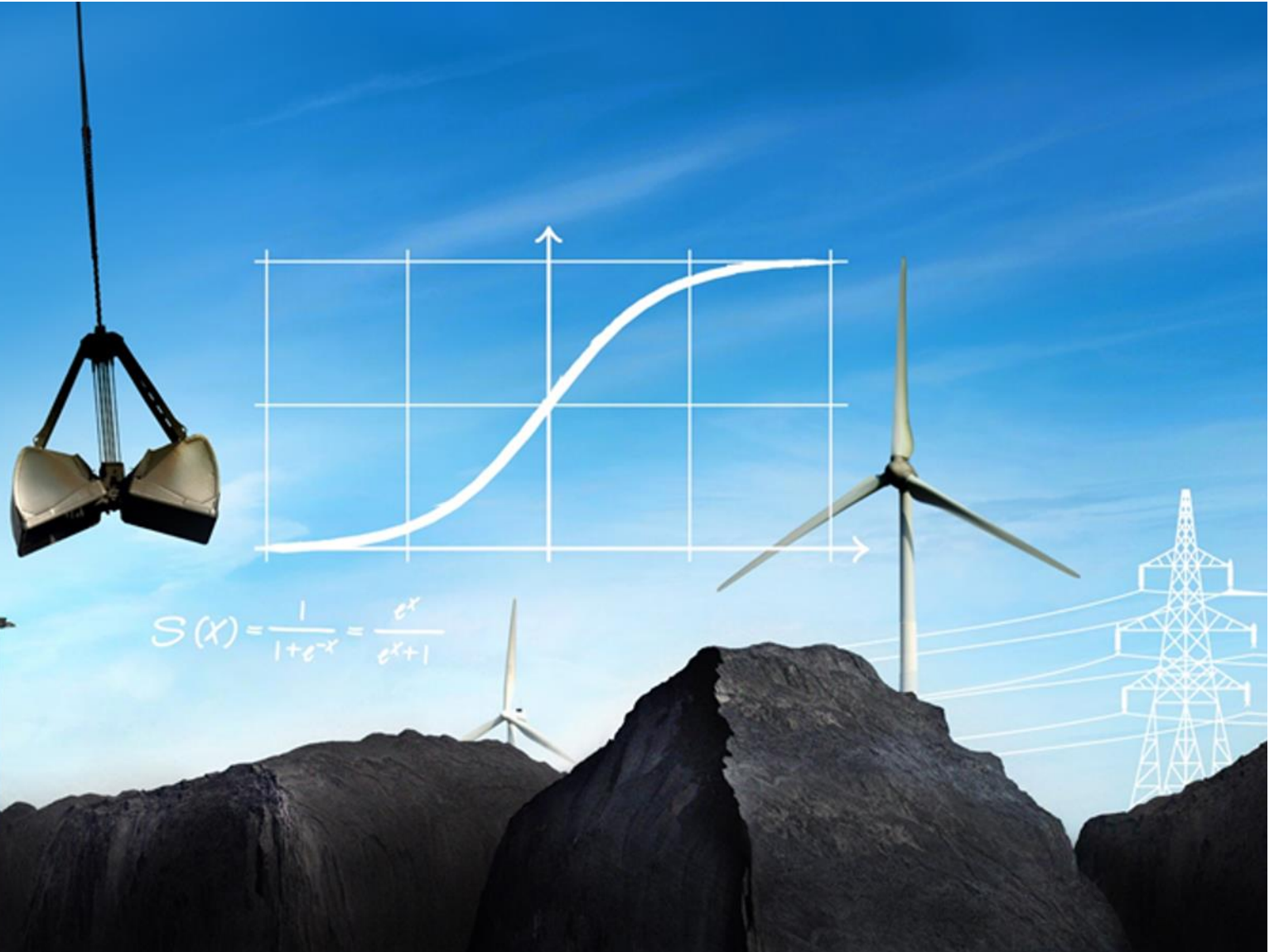


ENERGY TRANSITION OUTLOOK 2017

A global and regional forecast
of the energy transition to 2050

$$S(x) = \frac{1}{1+e^{-x}} = \frac{e^x}{e^x+1}$$

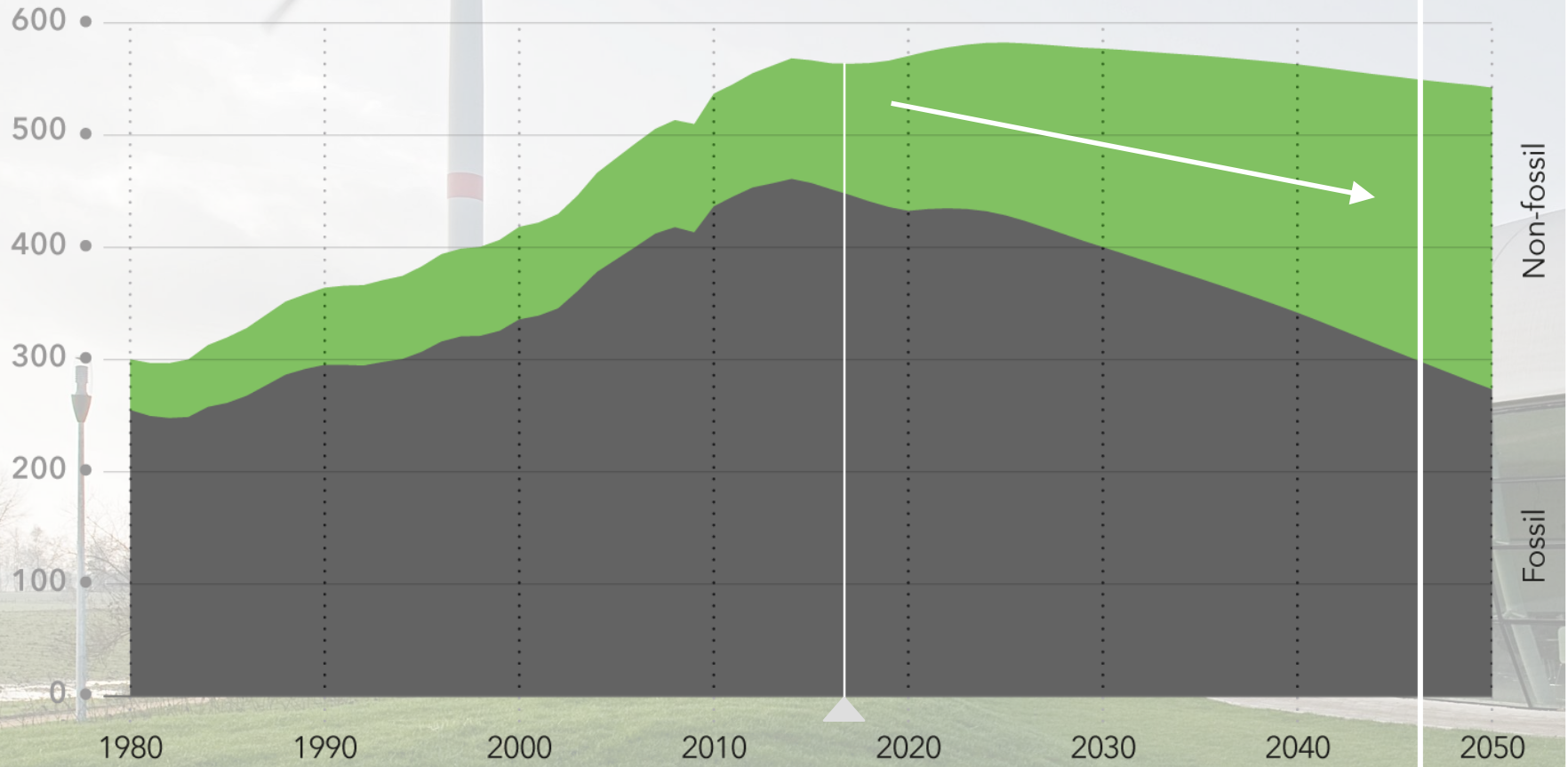
Ditlev Engel
CEO, DNV GL - Energy





Forecast world primary energy supply

Units: EJ/yr

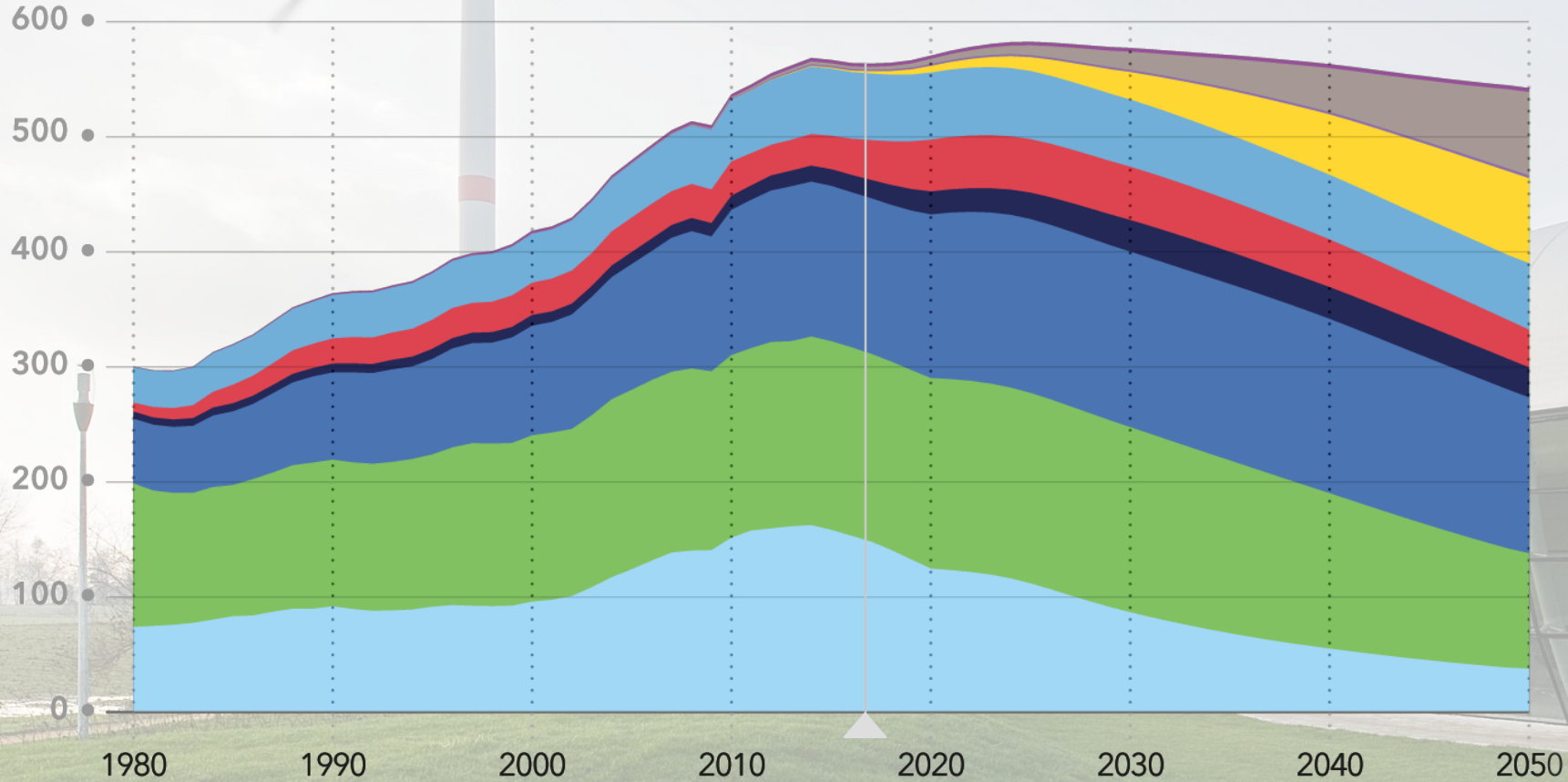


Non-fossil

Fossil

Forecast world primary energy supply by source

Units: EJ/yr



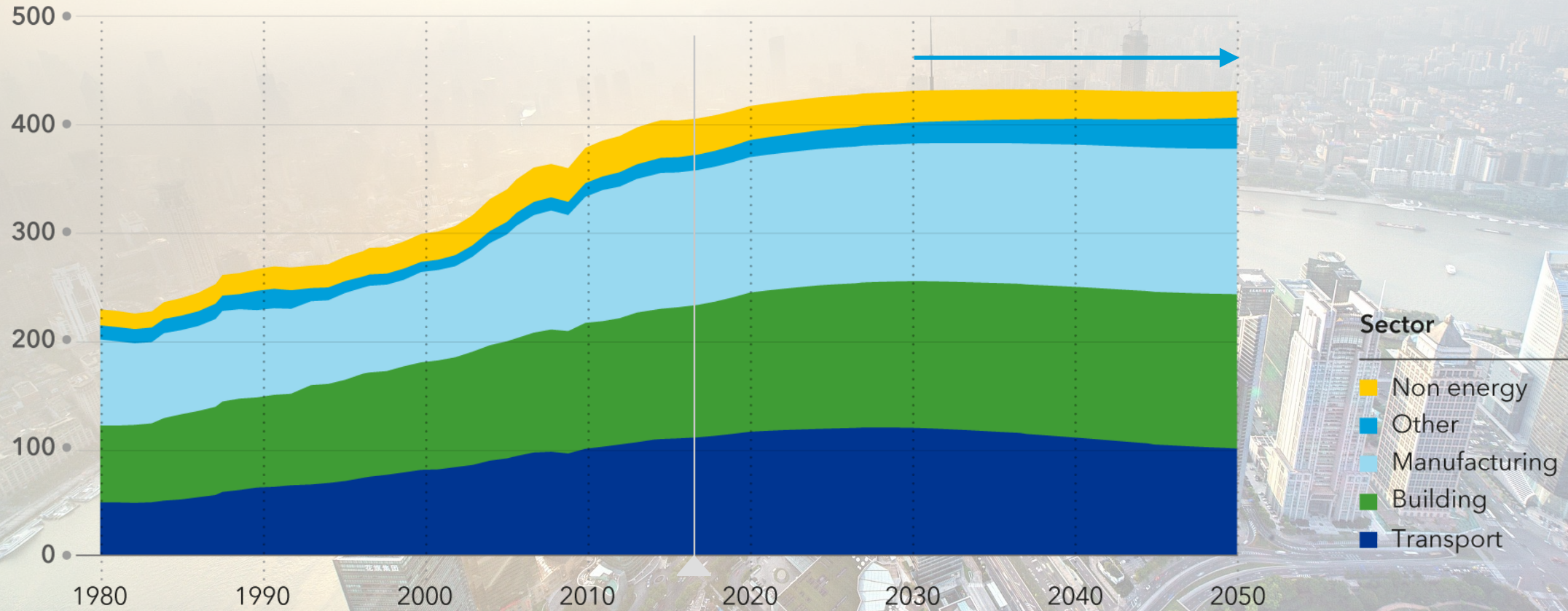
Energy source

- Geothermal
- Wind
- Solar thermal
- Solar PV
- Biomass
- Nuclear
- Hydro
- Gas
- Oil
- Coal



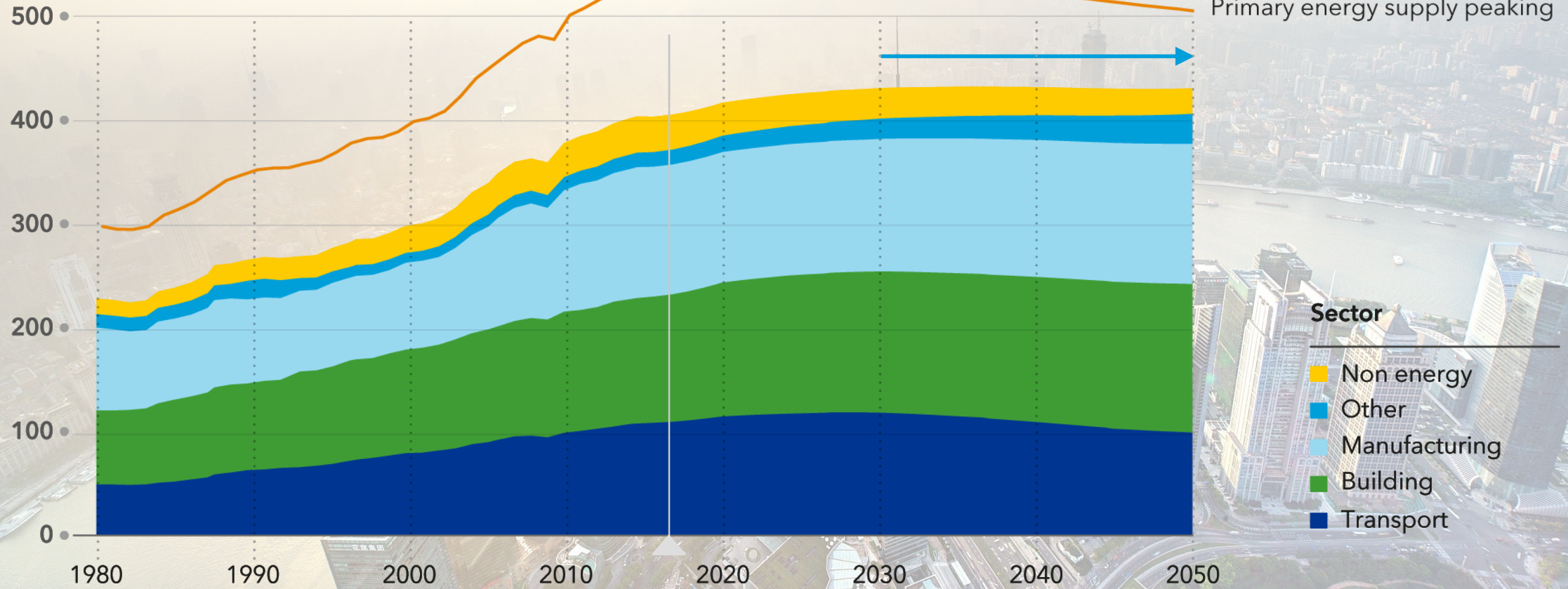
World final energy demand by sector

Units: EJ/yr



World final energy demand by sector

Units: EJ/yr



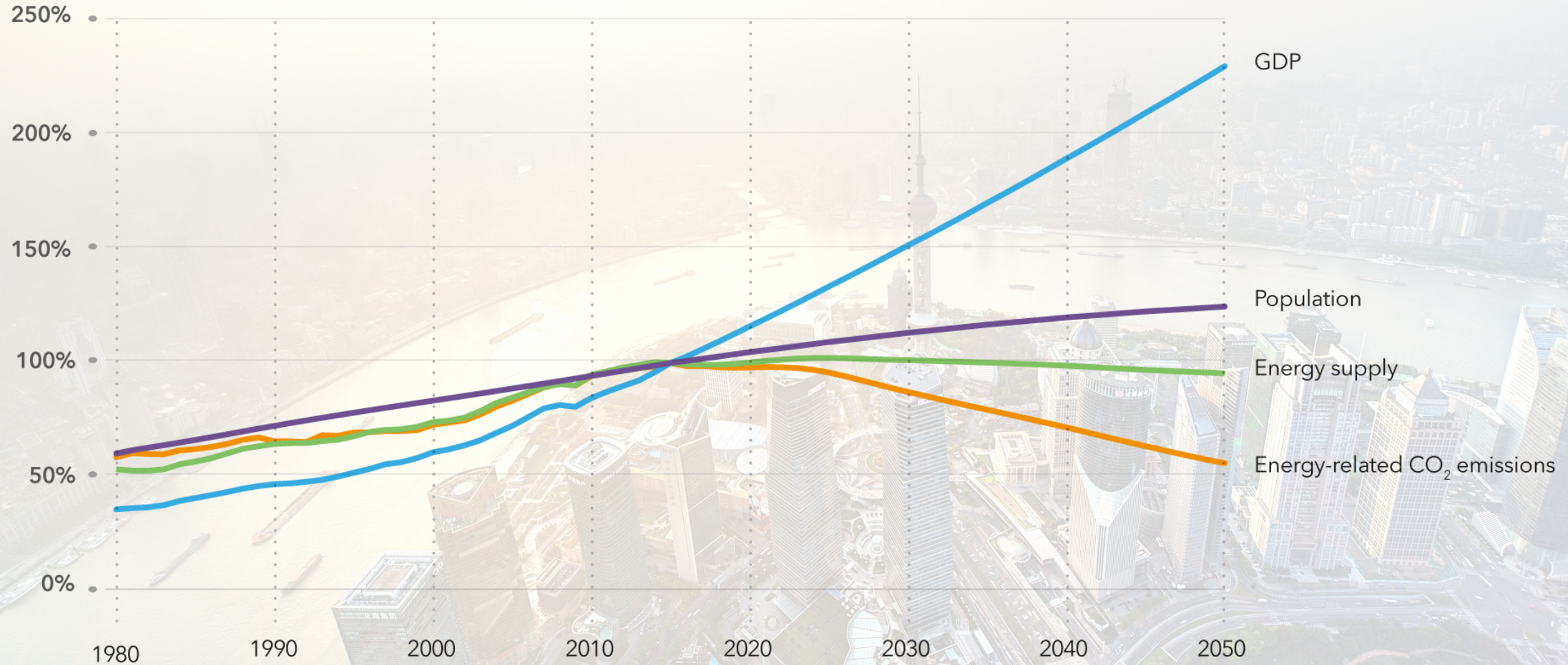
” *...humanity will start
to use less energy*



E > GDP

Economic growth vs. energy efficiency growth

Units: Percentage of 2015 level



Economic growth vs. energy efficiency growth

US Dollar generated per megajoule

2015



2050



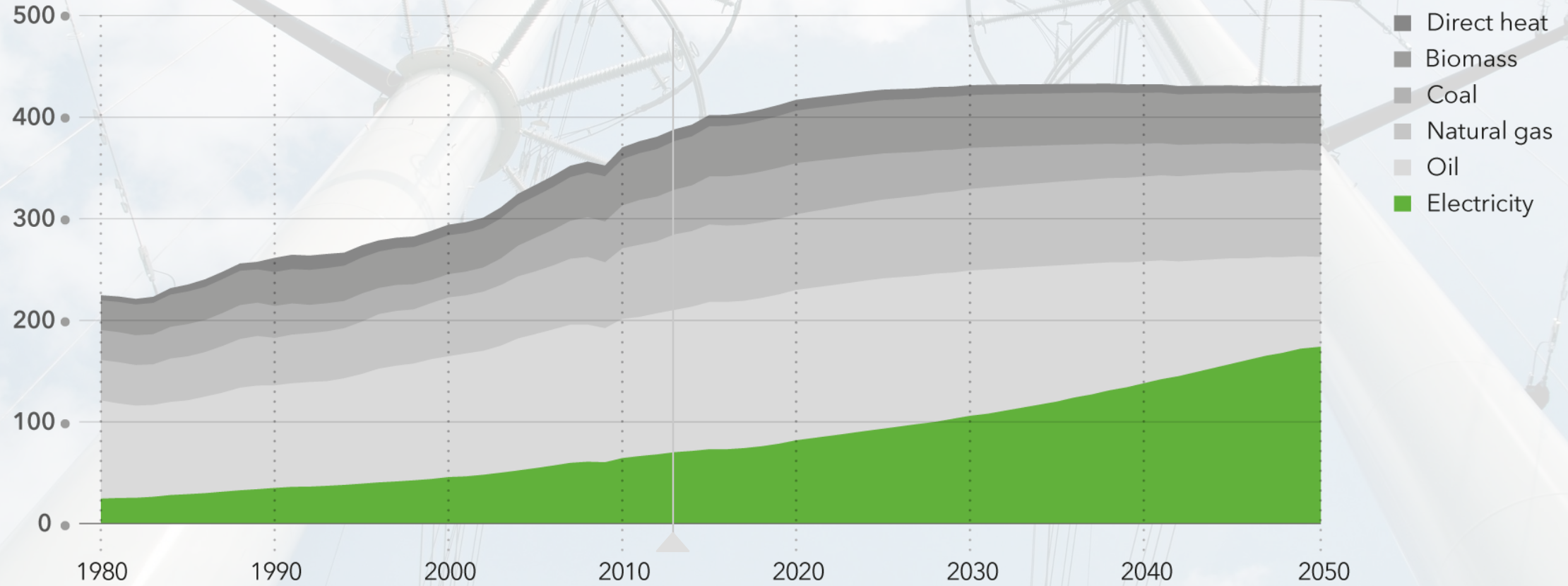
140% efficiency gain

Peak Energy Electrification Renewables



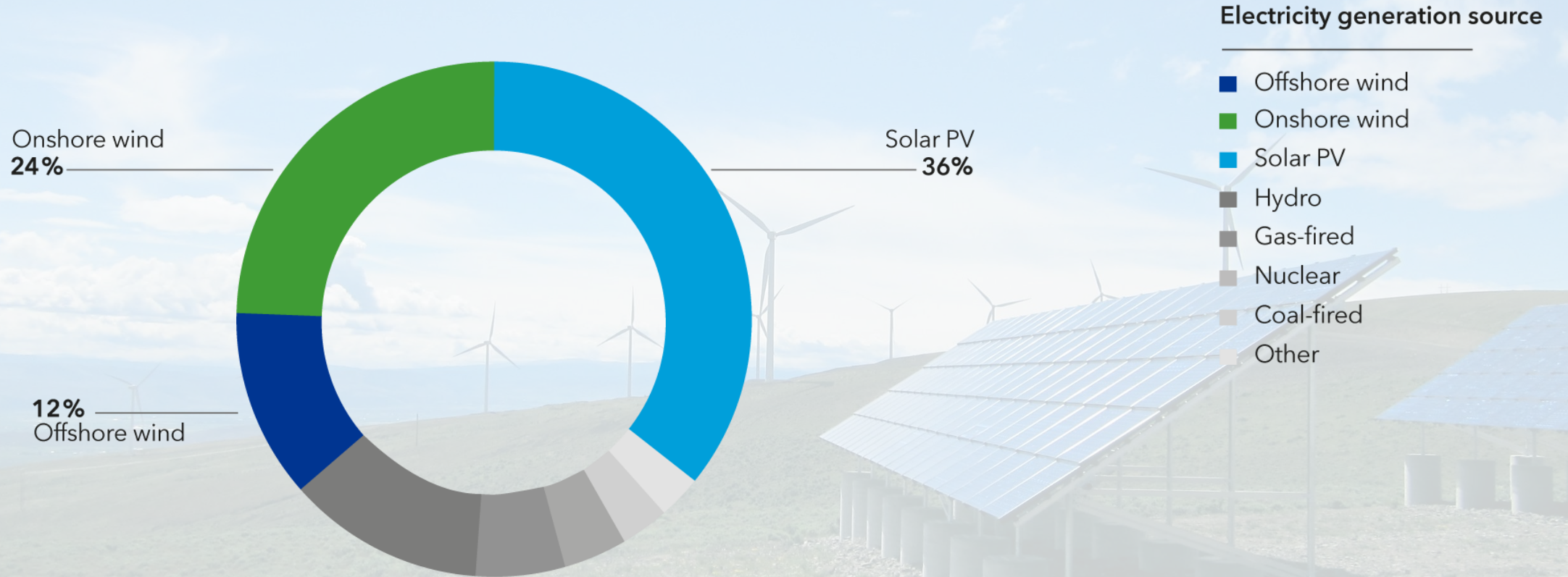
World final energy demand by energy carrier

Units: EJ/yr



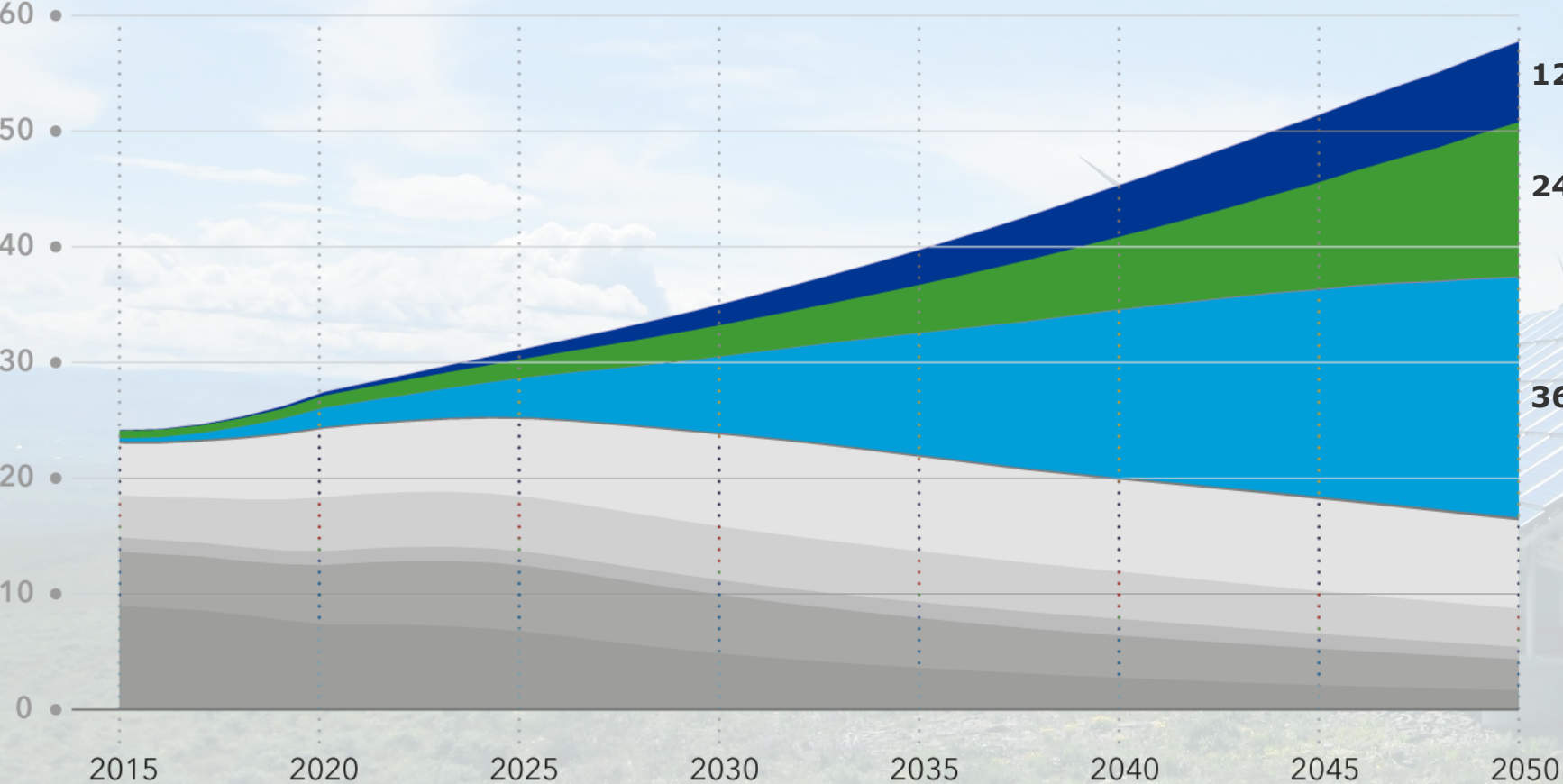


Global electricity production in 2050



Massive growth of solar and wind by 2050

Units: PWh/yr



Electricity generation source

- Offshore wind
- Onshore wind
- Solar PV
- Hydro
- Gas-fired
- Nuclear
- Coal-fired
- Other

1 NO POVERTY



2 ZERO HUNGER



3 GOOD HEALTH AND WELL-BEING



4 QUALITY EDUCATION



5 GENDER EQUALITY



6 CLEAN WATER AND SANITATION



7 AFFORDABLE AND CLEAN ENERGY



8 DECENT WORK AND ECONOMIC GROWTH



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



10 REDUCED INEQUALITIES



11 SUSTAINABLE CITIES AND COMMUNITIES



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



13 CLIMATE ACTION



14 LIFE BELOW WATER



15 LIFE ON LAND



16 PEACE AND JUSTICE STRONG INSTITUTIONS



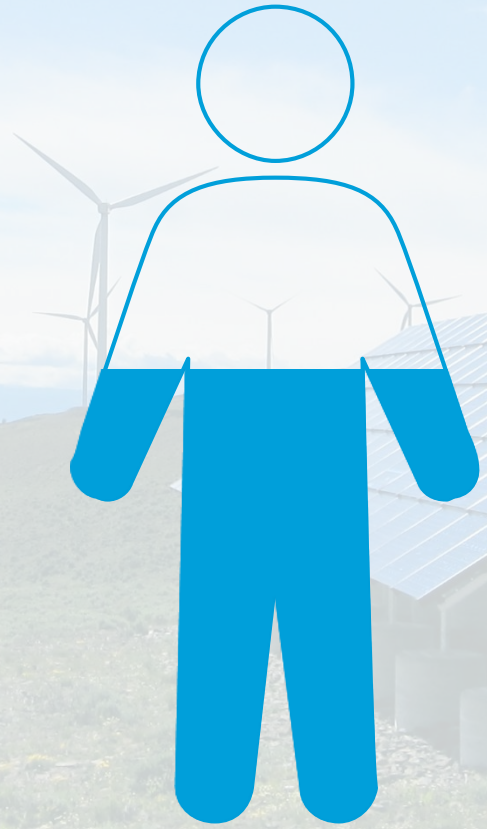
17 PARTNERSHIPS FOR THE GOALS

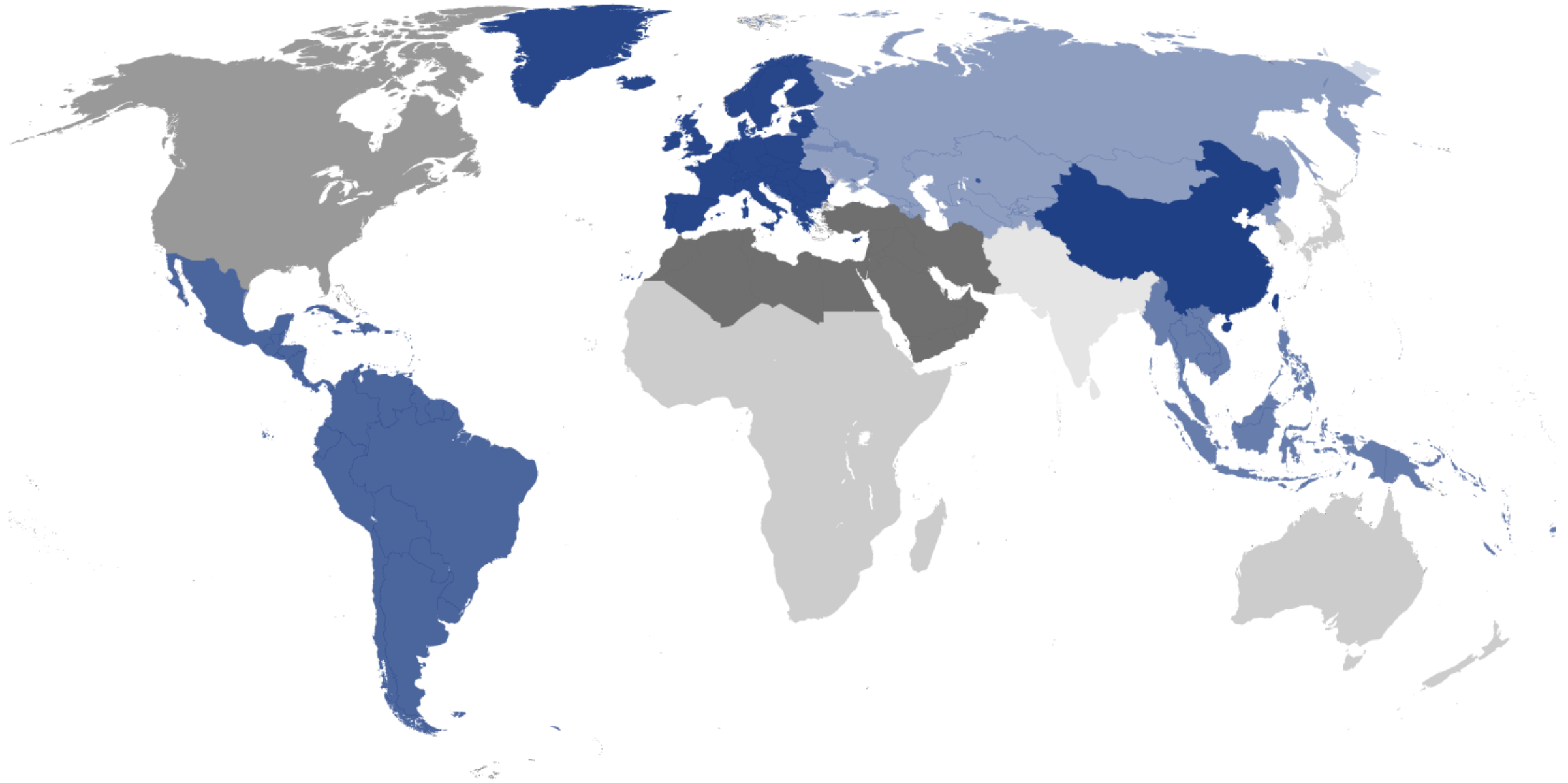


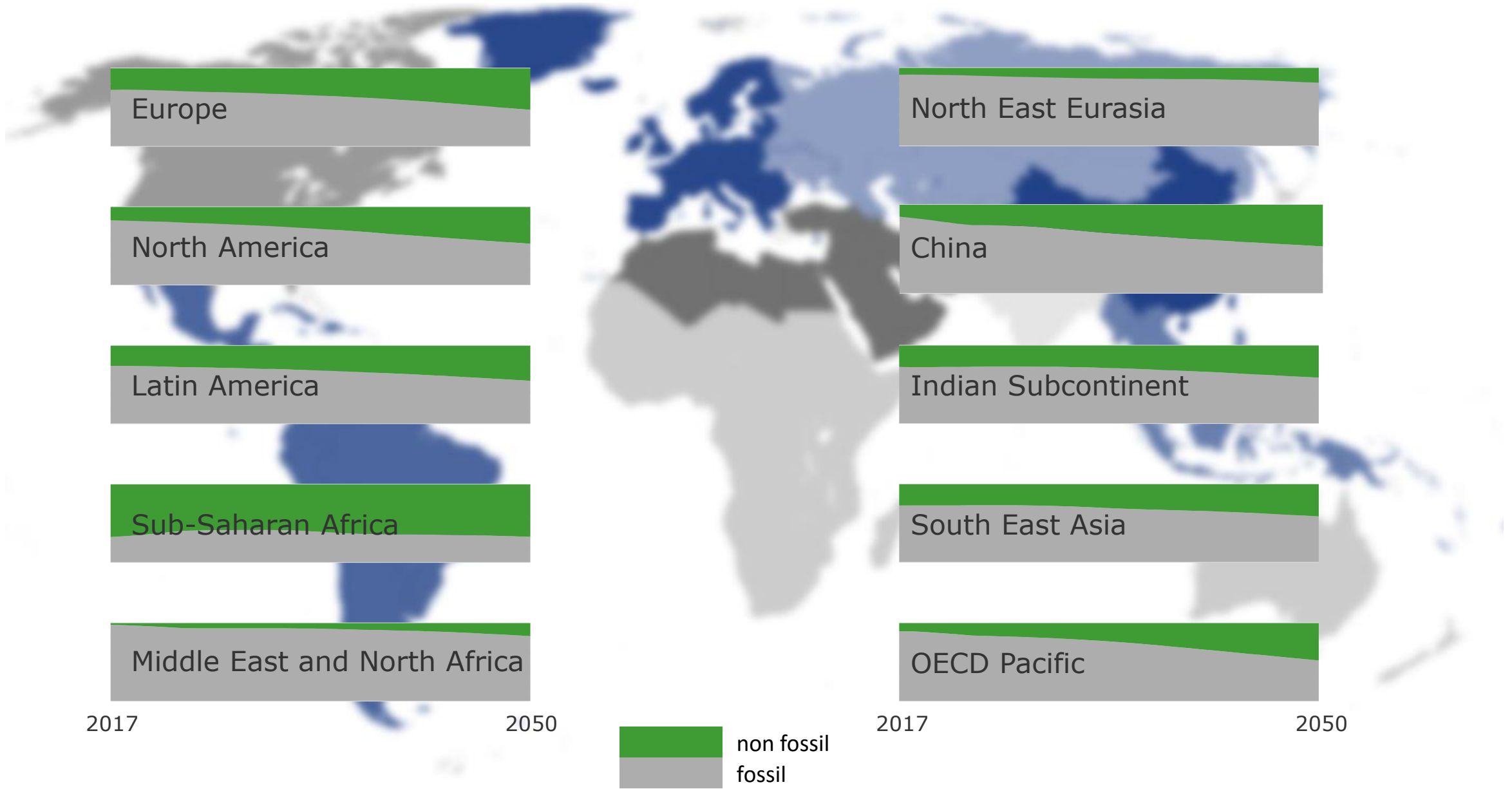
THE GLOBAL GOALS
For Sustainable Development

2015
135 GJ/year

2050
76 GJ/year







Rise of distributed generation in Singapore



Addressing the Energy Trilemma

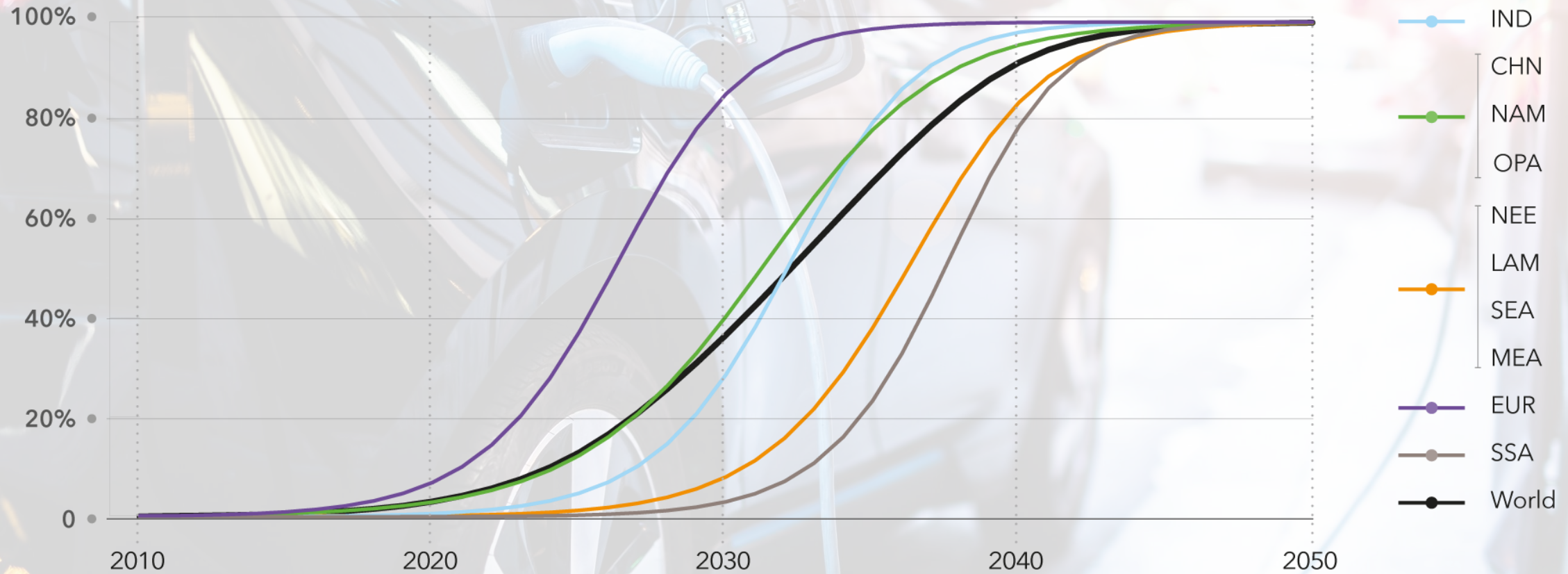






Market share of electric vehicles in new light vehicle sales

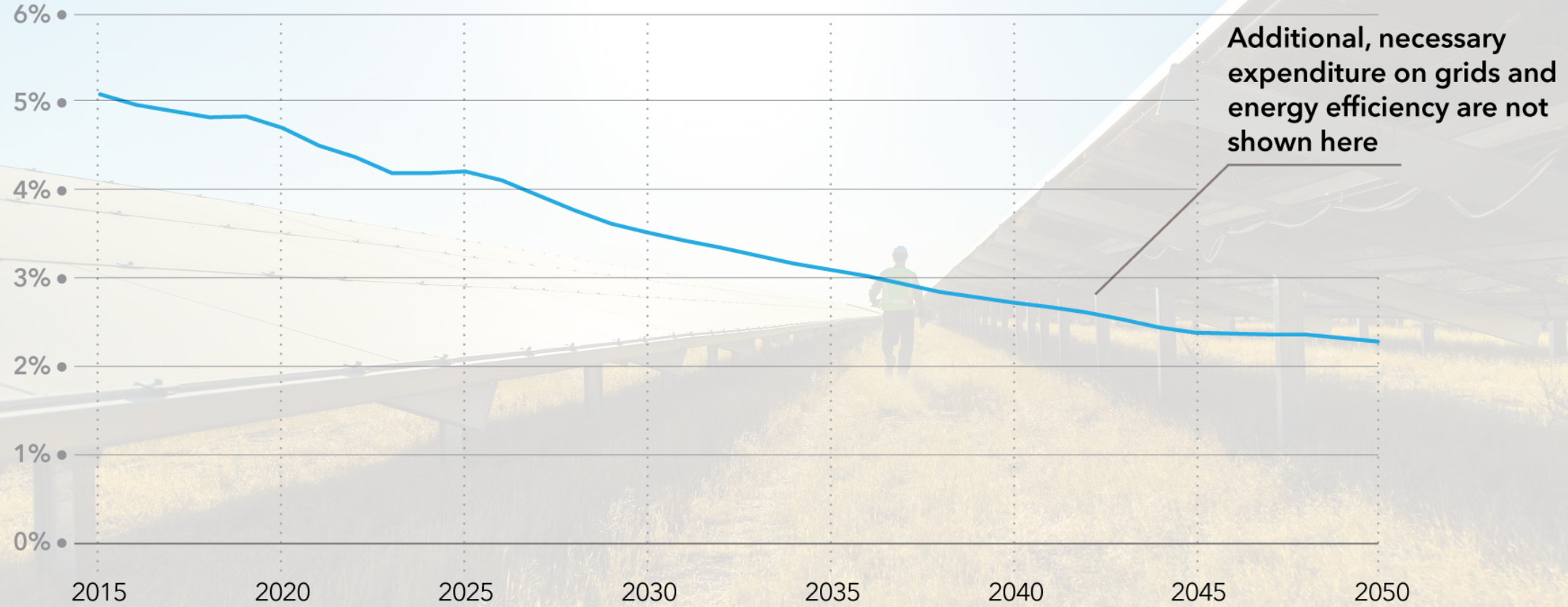
Units: Percentages



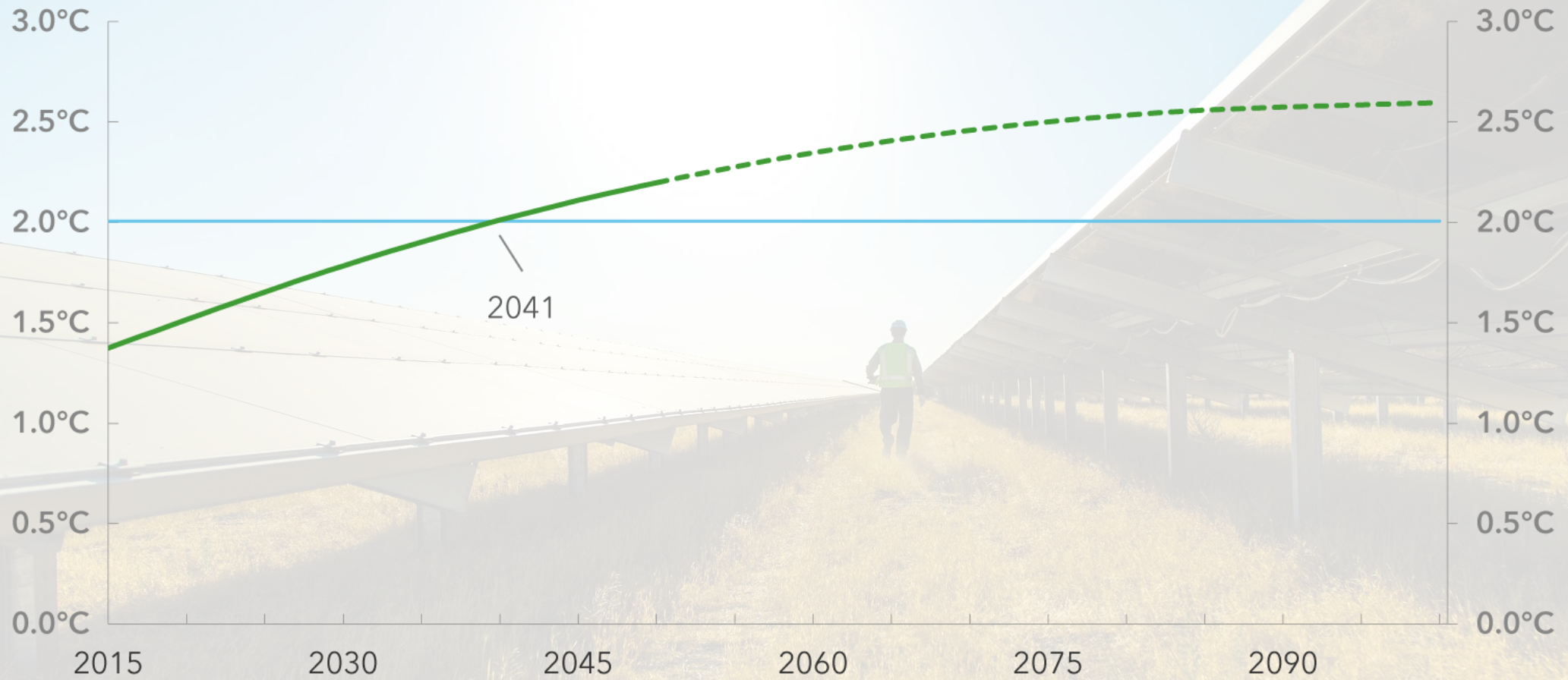


Global energy expenditure as a fraction of Global GDP


Units: Percentages



Global warming and carbon budget



DNV·GL




**RENEWABLES, POWER
AND ENERGY USE
FORECAST TO 2050**

Energy Transition Outlook 2017

SAFER, SMARTER, GREENER

DNV·GL




**OIL AND GAS
FORECAST TO 2050**

Energy Transition Outlook 2017

SAFER, SMARTER, GREENER

DNV·GL



**MARITIME
FORECAST TO 2050**

Energy Transition Outlook 2017

SAFER, SMARTER, GREENER



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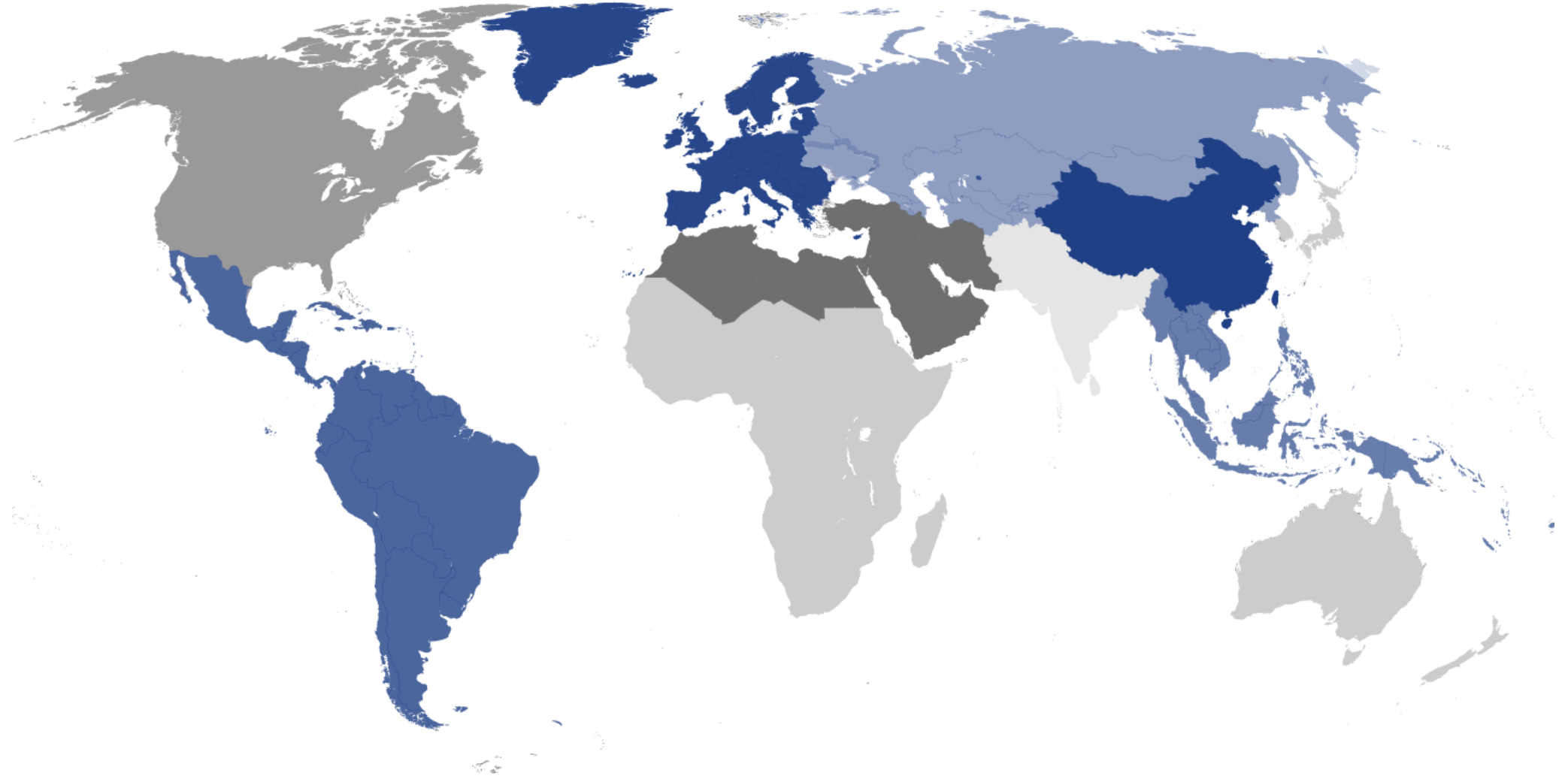
ENERGY TRANSITION OUTLOOK 2017

INSIGHTS AND IMPACT
FOR THE ENERGY SECTOR IN SOUTH-EAST ASIA

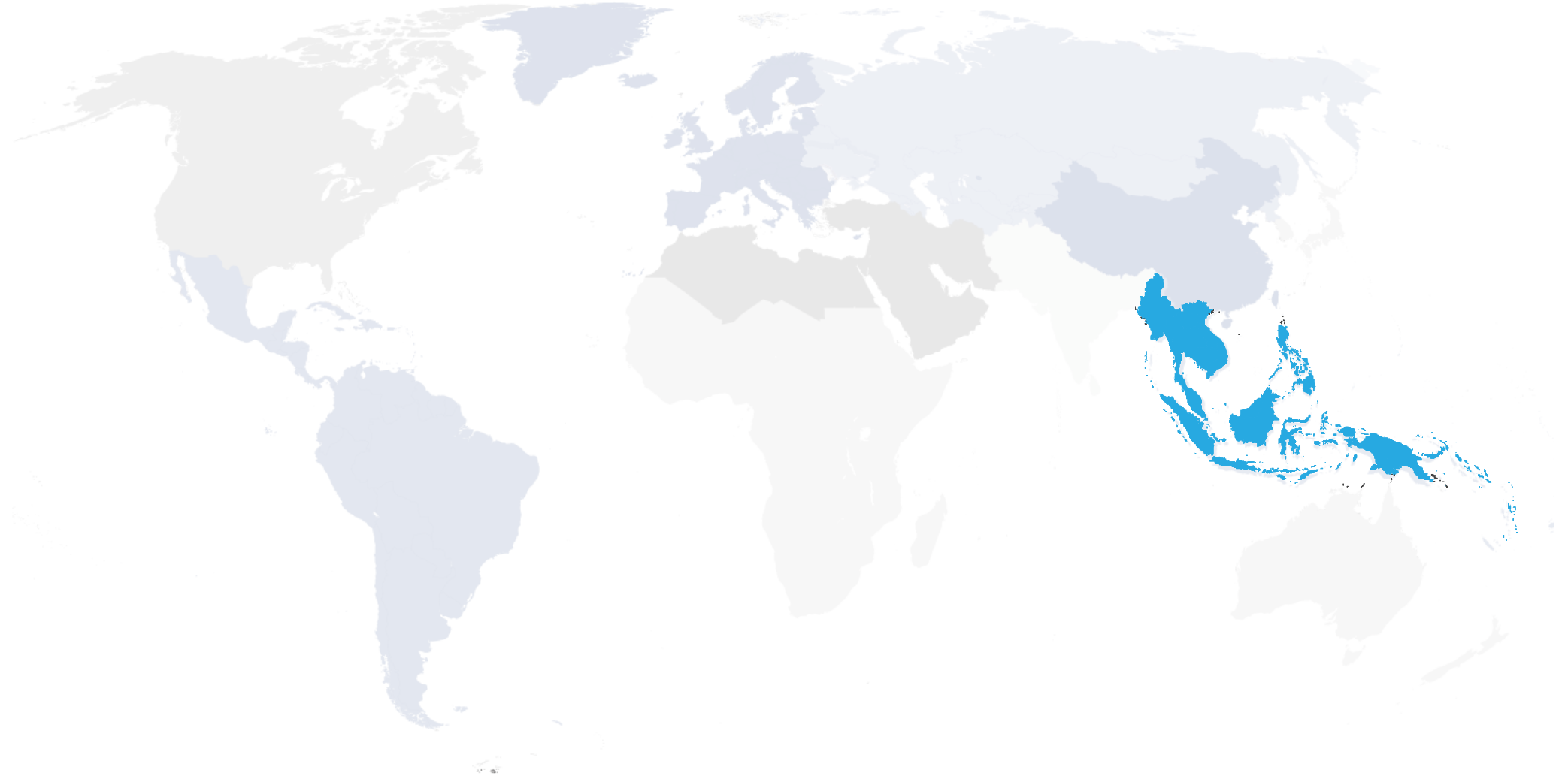
Paul Gardner
DNV GL - Energy



Global regions



South East Asia



South-East Asia region: critical characteristics

Very diverse, economically and geographically:

- stretching from Myanmar to Papua New Guinea, and including many smaller island states
- Indonesia, Thailand and the Philippines are the larger economies, while Singapore has the highest GDP per person
- It is a growth region, endowed with and using a variety of energy resources

Diverse energy characteristics:

- Indonesia, Malaysia and Brunei have a long petroleum heritage
- Coal and biomass are widely exploited for electricity generation
- Hydropower is developed, with untapped potential
- 120 million without electricity
- Mixed picture for energy & environmental targets

Energy demand is on the rise with growing GDP - and the region is a contender for becoming a new significant manufacturing hub of the world.

2015:

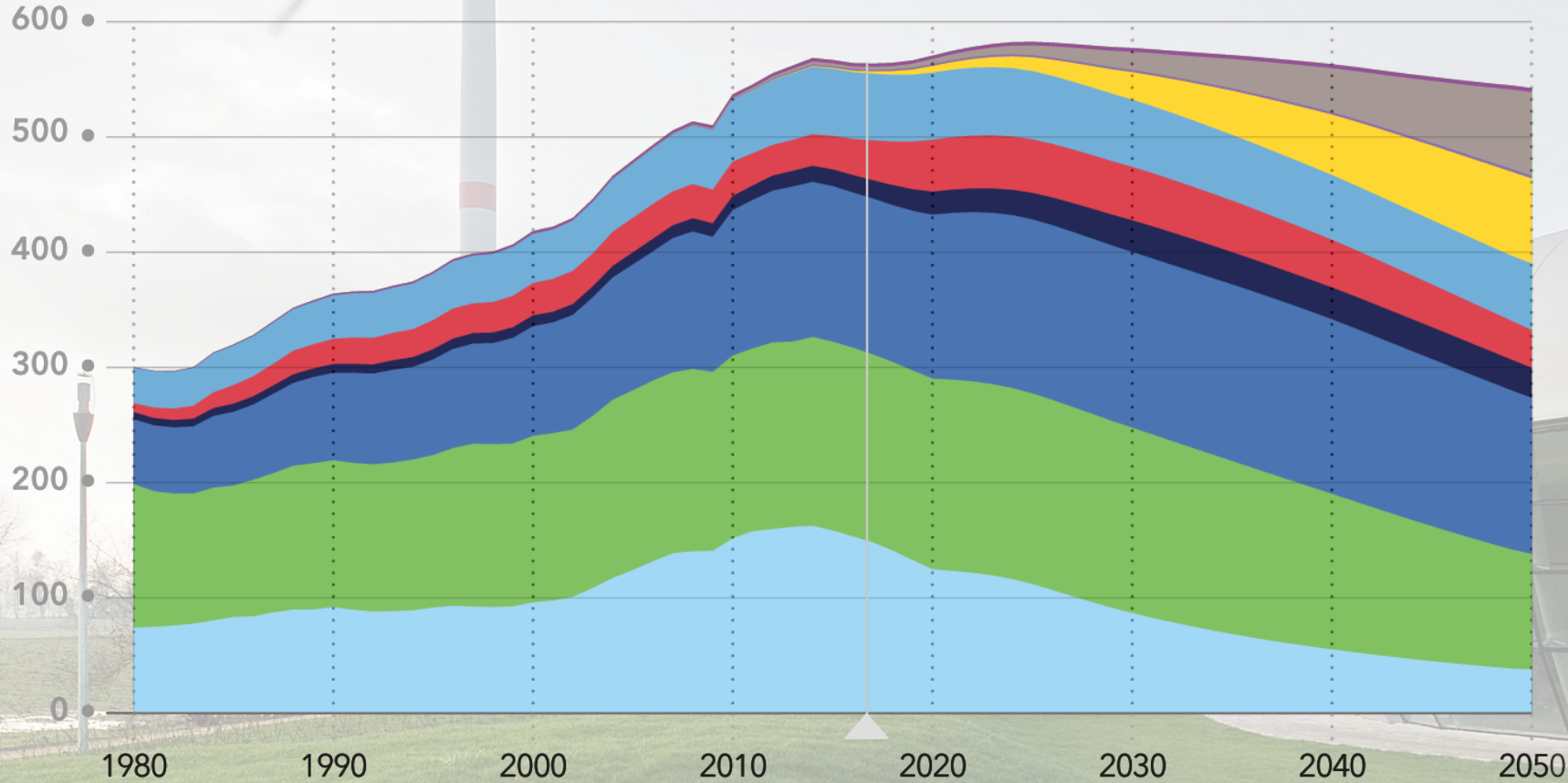
- GDP 5,700 USD per person
- Energy 39 GJ per person

2050:

- GDP 16,600 USD per person
- Energy 42 GJ per person

Forecast world primary energy supply by source

Units: EJ/yr

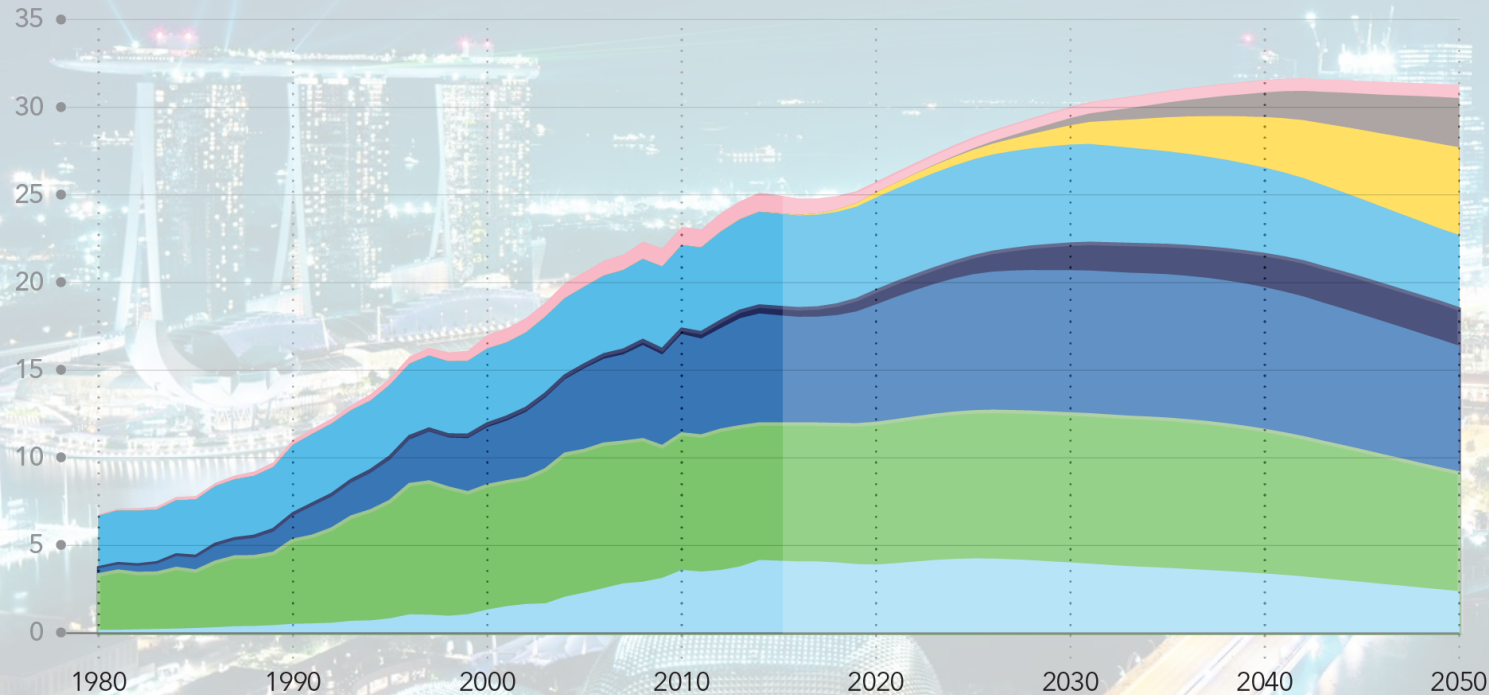


Energy source

- Geothermal
- Wind
- Solar thermal
- Solar PV
- Biomass
- Nuclear
- Hydro
- Gas
- Oil
- Coal

South-East Asia primary energy consumption by source

Units: EJ/yr



Energy source

- Geothermal
- Wind
- Solar thermal
- Solar PV
- Biomass
- Nuclear fuels
- Hydroelectric
- Natural gas
- Crude oil
- Coal

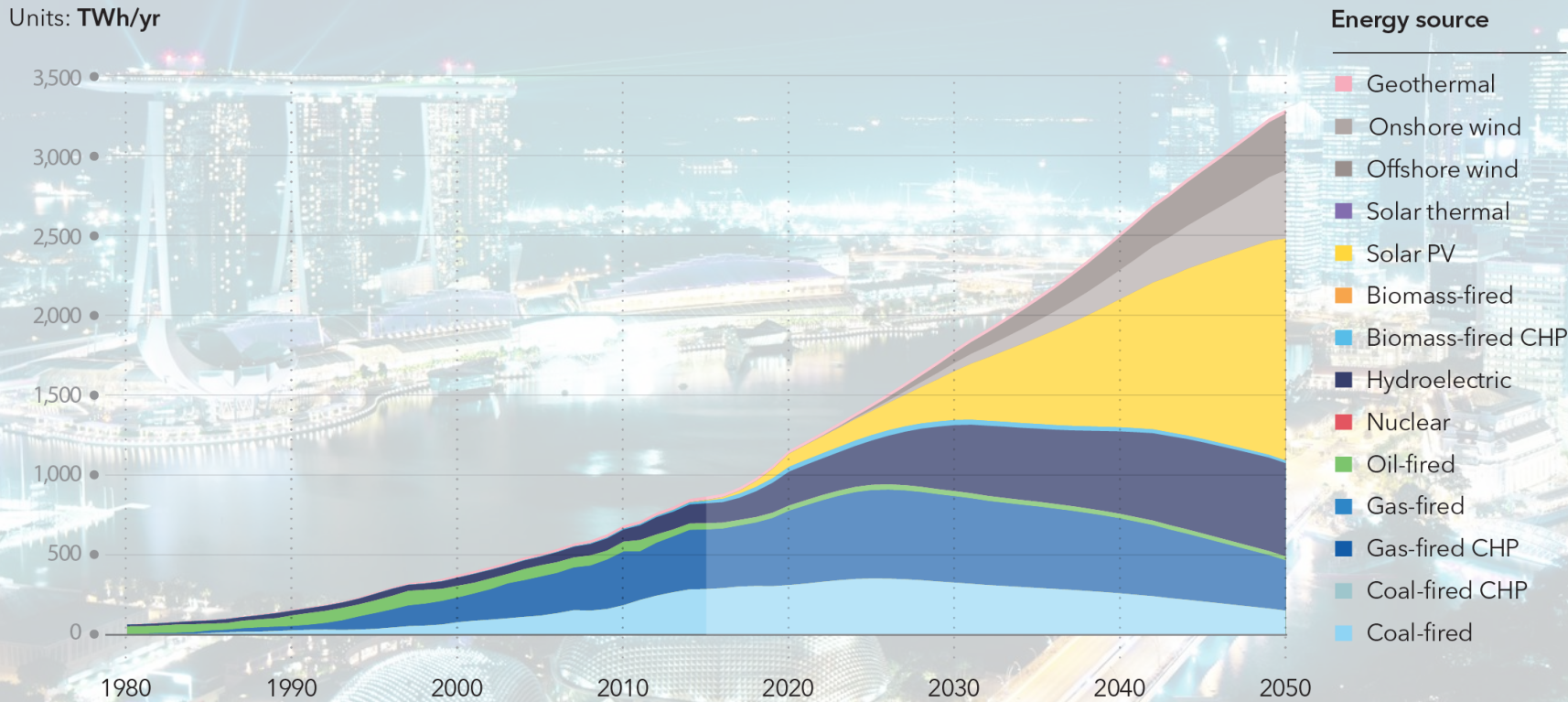
NEXT 10 YEARS

- Rising demand met mainly by gas and hydro
- Solar starts to contribute

LONGER TERM

- Coal use halves
- Oil consumption drops, but less than most other regions
- Biomass use drops due to electrification
- Wind and PV become significant
- Non-fossil sources ~45%

South-East Asia electricity generation by power station type



Significantly faster growth than experienced in the past

NEXT 10 YEARS

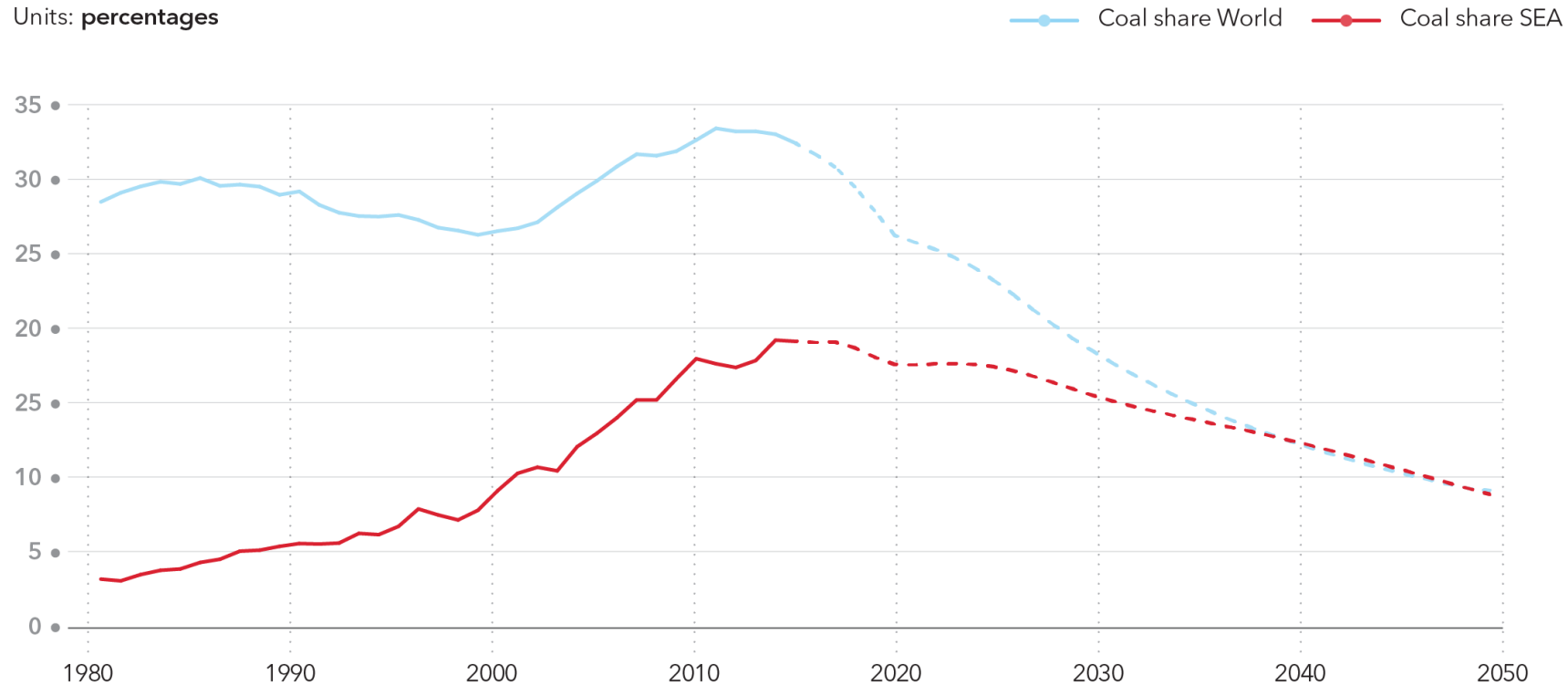
- Gas and hydro meet most of the growth
- Solar starts to contribute

LONGER TERM

- Coal and gas decline
- Massive growth in solar, 940 GW by 2050
- Hydro, onshore wind, offshore wind
- 2/3rds non-fossil

South-East Asia coal's share of total energy mix in SEA and globally

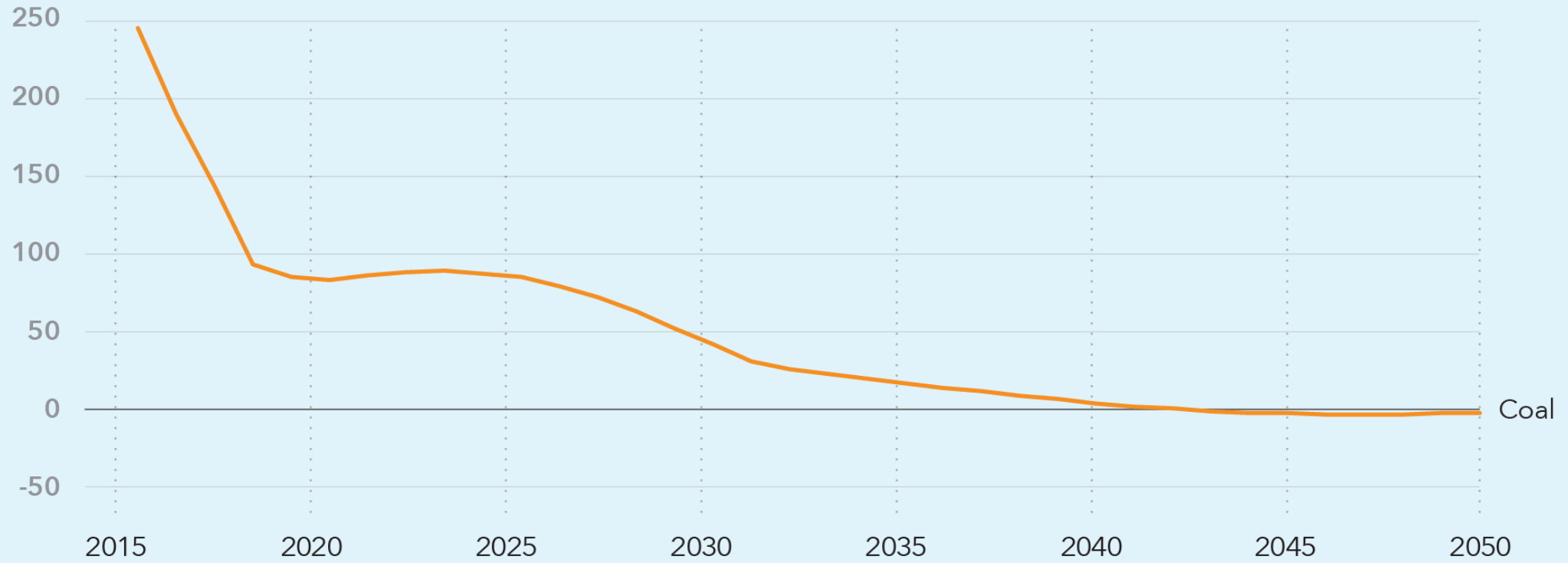
Units: percentages



- Rapid growth reverses
- Reduction not as great as global average
- Driven by reducing cost differential with PV and wind, and air quality concerns

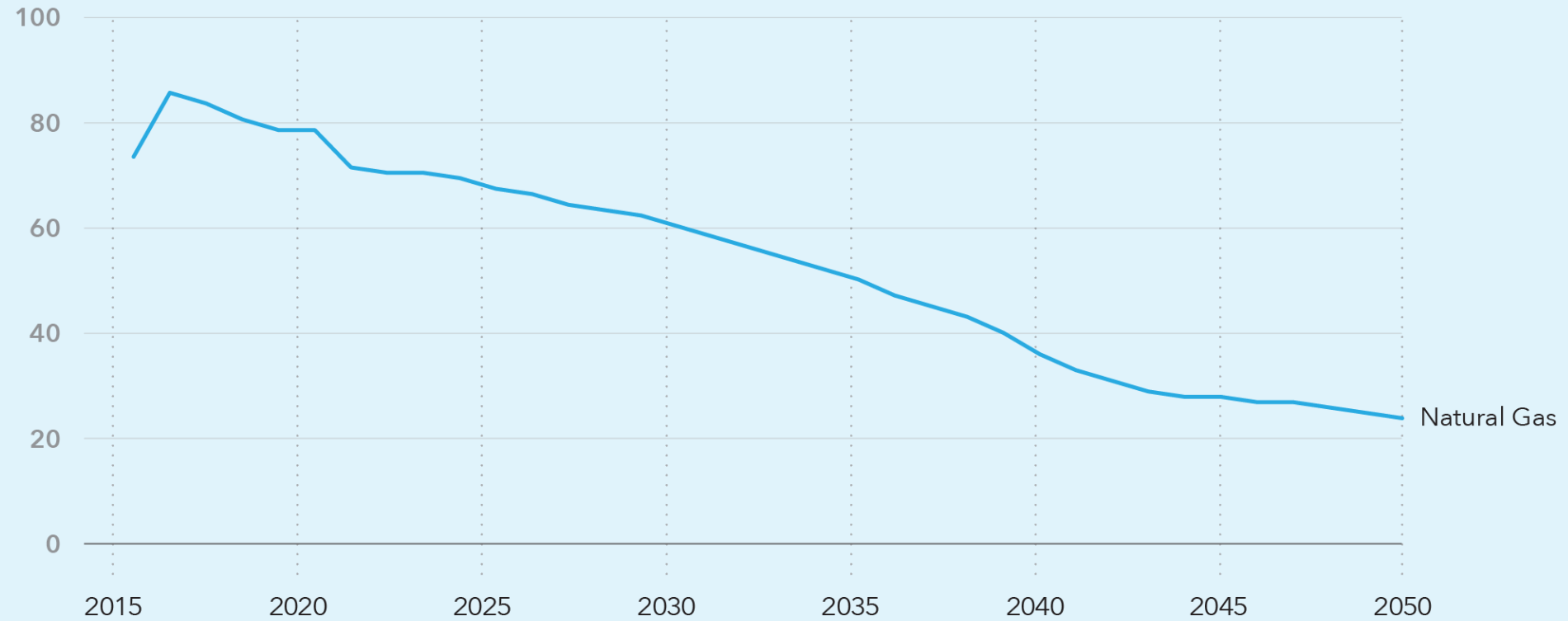
SEA Net coal exports

Units: Mtonnes/yr



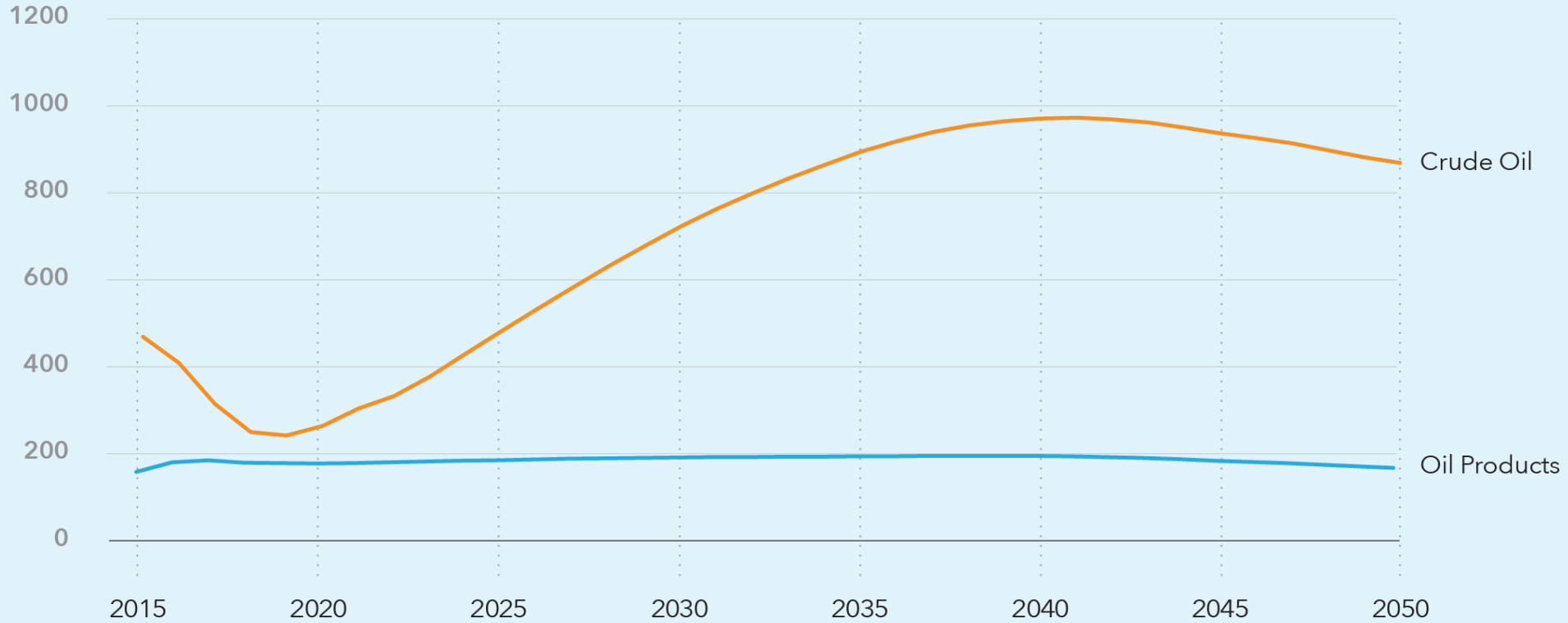
SEA Net natural gas exports

Units: Gm³/yr



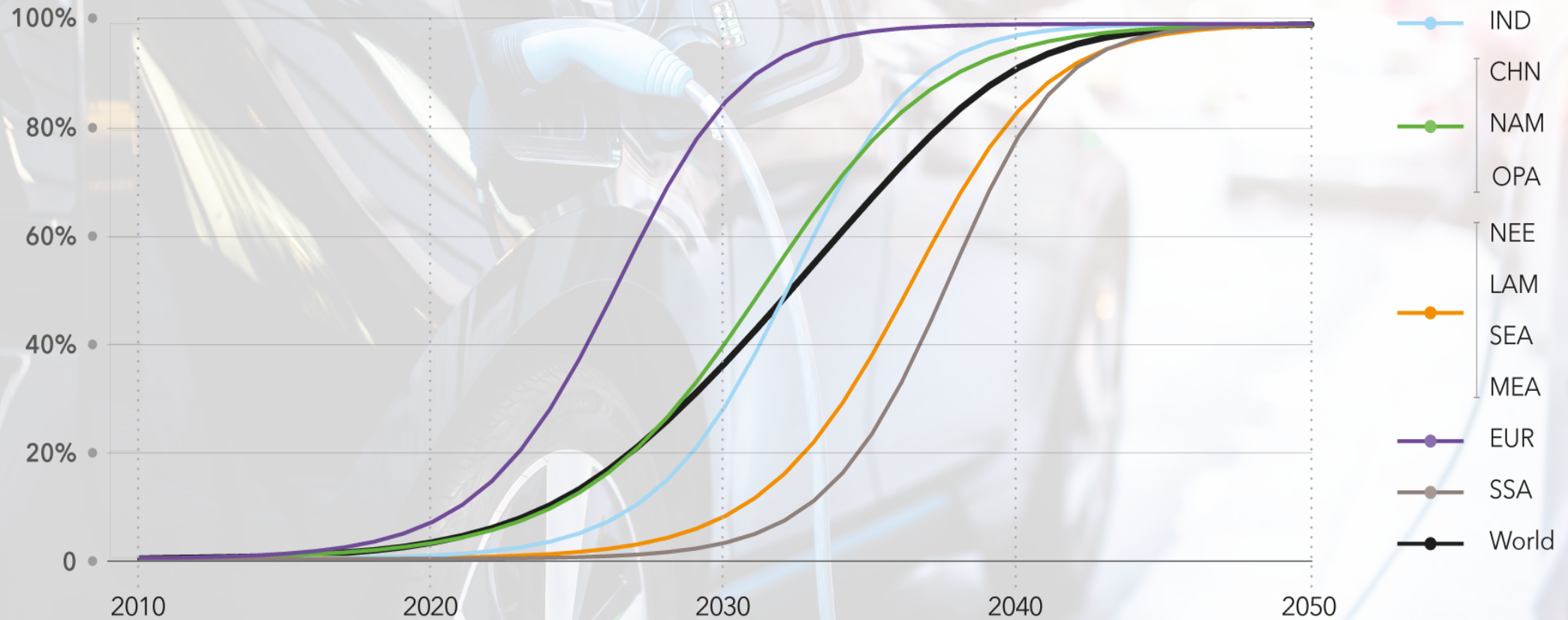
SEA Net crude oil and net oil products imports

Units: Mbb/yr



Market share of electric vehicles in new light vehicle sales

Units: Percentages



Implications for South-East Asia

Meeting growing energy demand from a rising population in expanding economies is the key priority for the countries within SEA, including 120 million people who lack access to electricity

Gas, hydro and solar make the main contributions

Rapid electrification (~2x historic rates) continuing to 2050 will challenge existing networks, and energy regulators

Rapid growth of solar PV in later years may be 'uncontrollable'

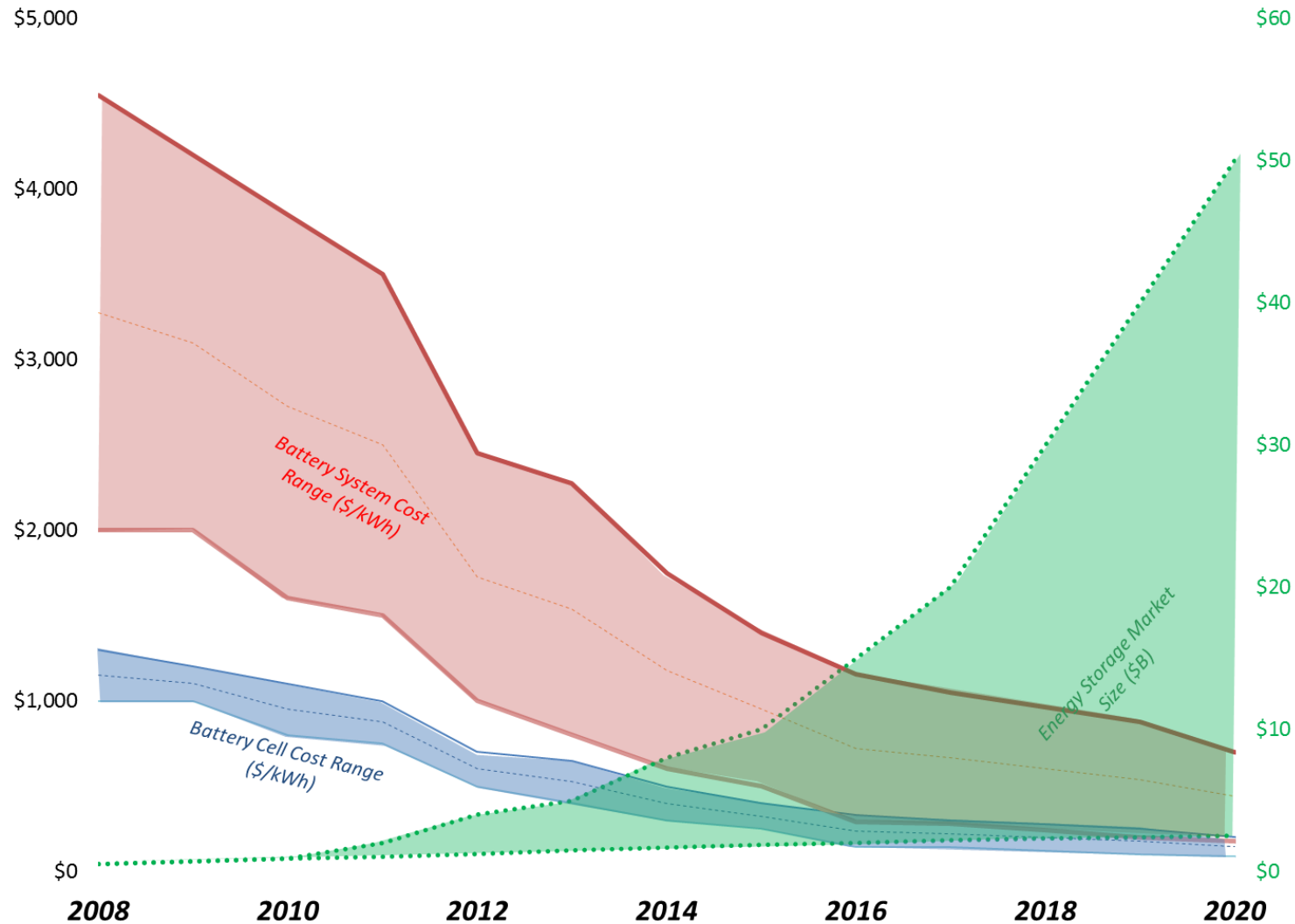
Electric vehicle growth is not forecast to be as problematic in the near-term, compared to other regions: but if this forecast is incorrect, the effect on networks could be significant

Similarly, the challenges of high fractions of variable renewables (solar and wind) will be seen later in SE Asia than in other regions: an opportunity to learn

Fossil-fuel exports decrease, and imports increase:

- regional energy security may decrease**

Coping with high fraction of variable renewables



This is real: Battery projects are being bid for < \$500/kWh installed.

A sense of perspective:

- Not as cheap as pumped hydro
 - But quicker to build
- Very expensive for seasonal storage
 - 'first world problem'?

