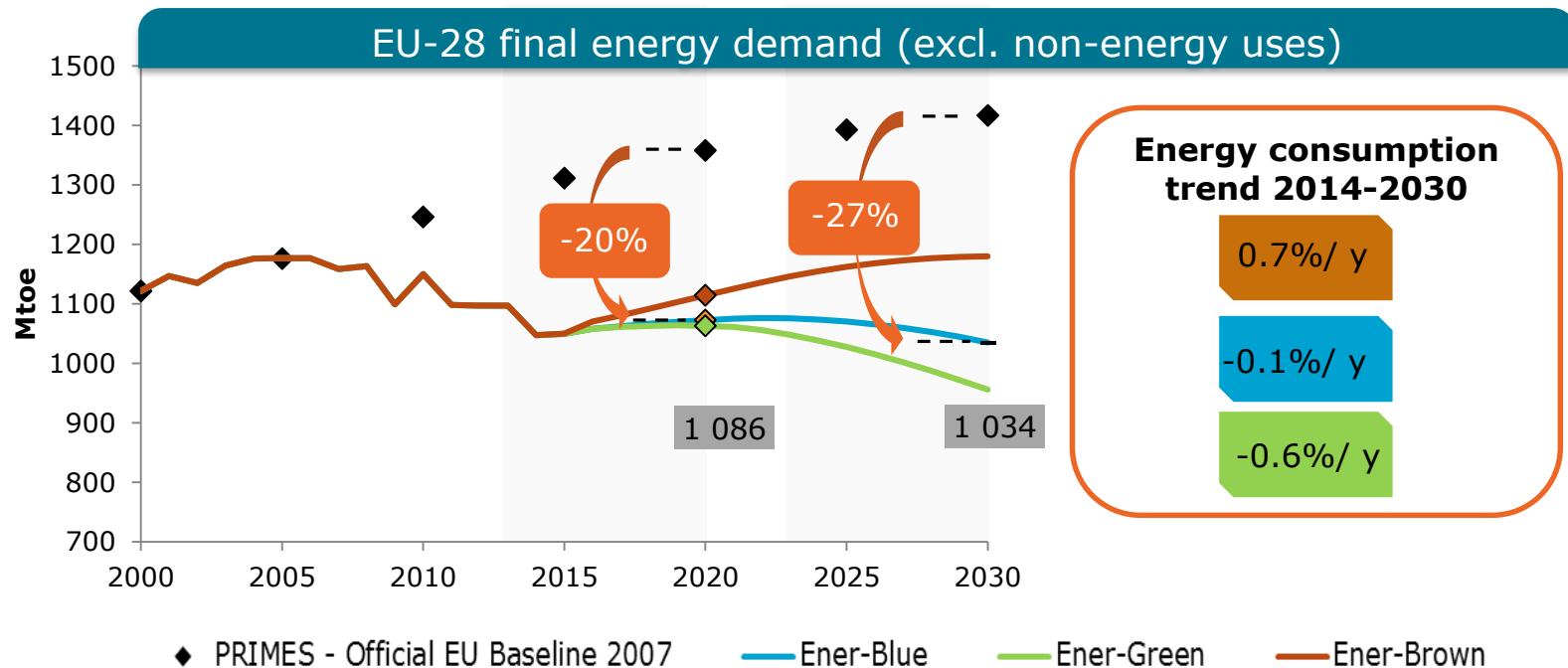
RES: up to 35% of EU's gross final consumption in 2030...



... but with increasing challenges as the share of wind and solar capacities compared to **back-up capacities** (thermal and hydro) rises from 25 to 43% between 2014 and 2030 (Ener-Green).



EU energy consumption objective: energy efficiency efforts should be intensified after 2020...

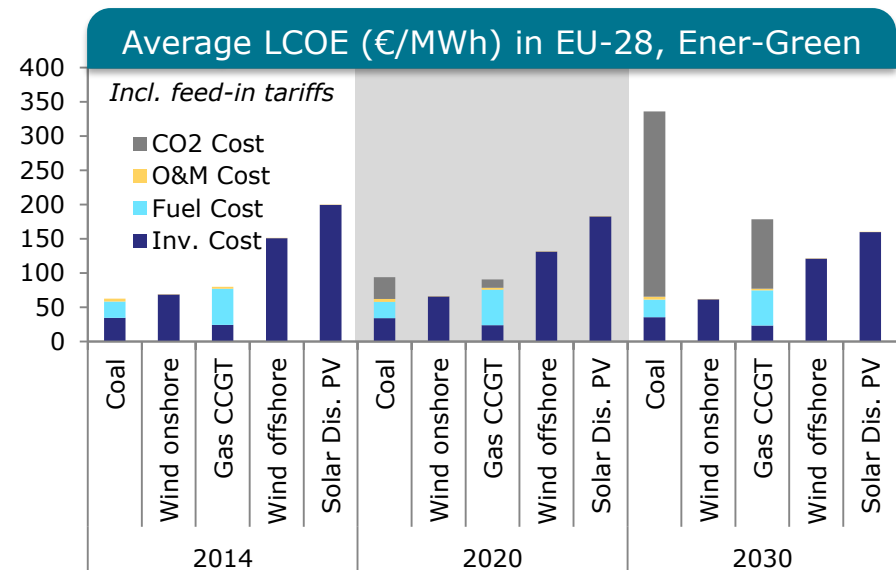
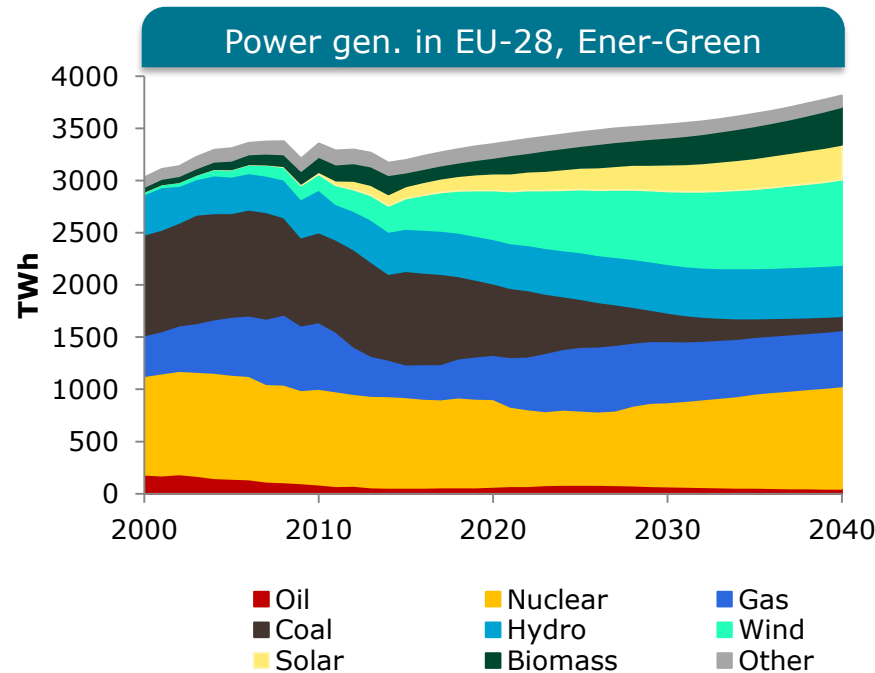


... with highest savings potentials coming from buildings.

Source: "Evaluating EU energy efficiency policies and future policy options up to 2020 and beyond", DG ENER, EnerFuture



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.

Source: EnerFuture, Ener-Green scenario

Conclusions

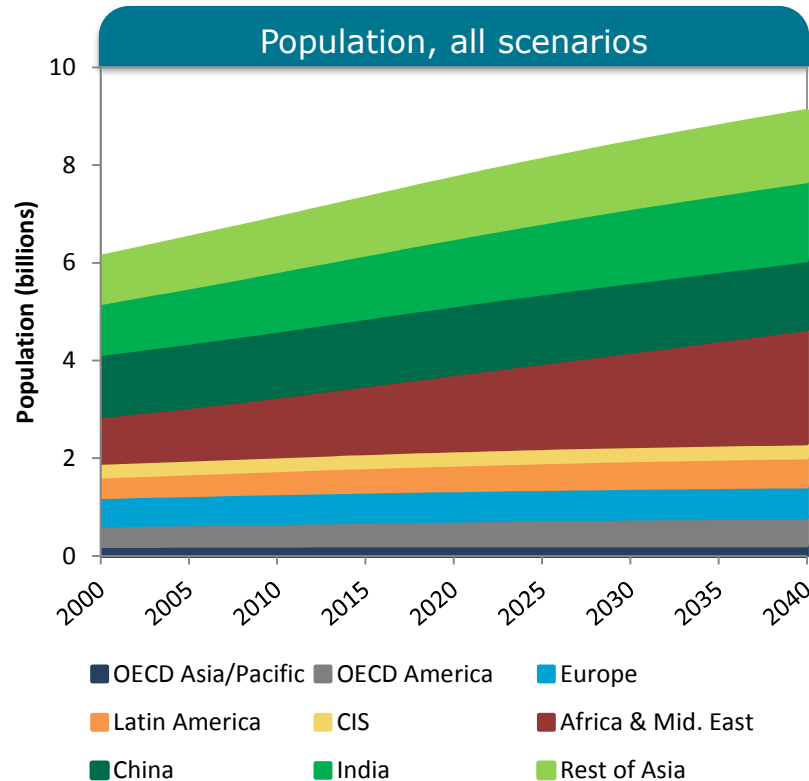
EnerFuture scenarios – wrap up

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

Appendix



In Europe and in CIS, population will be on a slight decrease while high growth rates are expected in the Mid. East and in Africa



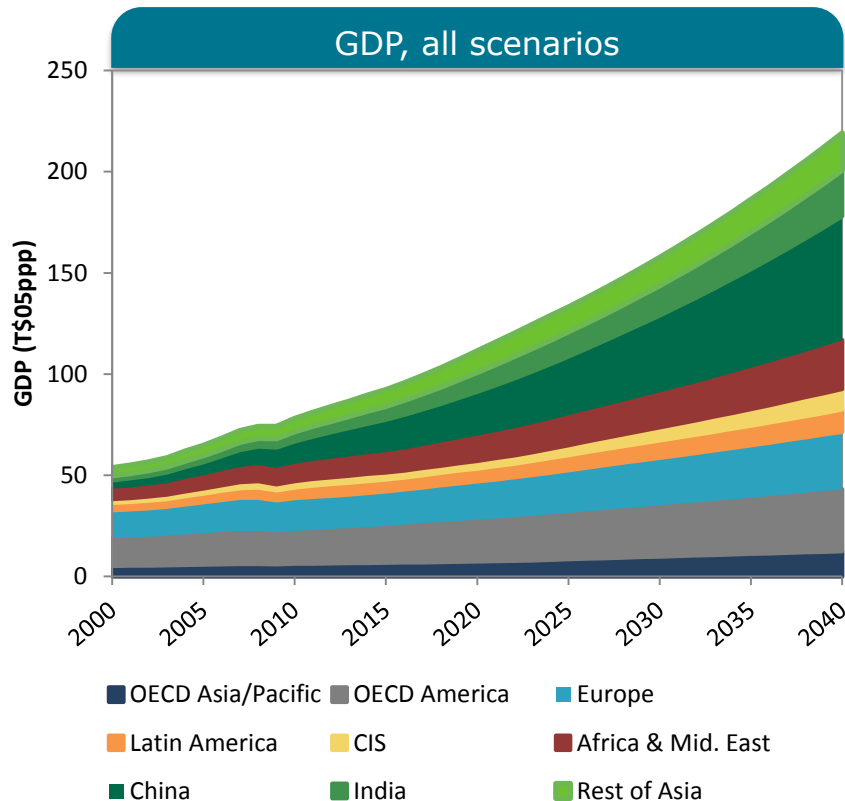
Annual growth rate (%), all scenarios

	2000 - 2014	2014 - 2020	2020 - 2030	2030 - 2040
Non OECD	1.3	1.2	1.0	0.8
E Europe / Eurasia	0.0	0.0	-0.1	-0.3
Russia	-0.1	-0.1	-0.3	-0.4
Asia	1.1	0.9	0.7	0.4
China	0.6	0.4	0.1	-0.1
India	1.5	1.2	1.0	0.7
Africa & Mid. East	2.5	2.4	2.2	1.9
Latin America	1.2	1.0	0.8	0.5
Brazil	1.1	0.8	0.6	0.3
OECD	0.7	0.5	0.4	0.2
North America	1	0.9	0.7	0.5
US	0.9	0.7	0.6	0.5
Europe	0.5	0.3	0.2	0.1
Pacific	0.4	0.2	0.1	-0.1
Japan	0	-0.2	-0.4	-0.5
World	1.2	1.1	0.9	0.7
EU28	0.3	0.1	0.0	-0.1

Source: UN World Population Prospects (2015 Revision)



Between 2014 and 2040, advanced economies grow slowly (2.1%/y), growth in emerging countries is solid (4.2%/y)



Annual growth rate (%), all scenarios

	2000 - 2014	2014	2015 - 2020	2020 - 2040
Non OECD	6.1	4.7	5.1	4.2
E Europe / Eurasia	4.6	1	2.3	5
Russia	4.1	0.6	1	5
Asia	7.6	6.5	6.2	4.6
China	9.8	7.3	6.2	5.4
India	7.2	7.3	7.6	4.4
Africa & Mid. East	4.8	3.2	4.3	3.3
Latin America	3.5	1	1.8	2.7
Brazil	3	0.1	1.7	2.5
OECD	1.7	1.9	2.2	2.1
North America	1.8	2.4	2.5	2.0
US	1.8	2.4	2.5	1.8
Europe	1.4	1.6	2	2
Pacific	1.7	1.1	1.8	2.7
Japan	0.7	-0.1	0.7	1.8
World	3.7	3.4	3.8	3.4
EU28	1.3	1.5	1.9	1.8

Source: IMF outlook (2014 – 2020)
CEPII Baseline (2020 – 2040)

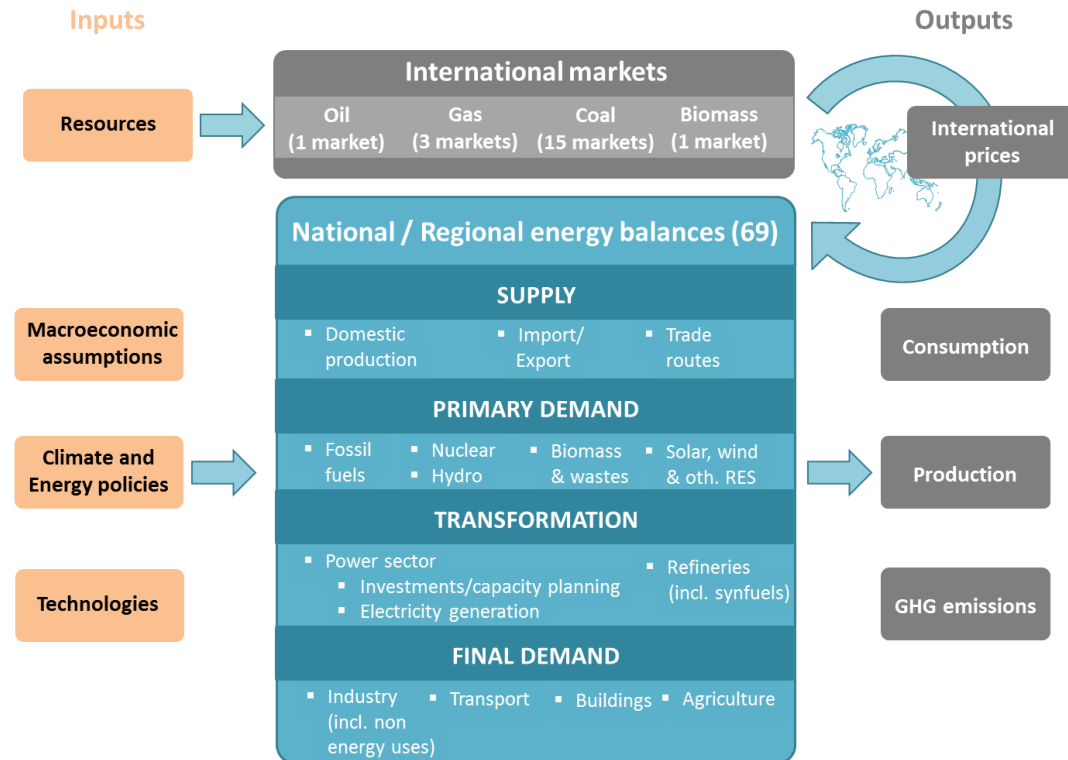
POLES – An integrated tool to assess the evolution of future energy systems

Main features

- forecasts by country/region and commodity up to 2050 (-2100)
- Outlook for international oil, gas, and coal prices + end user prices (incl. power)
- Simulation of GHG emissions, analysis of abatement strategies
- Simulation of future technology developments in the energy sector

Structure and functions

- Yearly dynamic recursive, includes anticipation behaviours
- Energy balances for 66 countries/regions
- Disaggregation into 15 energy demand sectors, 50 energy-related technologies & technological learning
- Simulation of oil and gas : 88 countries
- Full power generation system
- Uranium & renewables resources



Issues and topics covered by POLES

Energy Demand

- 66 countries
- 15 detailed sub-sectors industry, buildings & transportation, incl. detailed description of large Energy Intensive Industries : steel, aluminium...
- All key energies: oil, gas, coal, power, biomass, solar, wind
- End consumer prices
- Detailed demand technology description (buildings, transport)
- Demand function based on activity levels, prices effects, autonomous technological change

Energy supply

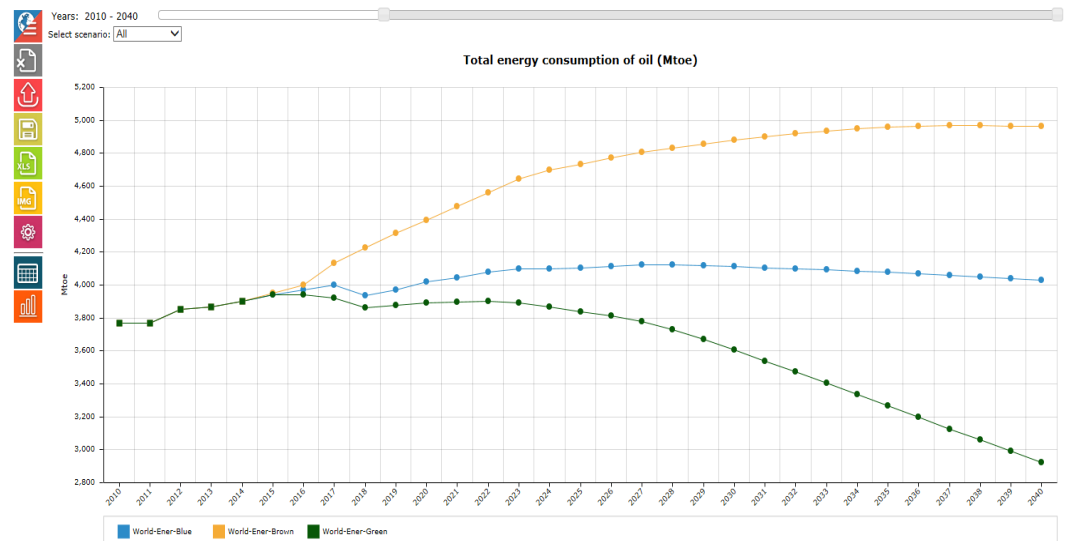
- Oil, gas, coal, and renewables
- Resources, discoveries and reserves for 88 producing countries
- Production strategies (countries)
- Unconventional oil and gas
- International and regional prices: oil, gas, coal, biomass
- Development potential for renewables
- Oil, gas, coal, and biofuels, imports & exports

Transformation

- 30 different power generation technologies
- Simulation of future power generation mix by country
- Power capacity planning
- Electricity load forecasting
- Power price analysis
- Technology availability scenarios: Nuclear revival or phase-out, CCS, wind & intermittency...
- Impact of support schemes for renewables (feed-in tariffs...)
- Hydrogen

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- 24/7 online access
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- Power mix forecasts to 2040 (capacities + production)
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- Unlimited Excel exports
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Contact:

Global Energy Forecasting

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