Lomonosov Moscow State University
Business School

Global Limits of Economic Growth

Lomonosov Moscow State University,
Inter-Departmental Course, 2023-2024, Spring Fall

Course Reader:

Evgeniya Anatolyevna Shvets, PhD.

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Requirements to Pass the Course

1) At least 50% of sessions are attended (6/12)

2) At least 60% points for the final course test

3) Individual Project (Presentation) is done properly and delivered in time

General Scheme for Resource Limitations Analysis

Scheme for the Individual Project (1-2 students per 1 project)

Resources	Steps of Analysis					
	Step 1	Step 2			Step 3	Step 4
	Role/ Importance	Limitations produced for			Ways used to overcome existing limitations	Suggestions how to improve these ways of coping with limitations
		World economy	National economy	Industries/ Business		
Unique Resource or Problem selected by you *Scale: world or a country or an industry*	...	...	...	...	...	...

Learning Schedule

- Our classes will take place on Wednesdays at 15:00 for 3 months (12 weeks)
- Communication with the course reader:
  - During classes
  - Via e-mail
  - All administrative issues should be addressed via your Personal Account in the MSU Learning Management System
- Before each session you will receive Pre-Reading and Food-for-Thought Assignment through your Personal Account

Pre-Reading and Food-for-Thought Assignment before and after Session 6 (March, 13)

RENEWABLES

1) What kind of data is presented in BP Statistical Reviews of World Energy (bp.com or https://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html) regarding renewables?
2) What are the actual trends in this area?

Read the Situation Analysis "Brazil and Biofuels"

1) What were advantages and disadvantages of producing biofuels in Brazil?
2) What kind of Measures to improve existing benefits and to reduce possible risks do you see?

Read the abstract of from Perkins J. "Confessions of an Economic Hit Man" (Chapter 33, pp.196-202):

1) What were positive and negative social and economic effects of oil dependence for Venezuela at different times?
2) How was the energy security understood by Chavez government and by multinational companies?

CHAPTER 33

Venezuela: Saved by Saddam

I had watched Venezuela for many years. It was a classic example of a country that rose from rags to riches as a result of oil. It was also a model of the turmoil oil wealth foments, of the disequilibrium between rich and poor, and of a country shamelessly exploited by the corporatocracy. It had become the epitome of a place where old-style EHMs like me converged with the new-style, corporate version.

The events I read about in the newspaper that day at Ground Zero were a direct result of the 1998 elections, when the poor and disenfranchised of Venezuela elected Hugo Chávez by a landslide as their president.[1] He immediately instituted drastic measures, taking control of the courts and other institutions and dissolving the Venezuelan Congress. He denounced the United States for its "shameless imperialism," spoke out forcefully against globalization, and introduced a hydrocarbons law that was reminiscent, even in name, to the one Jaime Roldós had brought to Ecuador shortly before his airplane went down. The law doubled the royalties charged to foreign oil companies. Then Chávez defied the traditional independence of the state-owned oil company, Petróleos de Venezuela, by replacing its top executives with people loyal to him.[2]

ILO climate change and employment

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Case study no. 1

Brazil and biofuels

February 2008

Introduction

Increasing developments in how best to address climate change – through mitigation and adaptation have in some cases led to aggressive market responses, none more so than in the rapid growth of the global biofuels industry. Analysts forecast that the global annual biofuel capacity will double to 25 billion gallons over the next five years and could reach 80 billion gallons by 2020 (Riese, 2007).

This recent boom in biofuel production is generating vigorous debate on social, economic and environmental grounds. This case study will examine the impact of climate change on livelihoods and employment, by looking at Brazil's rapidly growing biofuel industry and its impact on agriculture and poverty reduction.

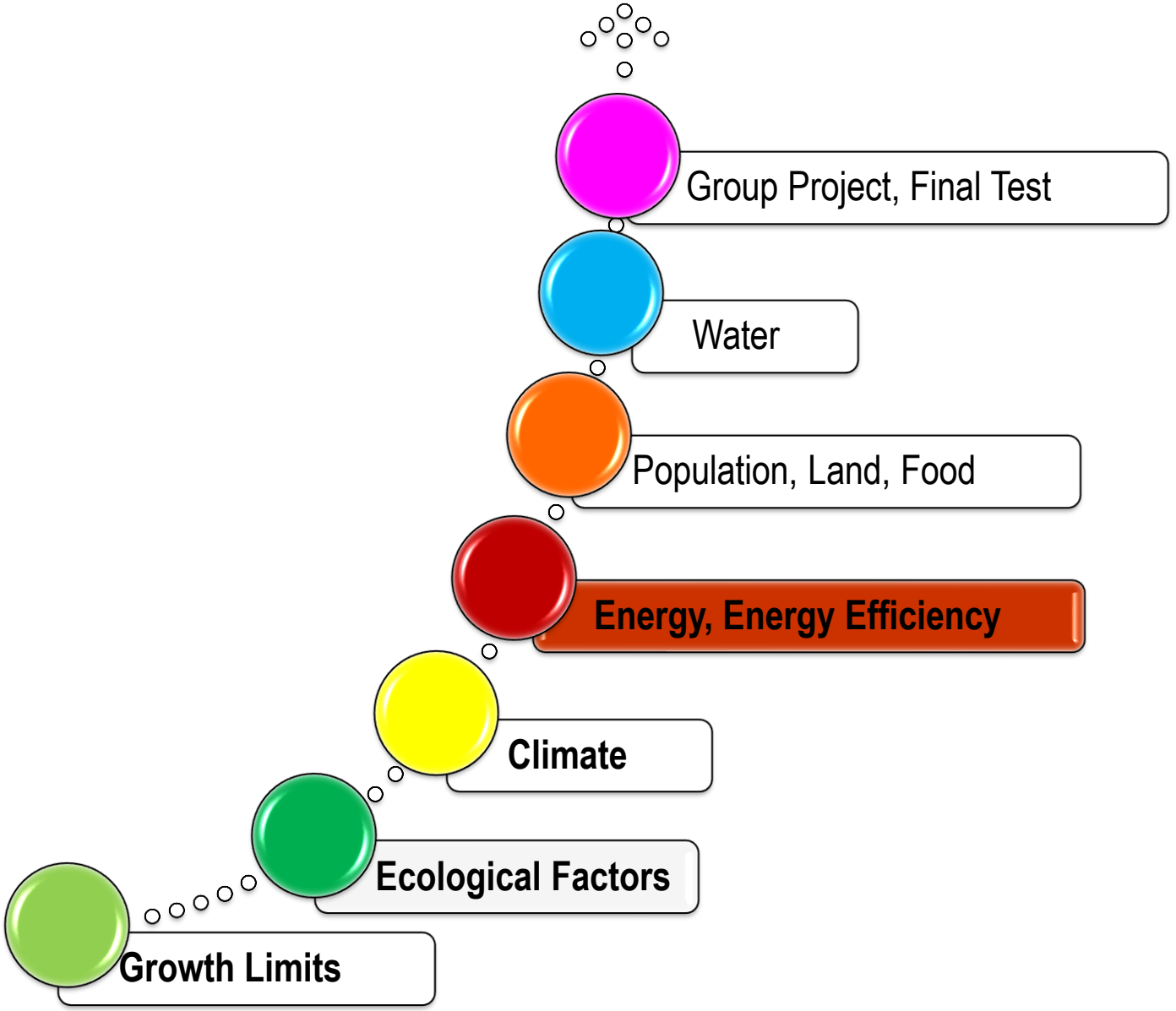
Biofuels

Global production of biofuels reached 20 million tons of oil equivalents (Mtoe) in 2005, representing about 1% of total road transport fuel energy consumption (International Energy Agency, 2007). Brazil and the United States together account for 90% (GTZ *et al*., 2006) of global supply. Ethanol production is increasing rapidly in many parts of the world due to higher oil prices, climate change, government incentives, increasing availability of flex fuel cars, and mandates on fuel blending.

Biofuels are liquid, solid or gas fuels derived from biomass, either from recently living organisms or from their metabolic waste. Biomass refers to organic matter made from plants and animals. (For an explanation of first- and second generation biofuels see Box 1.)

Brazil's ethanol experience

Course Route



Session 6

Energy Resources, Energy Security

2024

The Aims of the Session 6

1. To know peculiarities of different energy indicators and be able to interpret them correctly

2. To assess the effect of alternative energy sources comprehensively

PLAN of the Session 6

1. Energy Intensity of Different Economies and Industries

2. Alternative Energy Sources vs. Nonrenewables

3. Energy Politics, Energy Security Problem

   - International Energy Conflicts
   - Role of Multinationals Companies and Governments
   - Types of Energy Crises

Definitions of some energy terms & indicators

Energy	Electricity, fuels, steam, heat, compressed air, and other similar media.
Energy use	The manner or type of application of energy.
Energy consumption	The quantity of energy used.
Energy efficiency	Formally the ratio between energy input and energy output but usually used to mean energy performance.
Energy performance	The ratio between delivery of an output e.g. production output and energy input.
Energy conservation	Reducing energy use by reducing or stopping an energy using activity e.g. switching off a light or a machine.
Energy management	The set of processes and tools to manage energy demand within enterprises i.e. managing the process of improving energy efficiency, managing energy costs and managing energy risks.
Energy intensity	Energy use per unit of Gross Domestic Product e.g. toe/USD 1000 of GDP.
Energy productivity	Gross Domestic Product per unit of energy input – the inverse of energy intensity.

Fawkes S., Oung K., Thorpe D., (2016) Best Practices and Case Studies for Industrial Energy Efficiency Improvement – An Introduction for Policy Makers. Copenhagen Centre on Energy Efficiency.

Energy Intensity

- Energy intensity is the ratio of energy use to output.

$$\text{Energy intensity} = \frac{\text{Energy use}}{\text{Output}}$$

[MJ, Kcal, t, etc.]

[$ of GDP, $ of Gross Output, $ of Industry Production; tonnes, cubic metres, etc.]

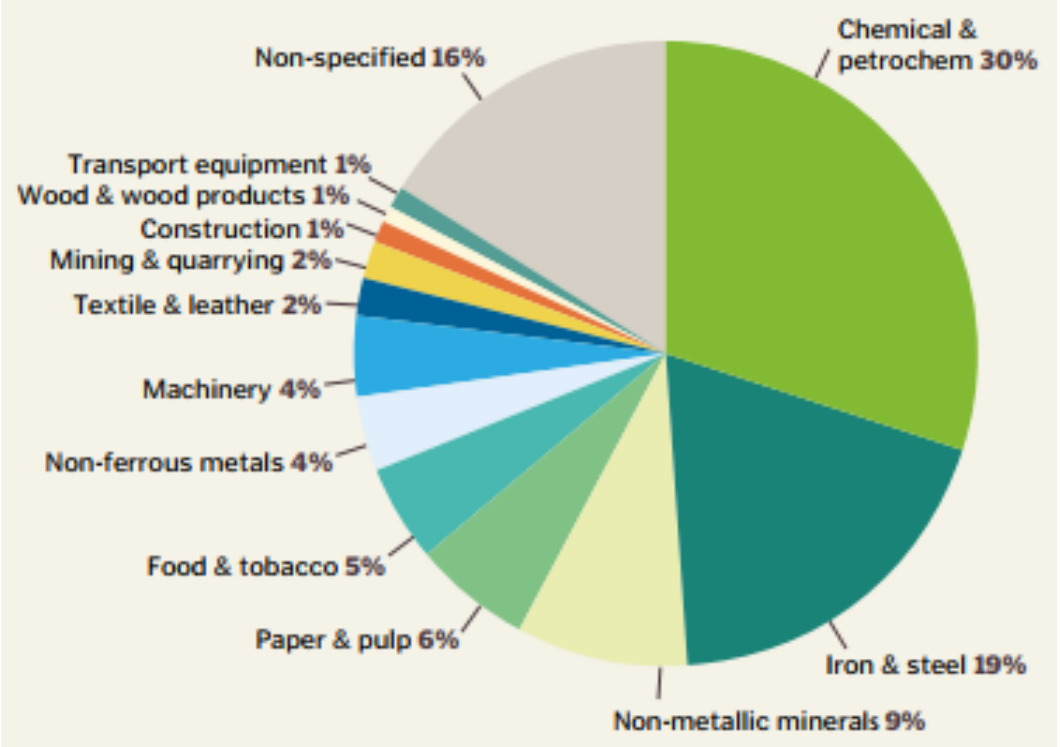
What factors influence the energy intensity of a country?

Energy Intensity of Industries

Nearly two-thirds of industrial energy use is accounted for by 4 industries:

1. *Chemical and petrochemical*
2. *Iron and steel*
3. *Non-metallic minerals*
4. *Paper and pulp*

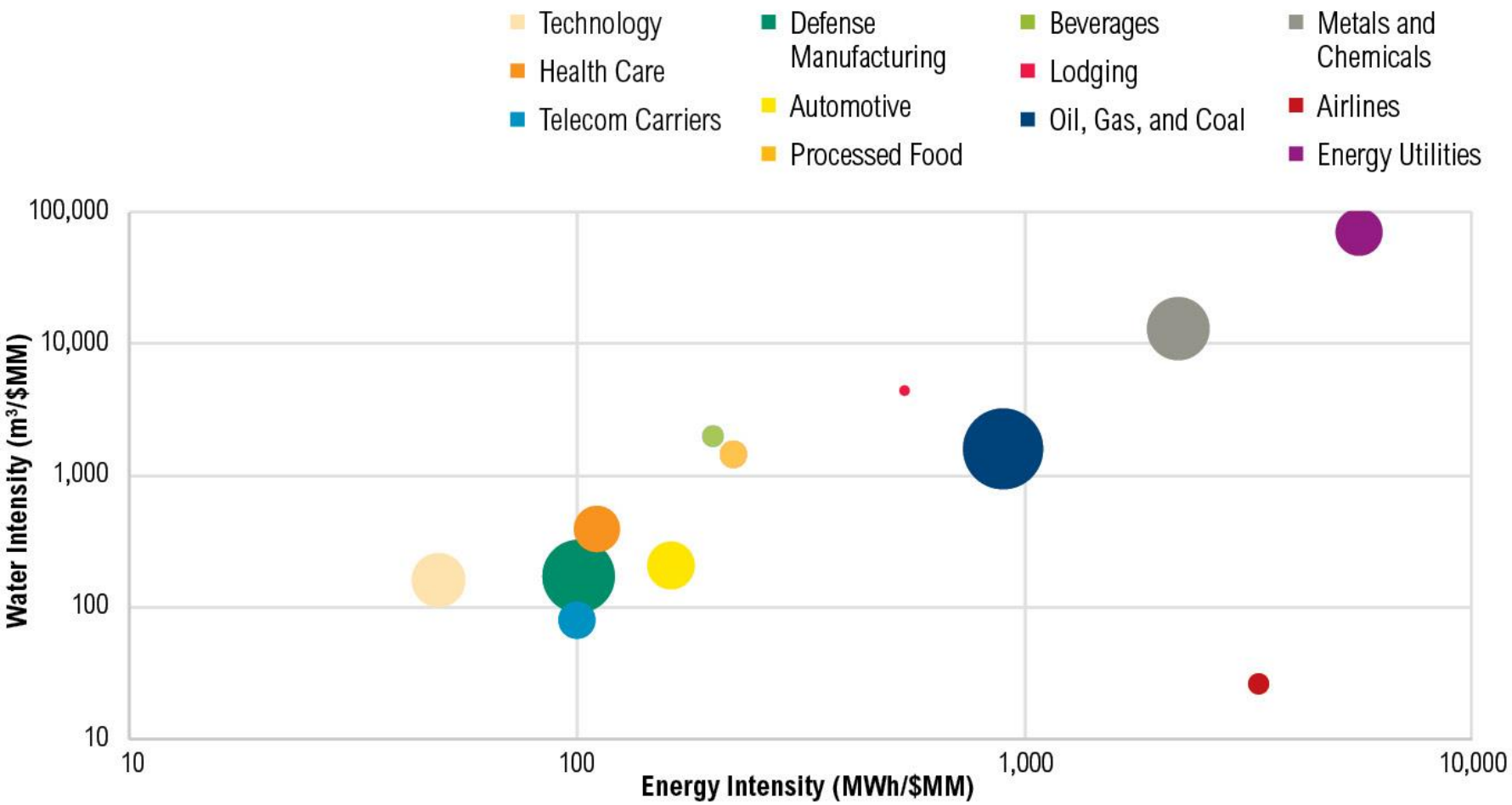
Breakdown of industrial energy use by sector 2004.



Sources:

- IEA, 2007
- Fawkes S., Oung K., Thorpe D., (2016) Best Practices and Case Studies for Industrial Energy Efficiency Improvement – An Introduction for Policy Makers. Copenhagen Centre on Energy Efficiency.

Water and Energy Intensity of Major Industries



Note: Bubble area proportional to total industry revenue.

Source: Industry data for 2013 accessed via Bloomberg Terminal (Bloomberg 2015).

www.wri.org/publication/water-energy-nexus

WORLD RESOURCES INSTITUTE

- **Energy Intensity of Countries**

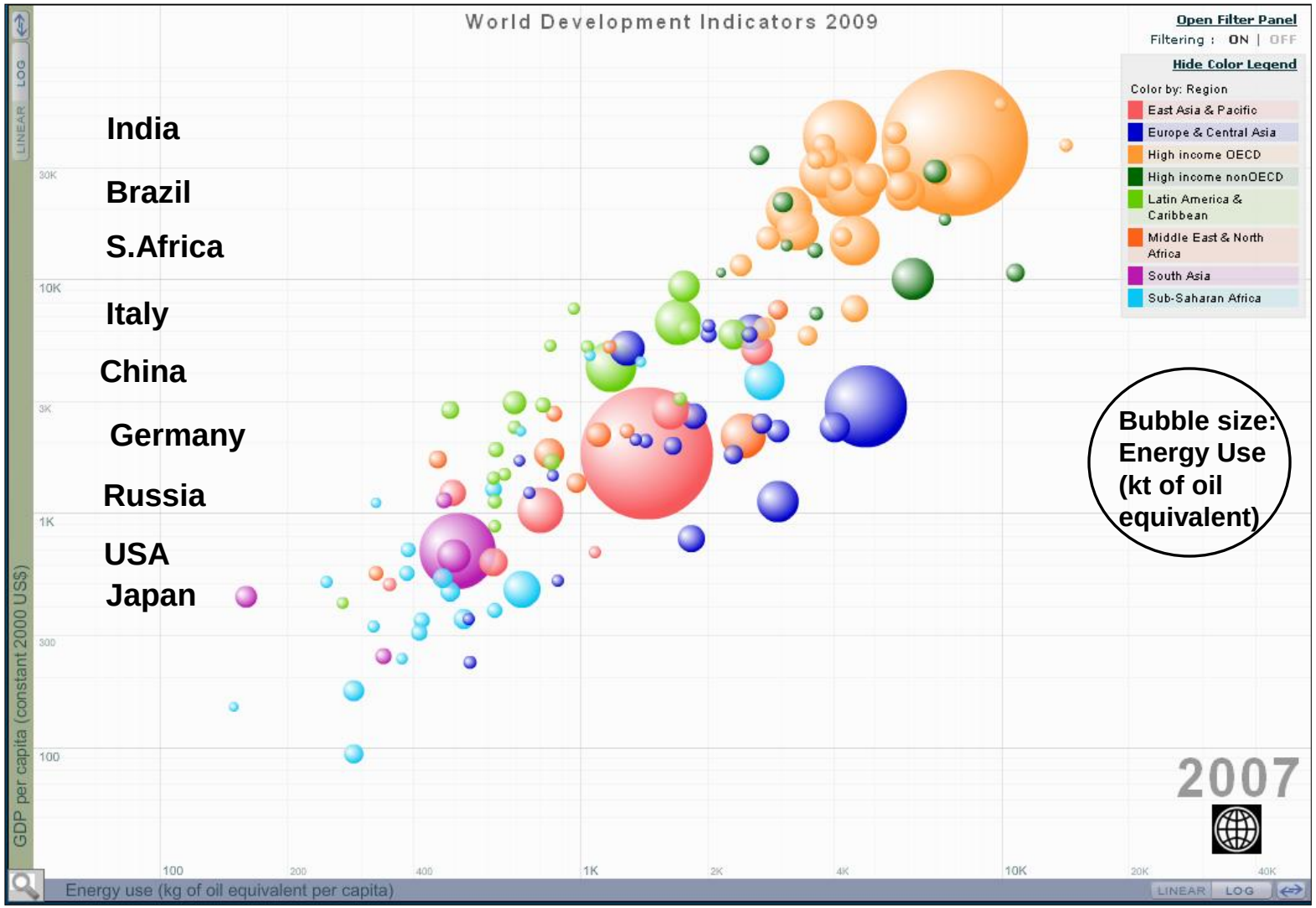
- What factors influence the energy intensity indicator of countries?

Factors influencing an economy's overall energy intensity

1. requirements for general standards of living
2. weather conditions in an economy
3. energy efficiency of appliances and buildings
4. fuel economy of vehicles
5. vehicular distances travelled (frequency of travel or larger geographical distances)
6. better methods and patterns of transportation
7. capacities and utility of mass transit
8. energy rationing or conservation efforts
9. economic shocks such as disruptions of energy due to natural disasters, wars, massive power outages
10. unexpected new energy sources
11. efficient uses of energy
12. energy subsidies

The list is not complete still!

Energy Intensity of Different Economies (colour by region)

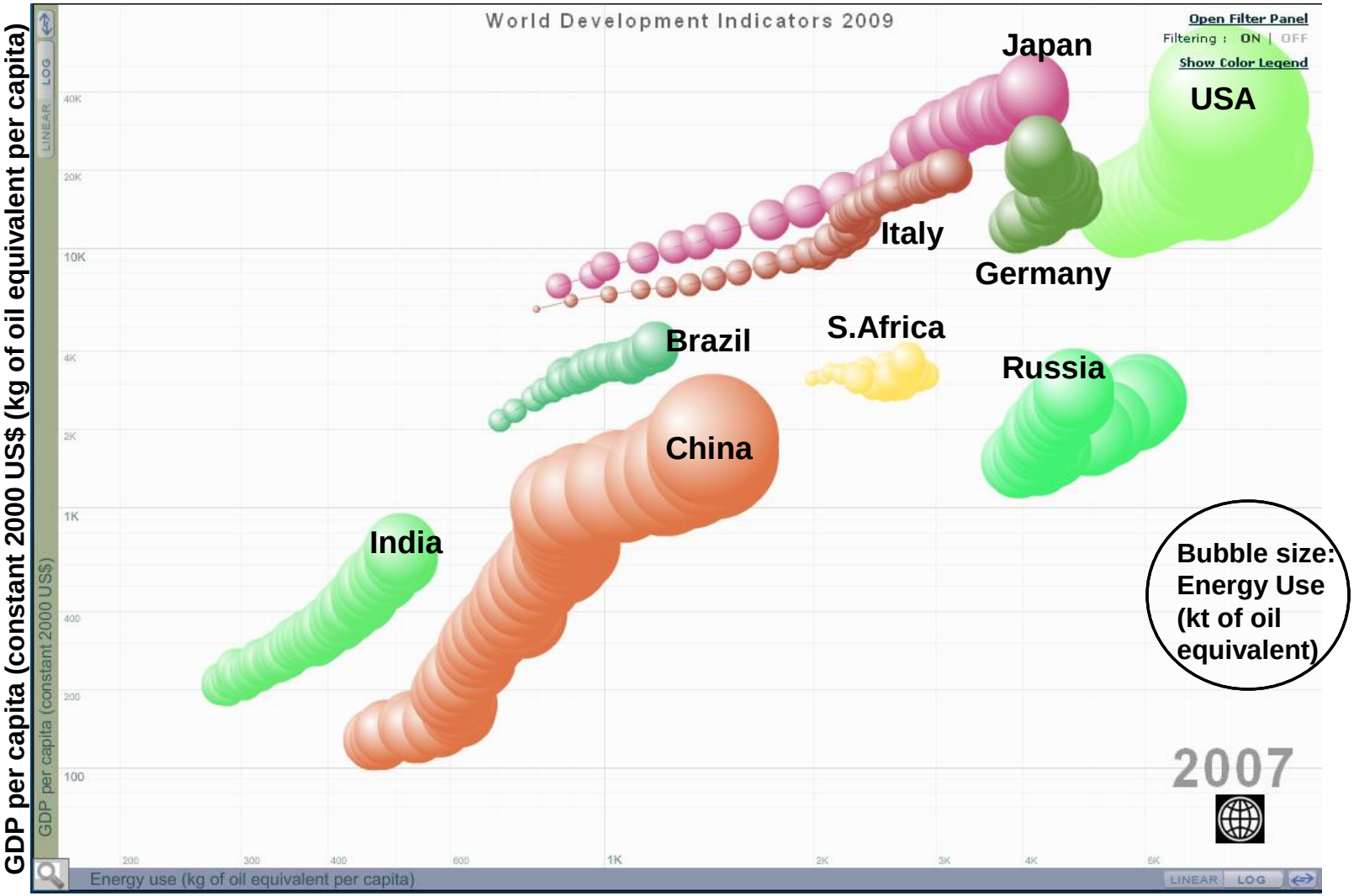


GDP per capita (constant 2000 US$ (kg of oil equivalent per capita)

Energy use (kg of oil equivalent per capita)

Source: World Bank Data Visualizer, http://devdata.worldbank.org/DataVisualizer/

Energy Intensity of Different Economies in Dynamics (1960- 2007)



Energy use (kg of oil equivalent per capita)

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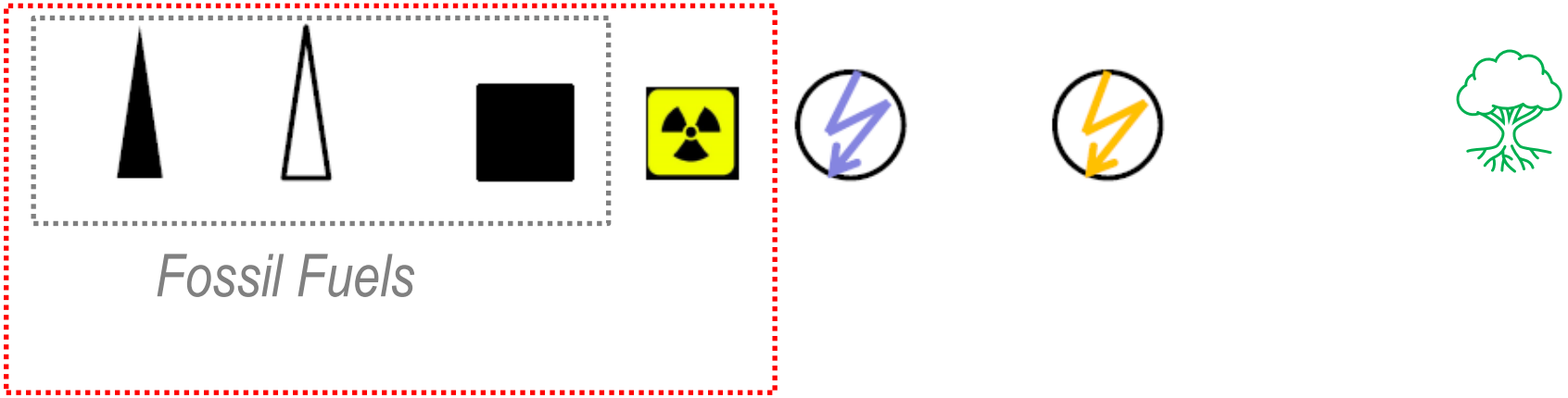
Renewable Energy

World Market of Energy Resources

- Primary energy sources
  - Oil, natural gas, coal, nuclear, hydro and geothermal power, biomass



World Market of Energy Resources

- Primary energy sources
  - Oil, natural gas, coal, nuclear, hydro and geothermal power, biomass

- Secondary energy sources
  - Electricity, such renewables as wind and solar power, different derivatives from oil like fuel oil, kerosene etc.

Alternative Energy ≈ Renewables

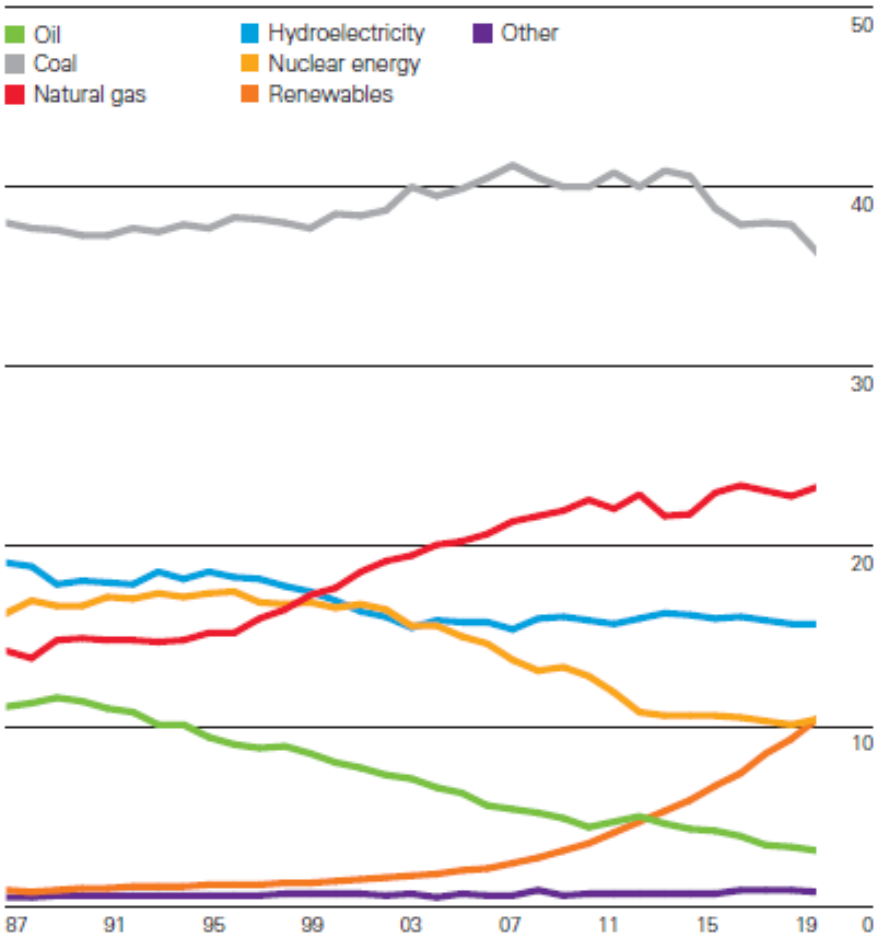
- 6 main renewable energy technologies:
  1) wind power
  2) solar energy
  3) biomass energy
  4) biofuels
  5) geothermal energy
  6) hydroelectric power
- Nuclear energy

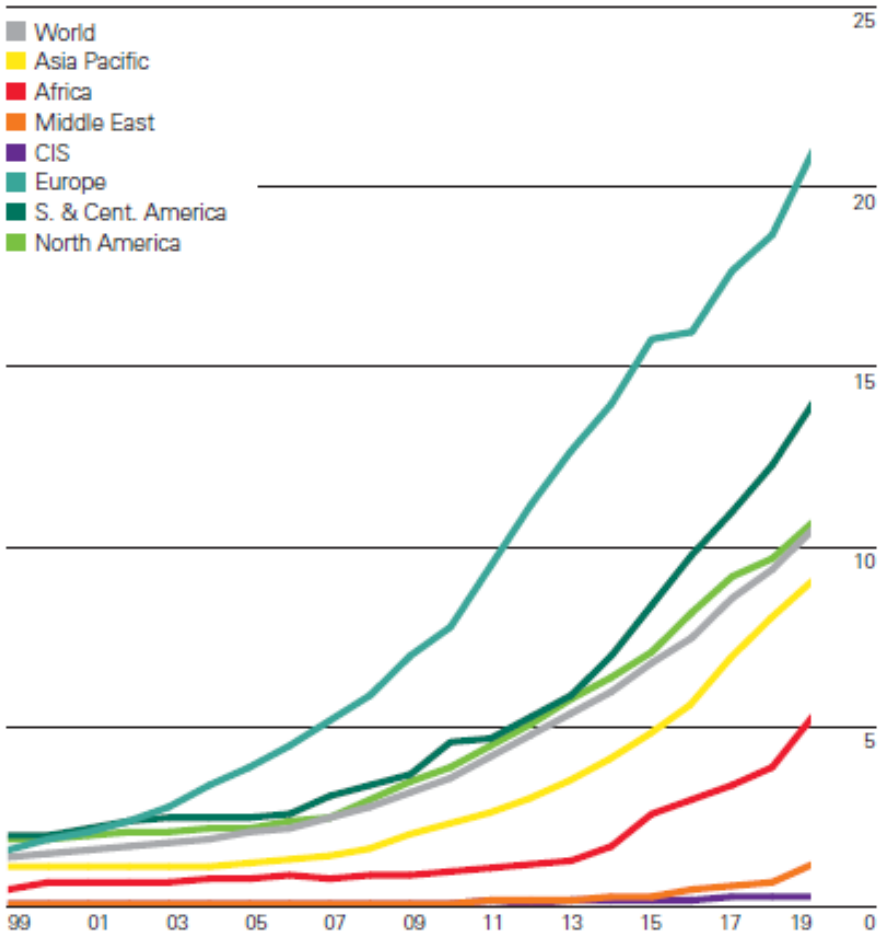
All of them faced unique economic challenges that made it difficult for them to compete with energy generated by traditional fossil fuels.

Nowadays the situation is changing.

Global Trends in Energy Use

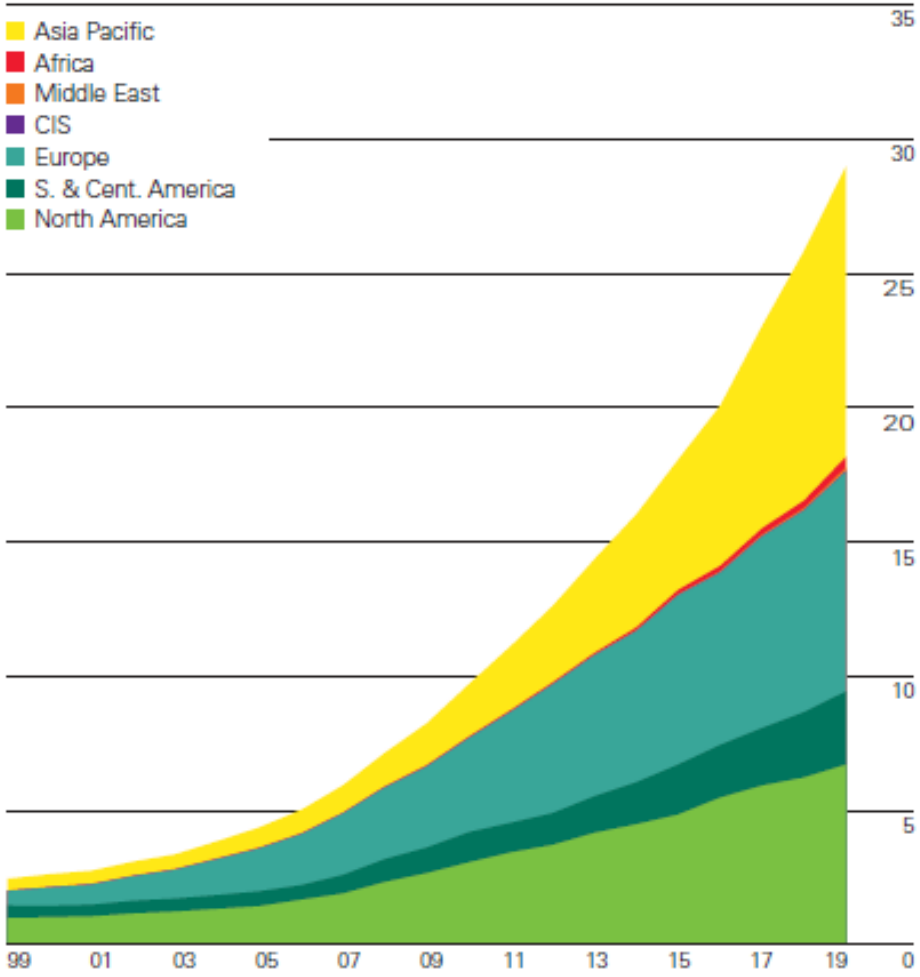
- Renewables are the fastest growing energy source (but from a relatively small base)





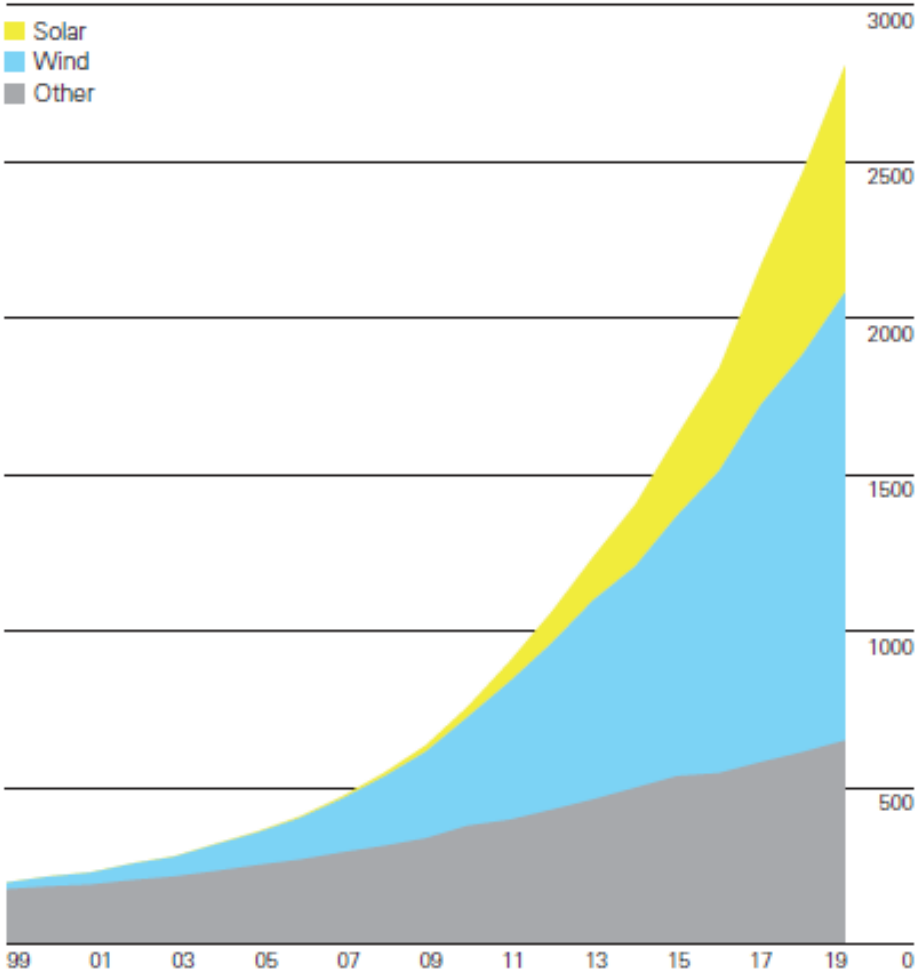
Renewables consumption by region

Exajoules



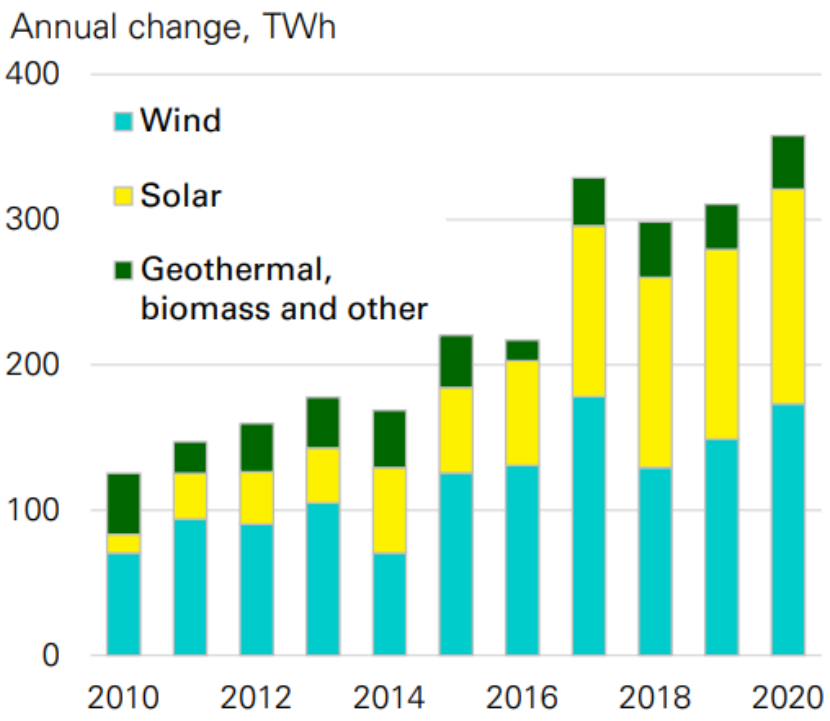
Renewables generation by source

Terawatt-hours

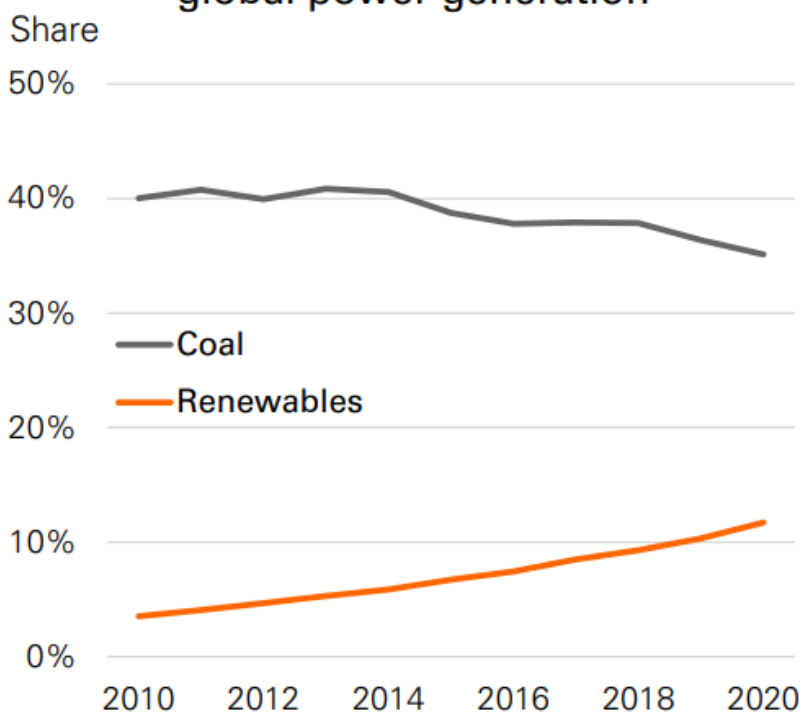


Power generation

Renewable power generation



Share of renewables and coal in global power generation



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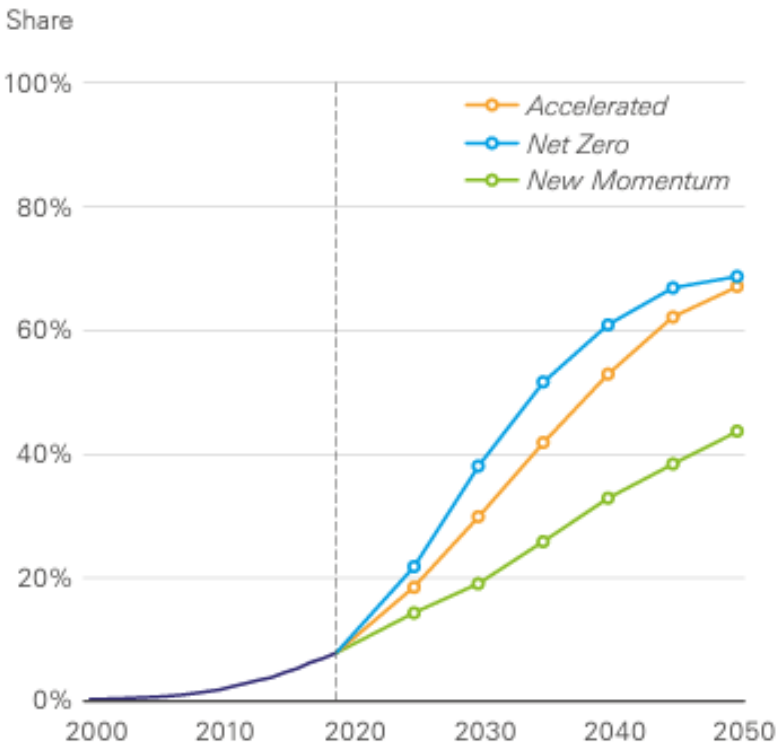
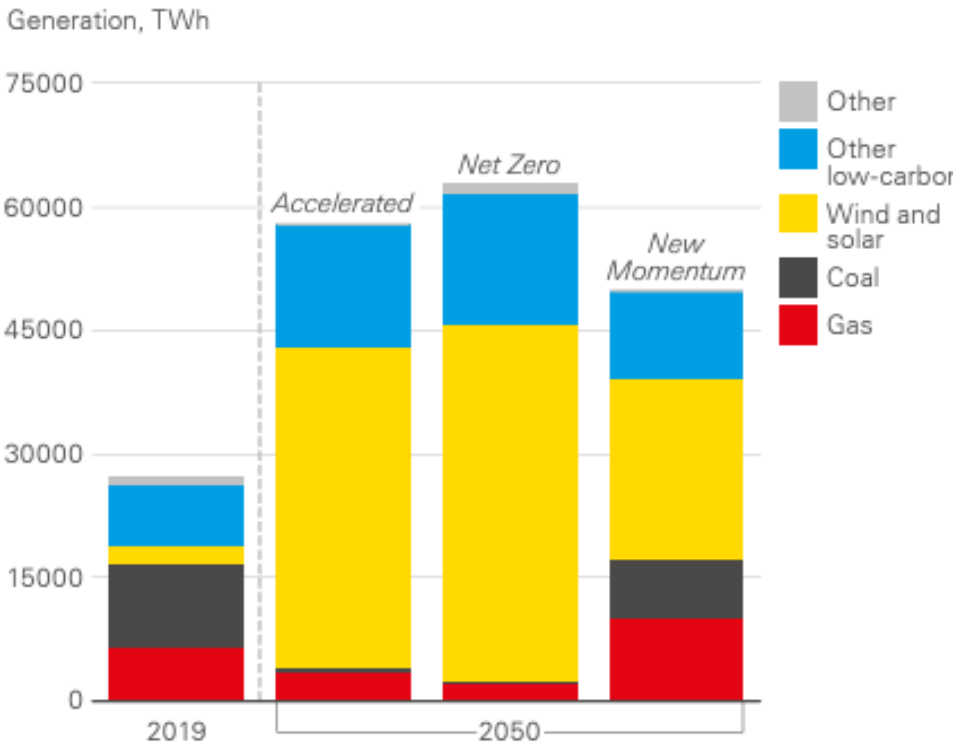
Growth in power generation is dominated by wind and solar as the global power system decarbonizes

Wind and solar as a share of total power generation



Electricity generation by fuel



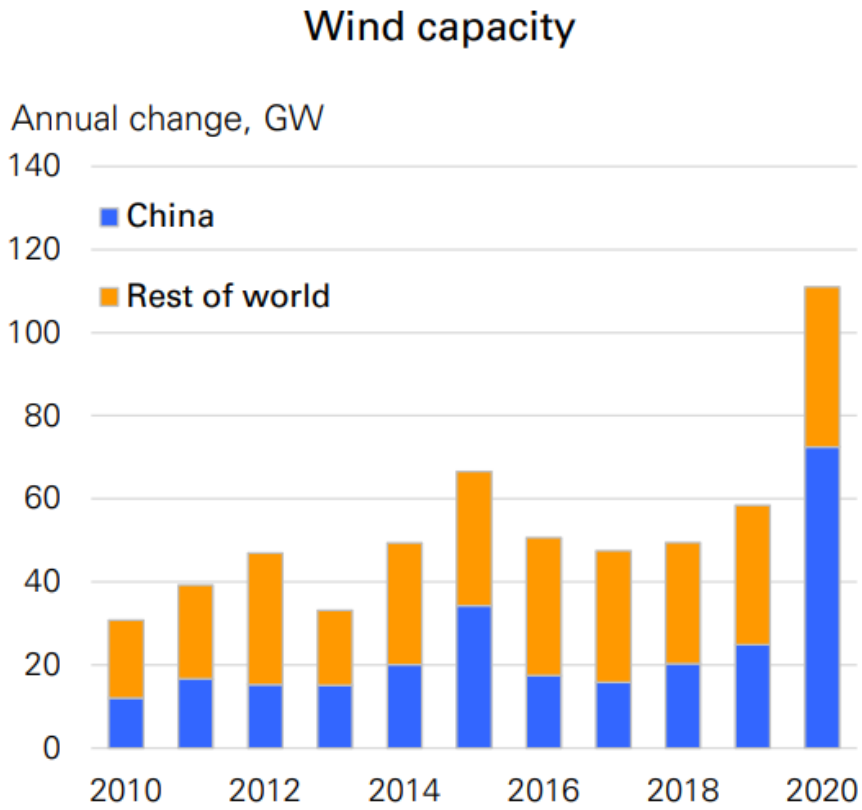
Gas includes natural gas and biomethane
Other low-carbon includes biomass, nuclear, hydro and geothermal

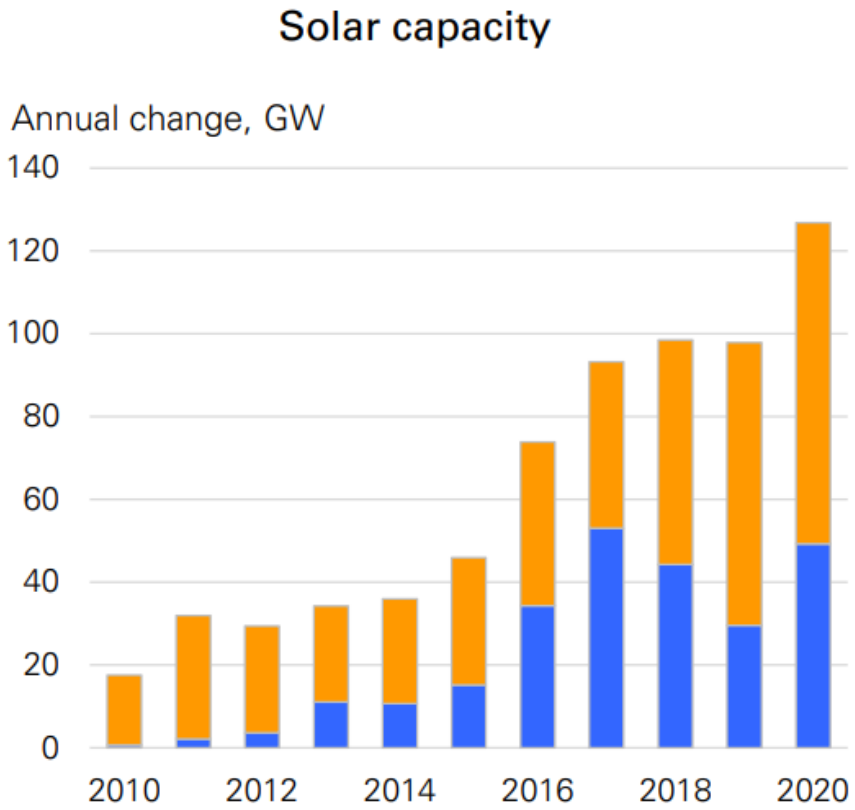
Structural changes in global macro conditions in Favor of Renewables

What factors do contribute to the Growth of Renewables?

1. …
2. …
3. …
4. …
5. …

Wind and solar power capacity





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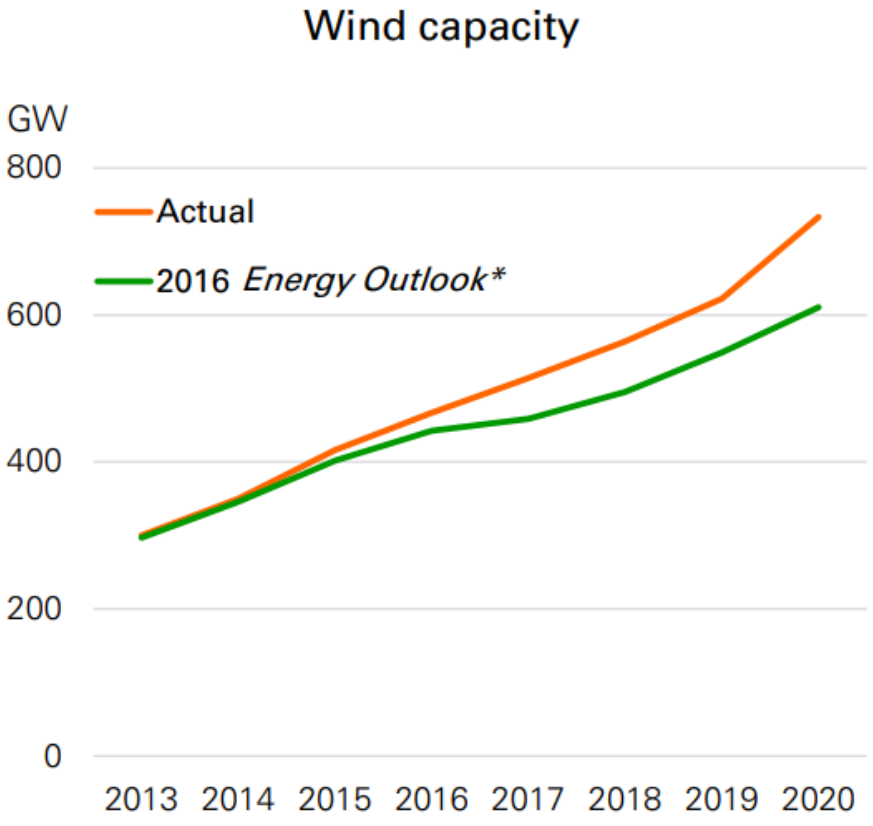
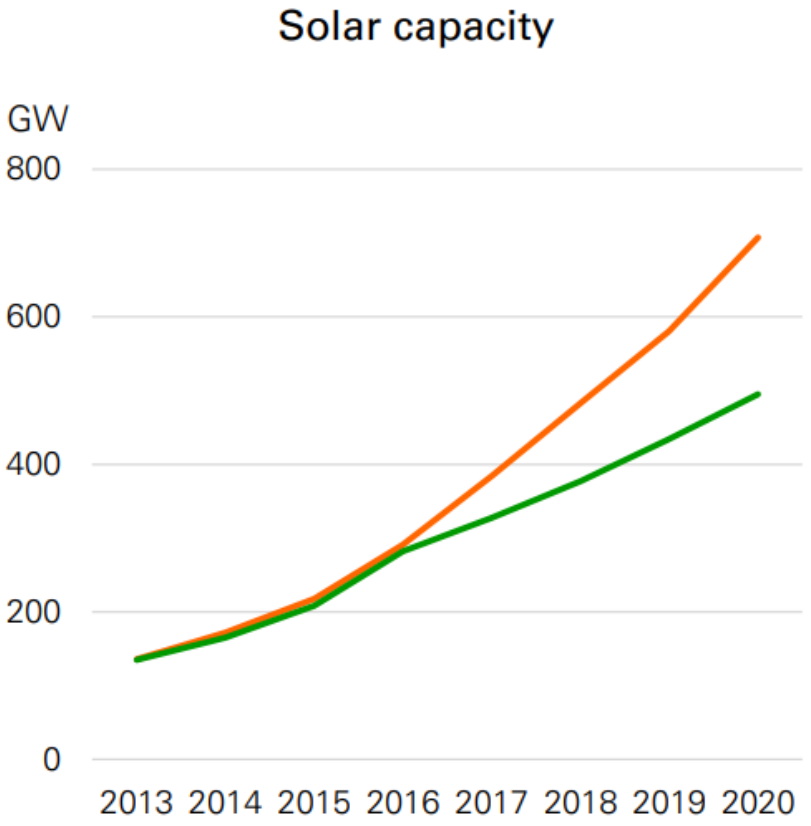
Wind and solar capacity





*2016 Energy Outlook (EO 2016) capacity profiles based on EO 2016 generation and EO 2020 historic capacity factors.

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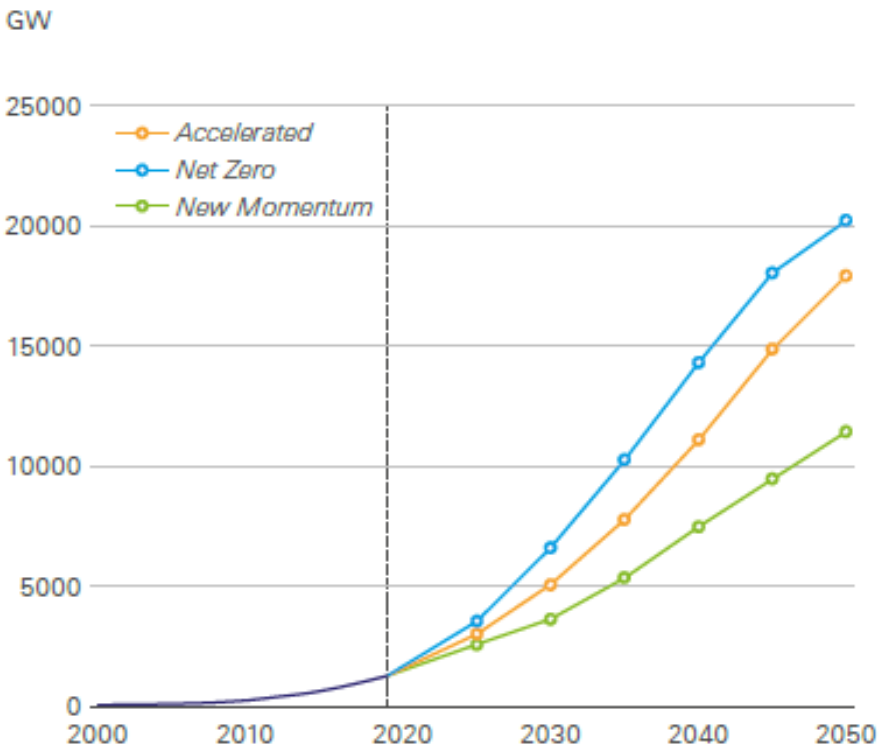
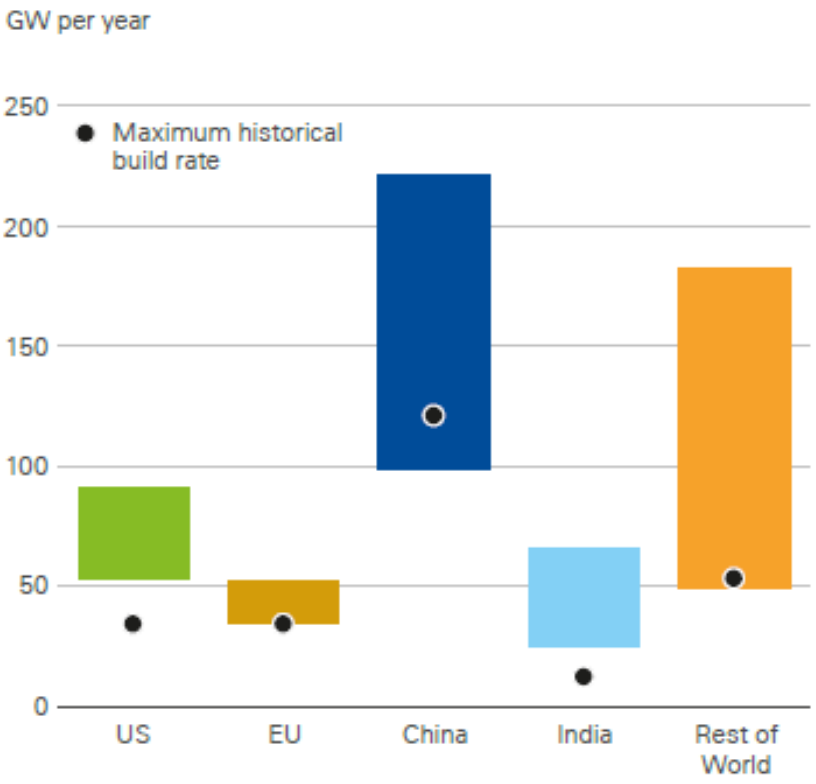
Wind and solar power expands rapidly, requiring significant acceleration in financing and building new capacity

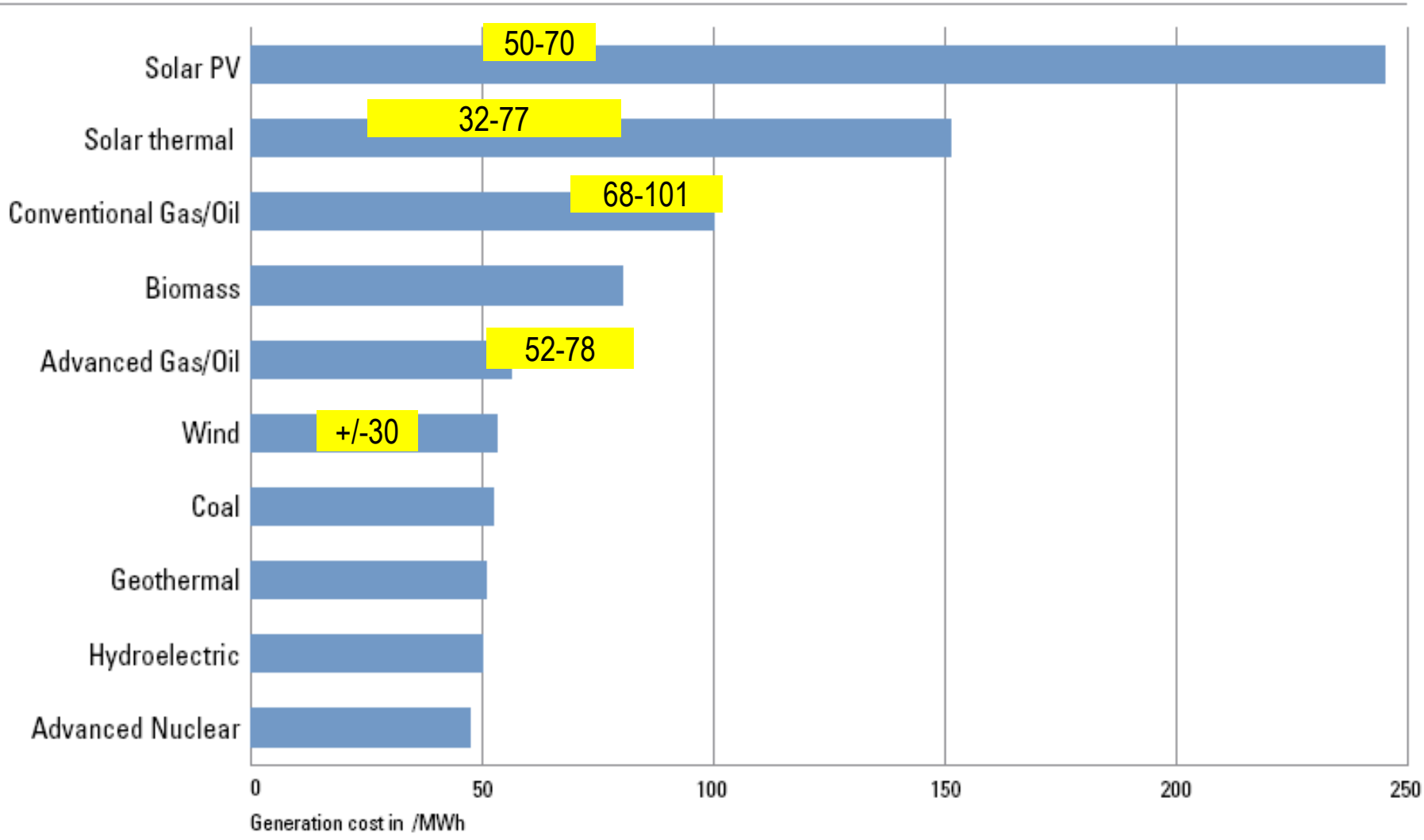
Installed wind and solar capacity



Range of wind and solar capacity build rates in the three scenarios 2022-2035

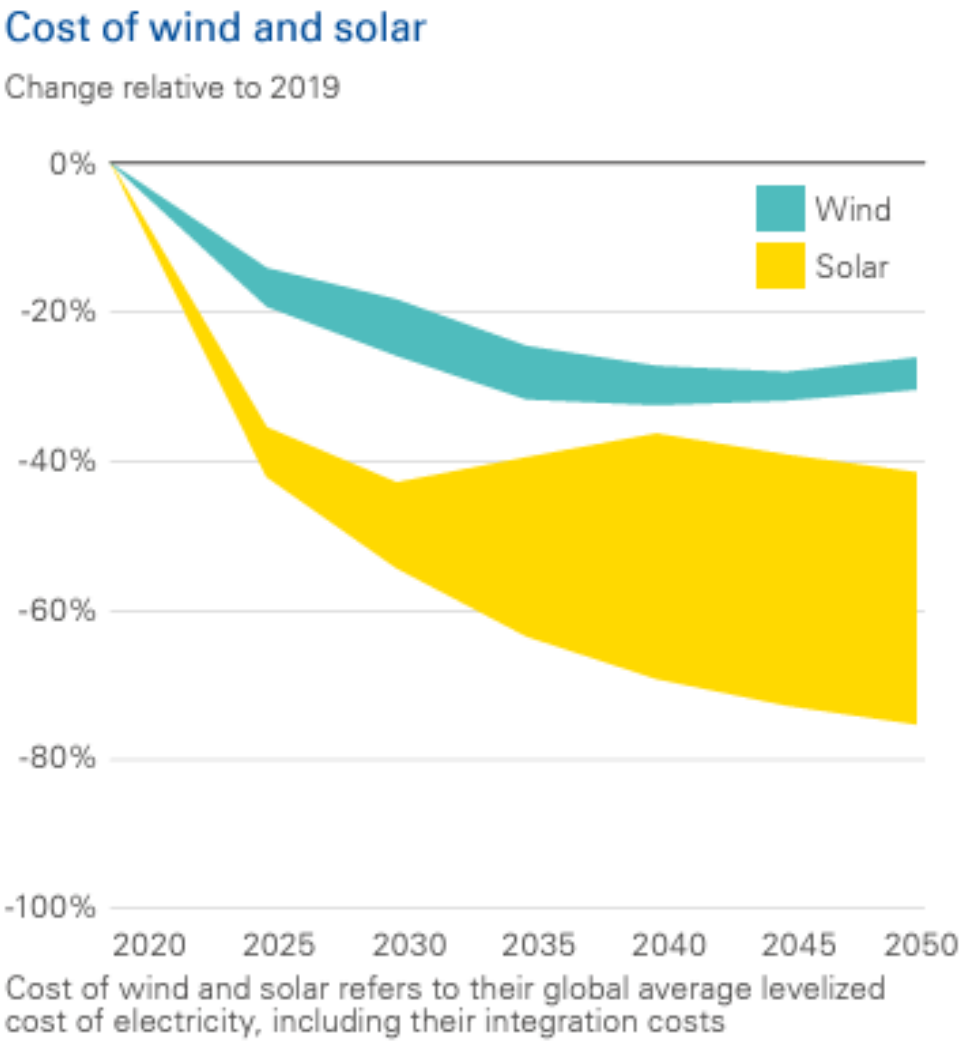


Cost Competitiveness of Electricity Sources

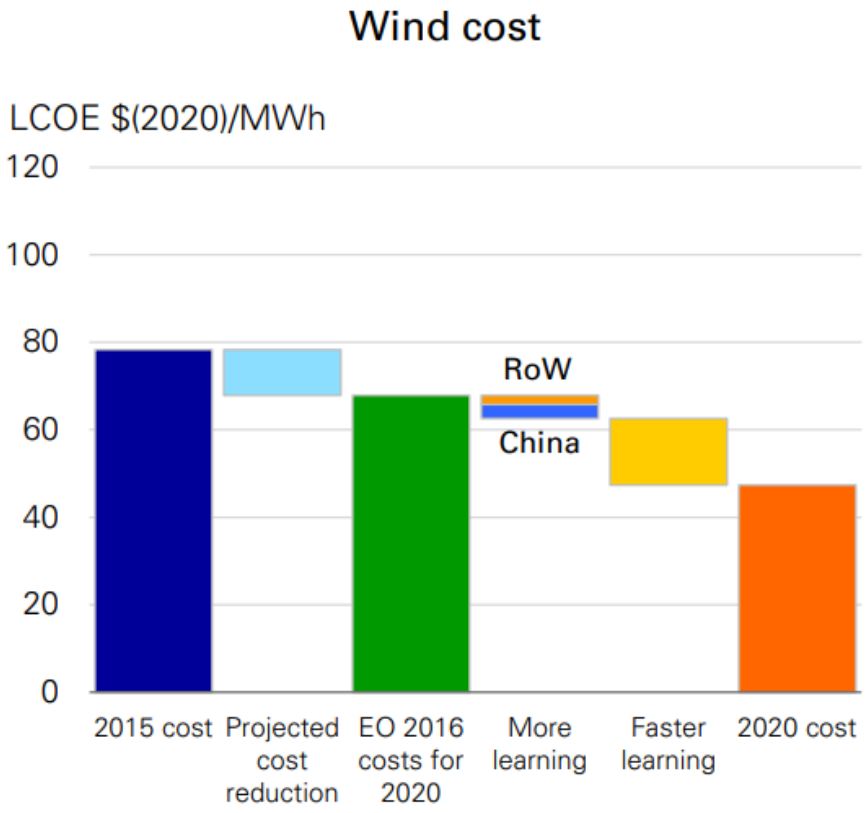


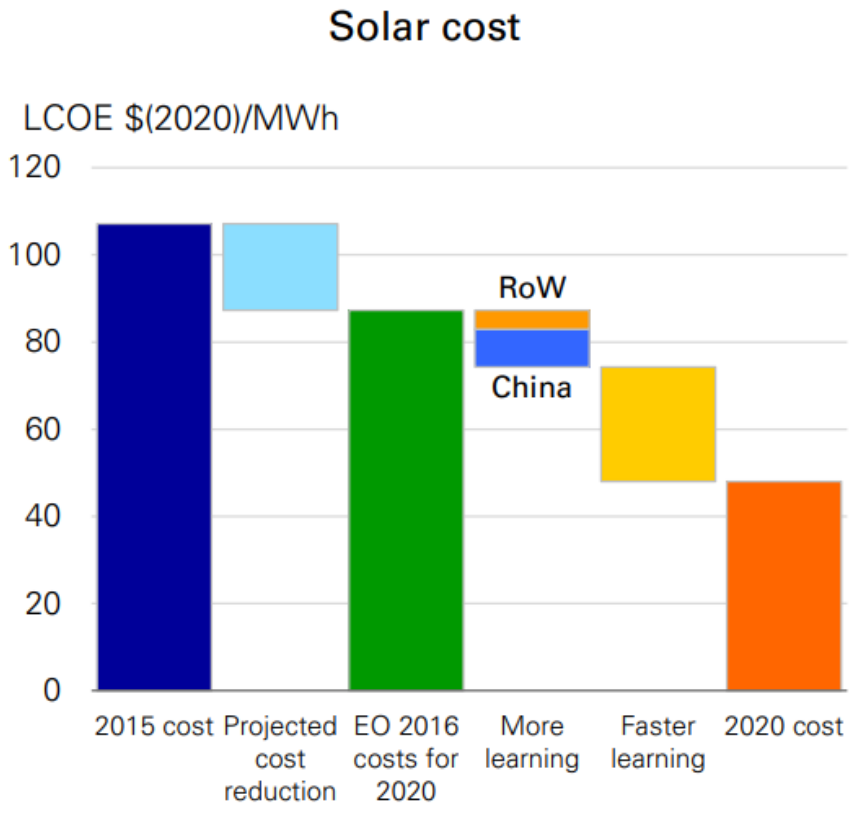
Source: IEA, European Solar Thermal Industry Association, 2006.

Wind and solar power grow rapidly



Cost of wind and solar





LCOE: Levelized cost of energy, global benchmark.

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Table 1b. Estimated unweighted levelized cost of electricity (LCOE) and levelized cost of storage (LCOS) for new resources entering service in 2027 (2021 dollars per megawatthour)

Plant type	Capacity factor (percent)	Levelized capital cost	Levelized fixed O&M[a]	Levelized variable cost	Levelized transmis-sion cost	Total system LCOE or LCOS	Levelized tax credit[b]	Total LCOE or LCOS including tax credit
Dispatchable technologies								
Ultra-supercritical coal	85%	$52.11	$5.71	$23.67	$1.12	$82.61	*NA*	$82.61
Combined cycle	87%	$9.36	$1.68	$27.77	$1.14	$39.94	*NA*	$39.94
Advanced nuclear	90%	$60.71	$16.15	$10.30	$1.08	$88.24	-$6.52	$81.71
Geothermal	90%	$22.04	$15.18	$1.21	$1.40	$39.82	-$2.20	$37.62
Biomass	83%	$40.80	$18.10	$30.07	$1.19	$90.17	*NA*	$90.17
Resource-constrained technologies								
Wind, onshore	41%	$29.90	$7.70	$0.00	$2.63	$40.23	*NA*	$40.23
Wind, offshore	44%	$103.77	$30.17	$0.00	$2.57	$136.51	-$31.13	$105.38
Solar, standalone[c]	29%	$26.60	$6.38	$0.00	$3.52	$36.49	-$2.66	$33.83
Solar, hybrid[c,d]	28%	$34.98	$13.92	$0.00	$3.63	$52.53	-$3.50	$49.03
Hydroelectric[d]	54%	$46.58	$11.48	$4.13	$2.08	$64.27	*NA*	$64.27
Capacity resource technologies								
Combustion turbine	10%	$53.78	$8.37	$45.83	$9.89	$117.86	*NA*	$117.86
Battery storage	10%	$64.03	$29.64	$24.83	$10.05	$128.55	*NA*	$128.55

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2022*

[a] O&M = operations and maintenance

Risks of Solar and Wind Energy

	SOLAR stations	WIND stations
Environmental Risks	Deforestation, utilization problems, cleaning chemicals, soil deterioration, local warming effect	Construction materials (steel, copper, aluminum, concrete), infrastructure around, special roads, deforestation (1 wind generator → 0.35 sq.km), industrial pollution, fire cause, utilization problem, local warming effect


NORDEX
COLLETT
HEAVY TRANSPORT

Risks of Solar and Wind Energy

	SOLAR stations	WIND stations
Risks for Health	Utilization → soil & water contamination, especially in Africa, due to the impossibility of rare earths safe storage or utilization	Reduction of bird's population, negative effect on health of animals and people on local farms nearby, animal's miscarriages on local farms
Risks of New Technologies	Public unpopularity of this topic (it is customary to respond only positively)	Underestimating noise pollution (only the audible range is considered, without infrasound and vibrations) Public unpopularity of this topic (it is customary to respond only positively)
Energy Security Risks	Dependence on sun Deterioration of the stability of the power grid and dependence on electricity imports	Dependence on wind Deterioration of the stability of the power grid and dependence on electricity imports

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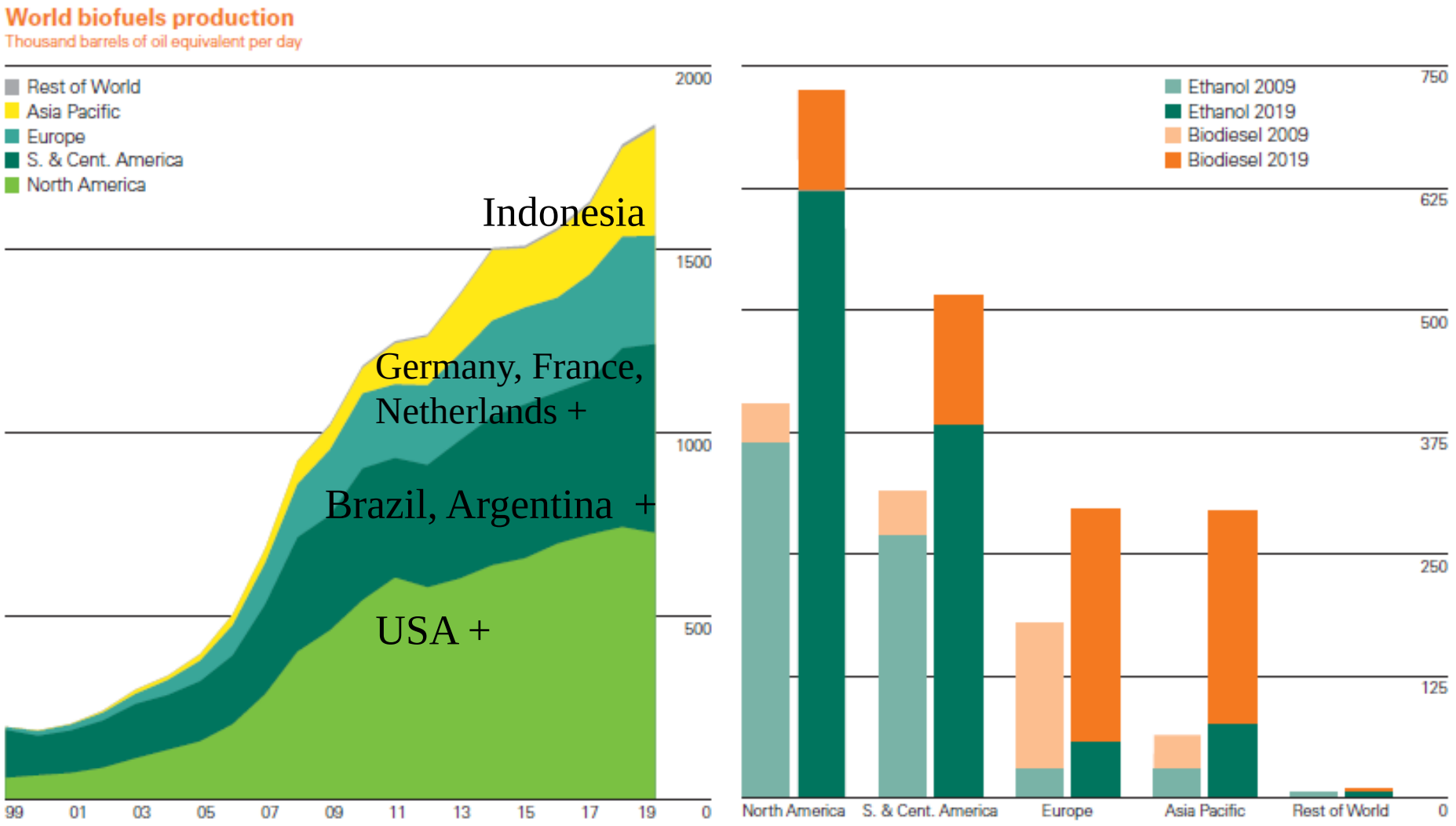
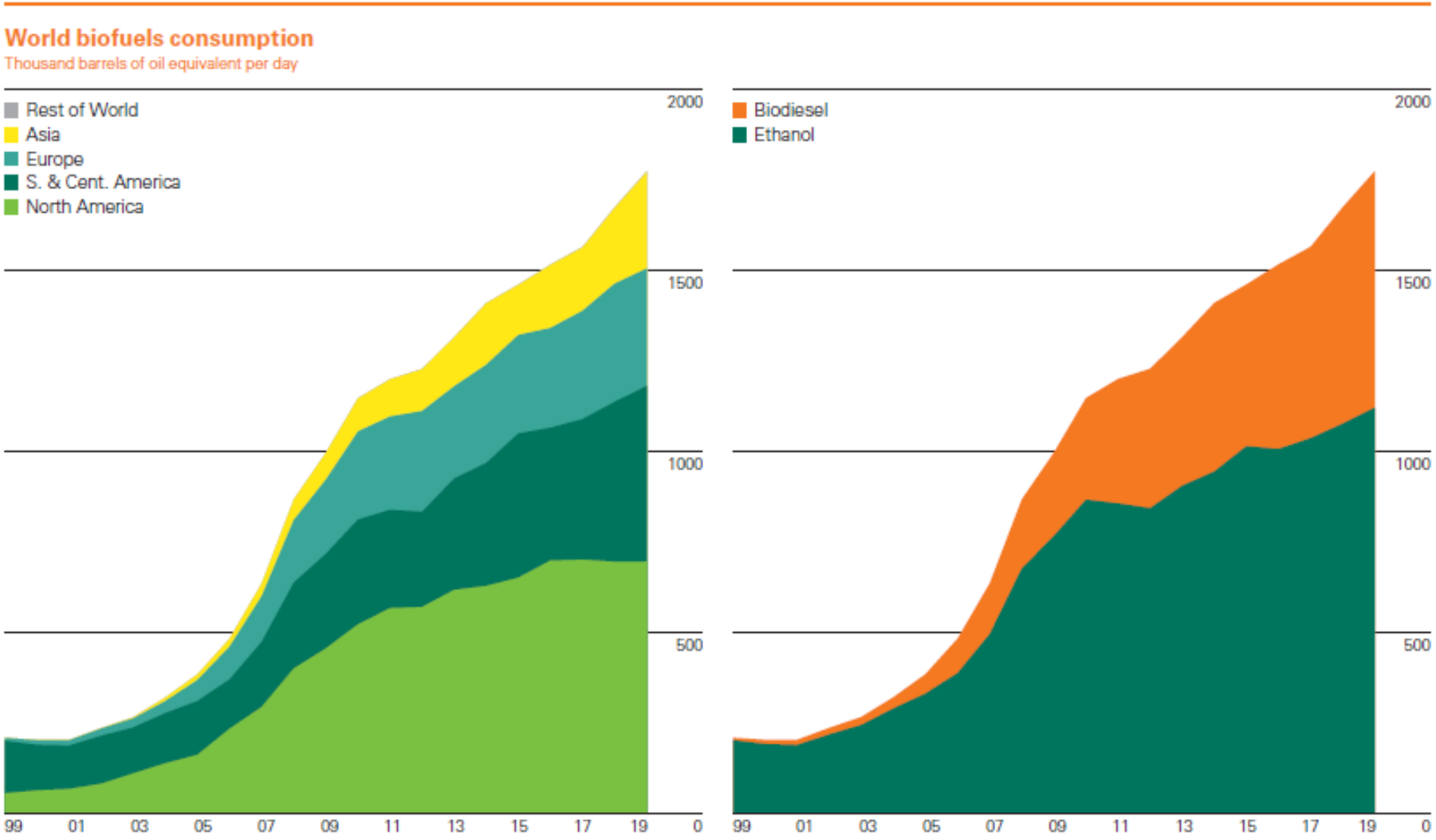
World Biofuels Production



Source: BP Statistical Review of World Energy, 2020

World Biofuels Consumption



Ethanol Production Obstacles

More land for sugar cane or maize → Rising soil erosion and contaminati on with fertilizers → Less land for food production → **Food prices grow up**

Energy volume necessary to grow up future ethanol crops is very close to the energy volume that this ethanol fuel will provide being used in vehicles

Common ethanol fuel mixtures