The role of energy in the mitigation of climate change

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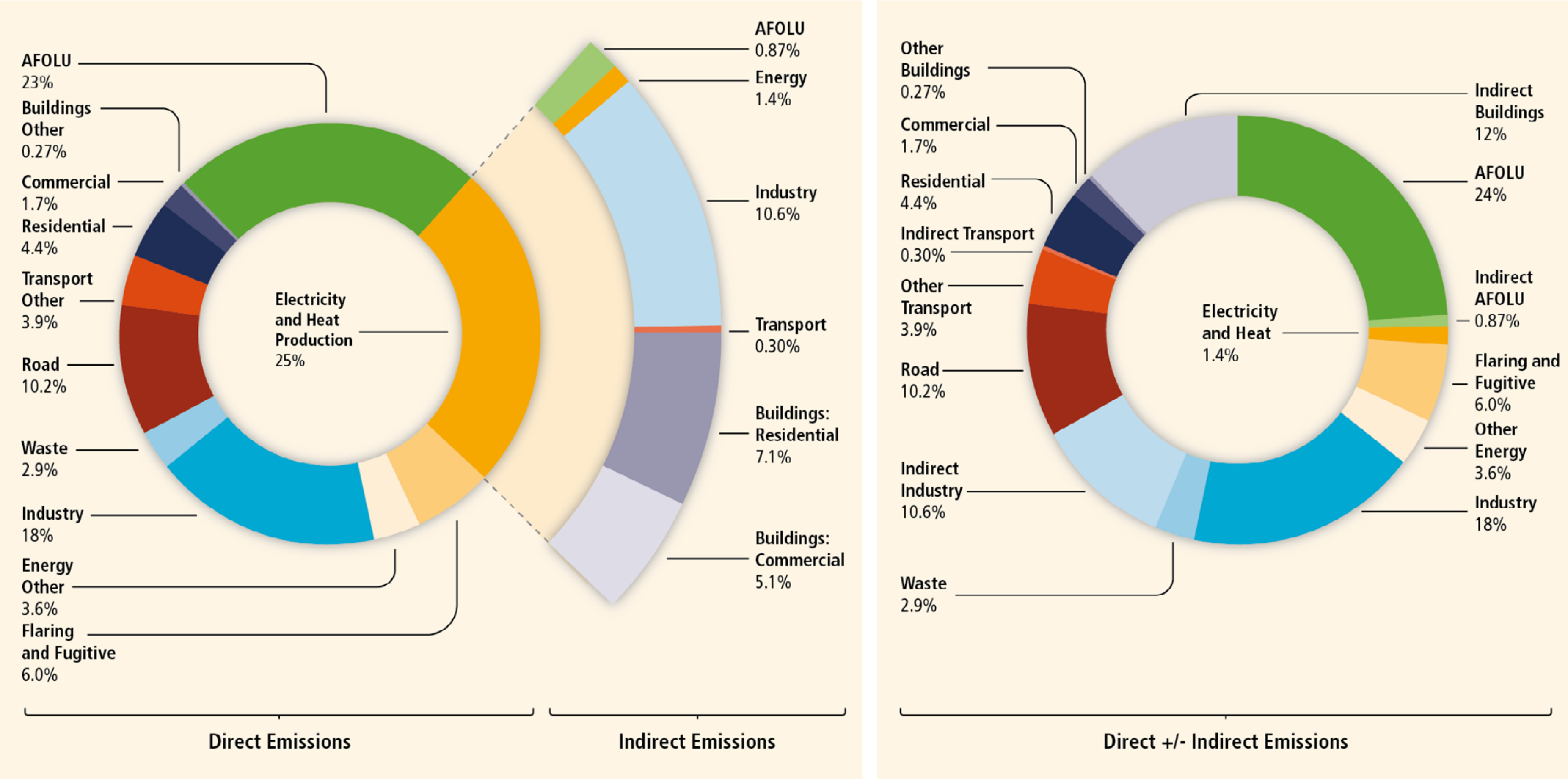
BC3 Summer School

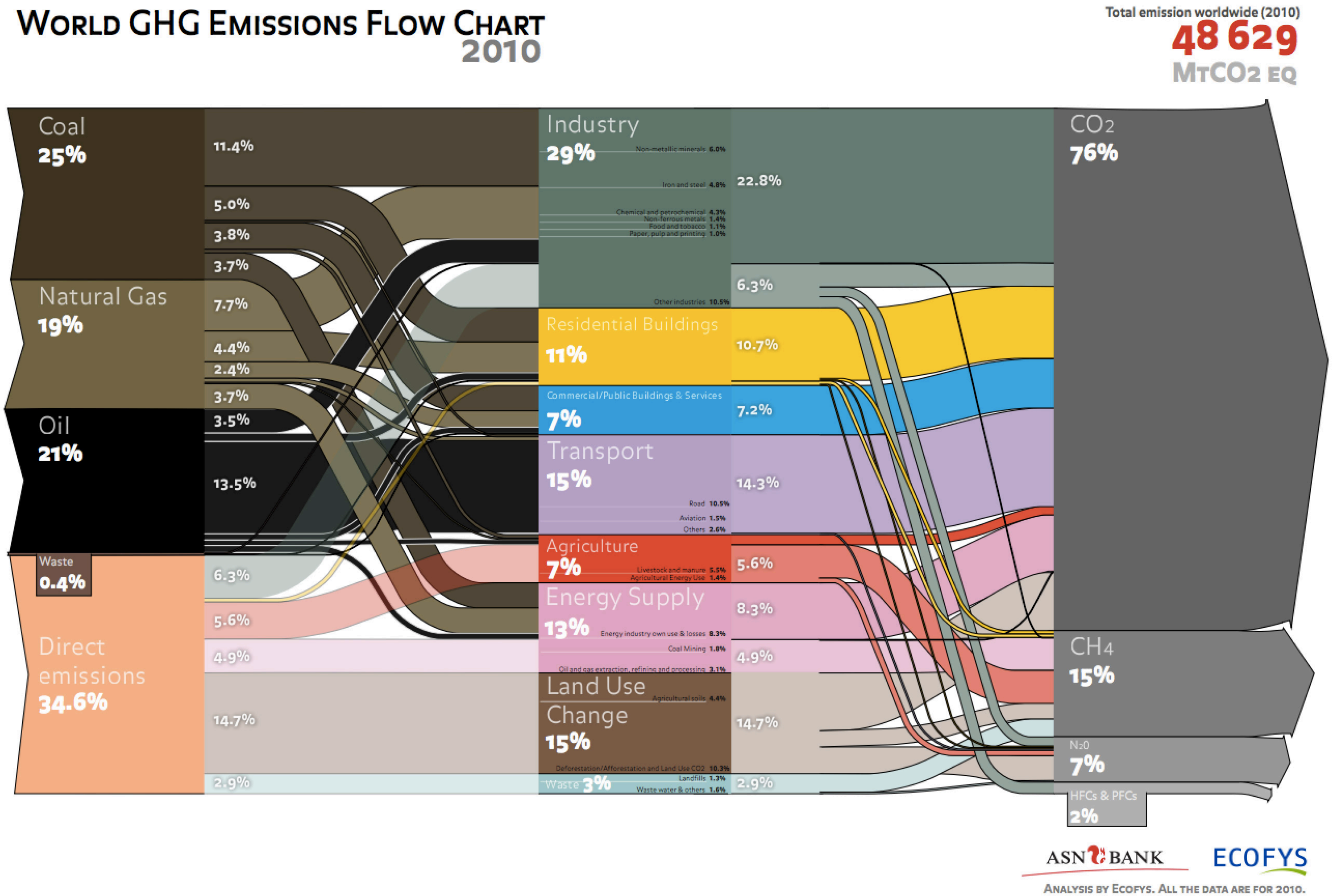
San Sebastian, San Fermín 2017

The role of energy in GHG emissions (I)

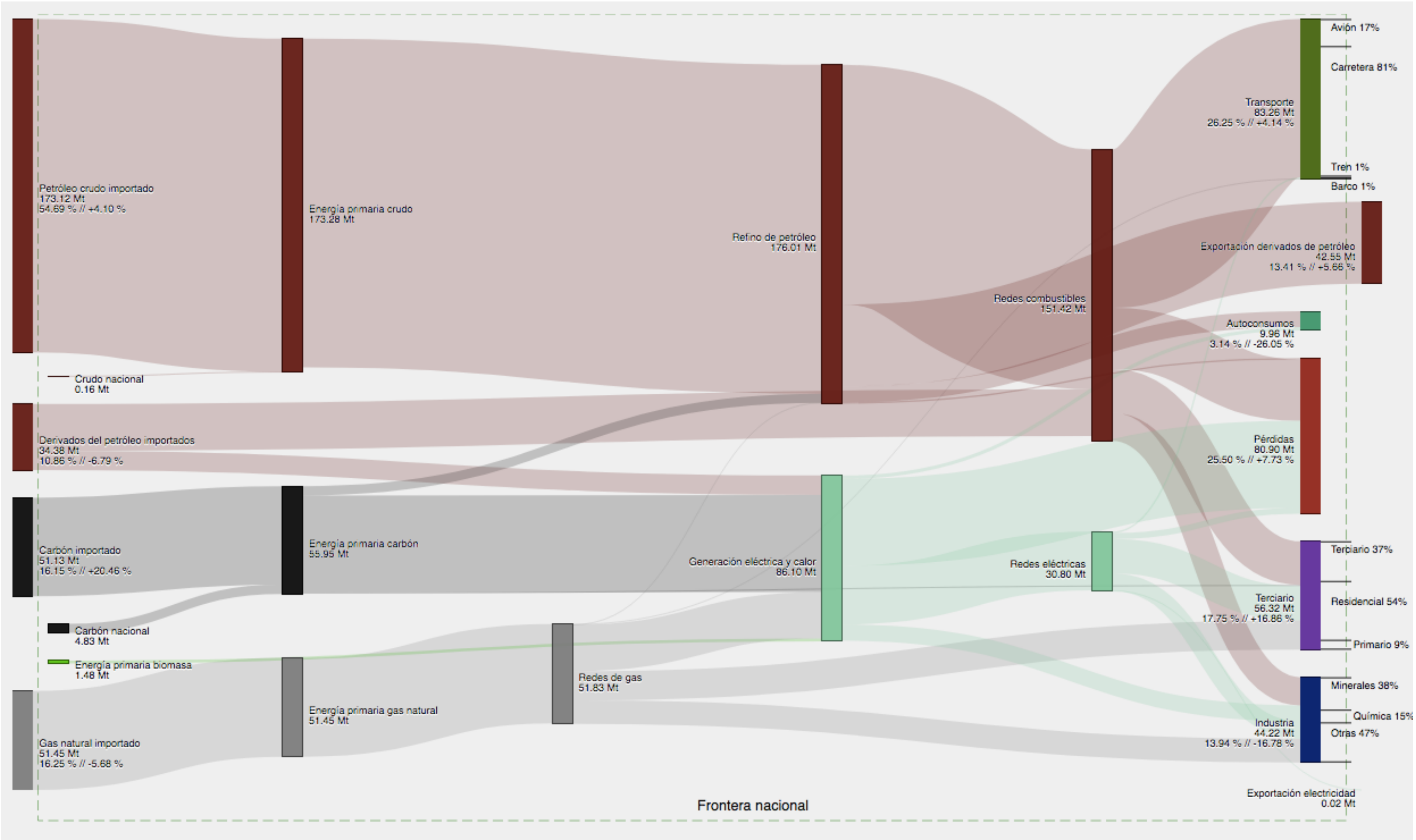


IPCC AR5, WG3 Technical Summary

The role of energy in GHG emissions (II)



Carbon-energy flows



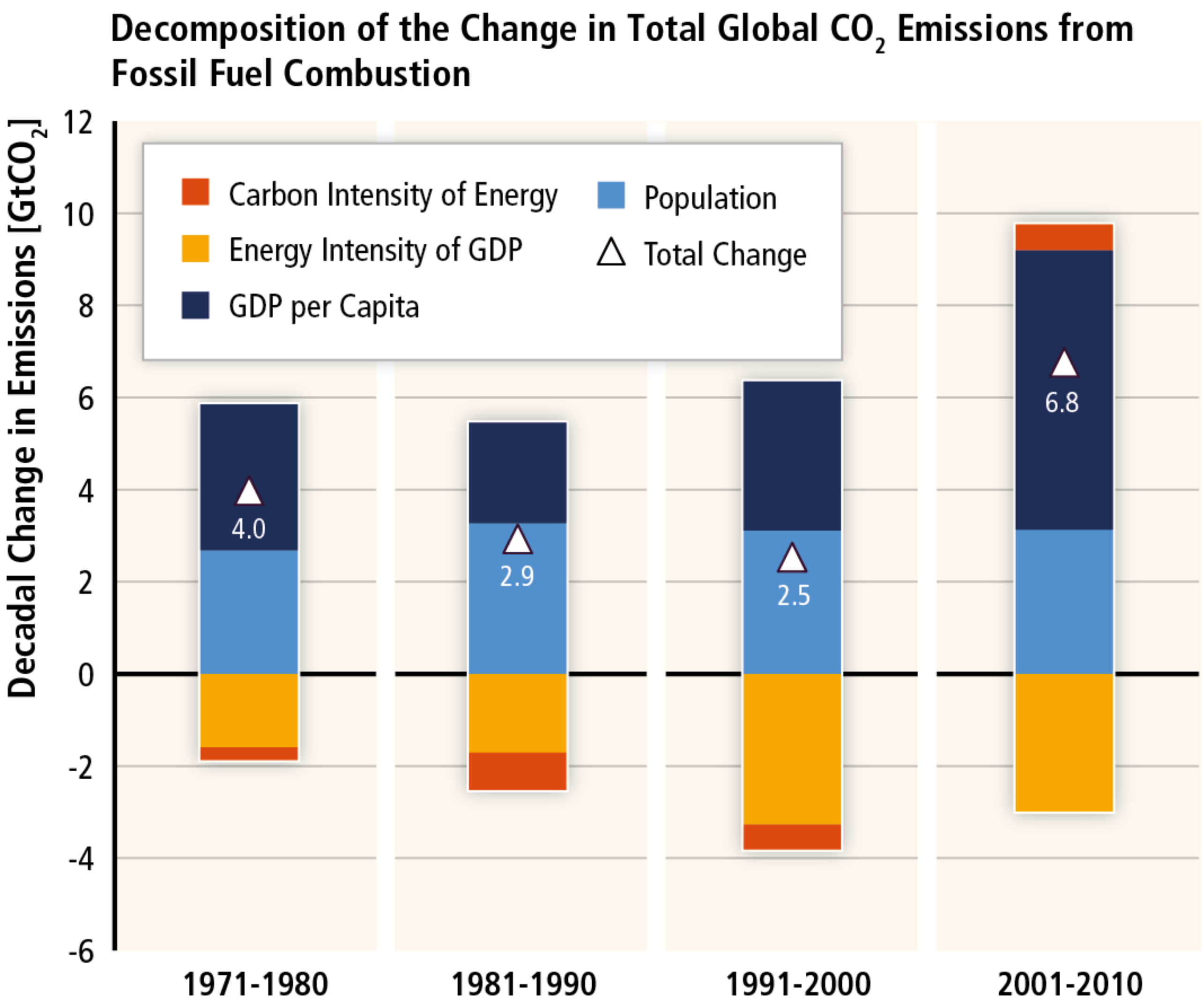
http://www.comillas.edu/Documentos/BP/sankey_energy.html

The role of energy in mitigation

- *Reaching atmospheric concentration levels of 430 to 650 ppm by 2100 will require large-scale challenges to global and energy systems over the coming decades [high confidence]*
  - *3x – 4x share low-carbon energy in 2050*
  - *2100 concentration levels unachievable if the full suite of low-carbon technologies is not available*
  - *Demand reductions on their own will not be sufficient*
  - *But will be a key mitigation strategy and will affect the scale of the mitigation challenge for the energy supply side*

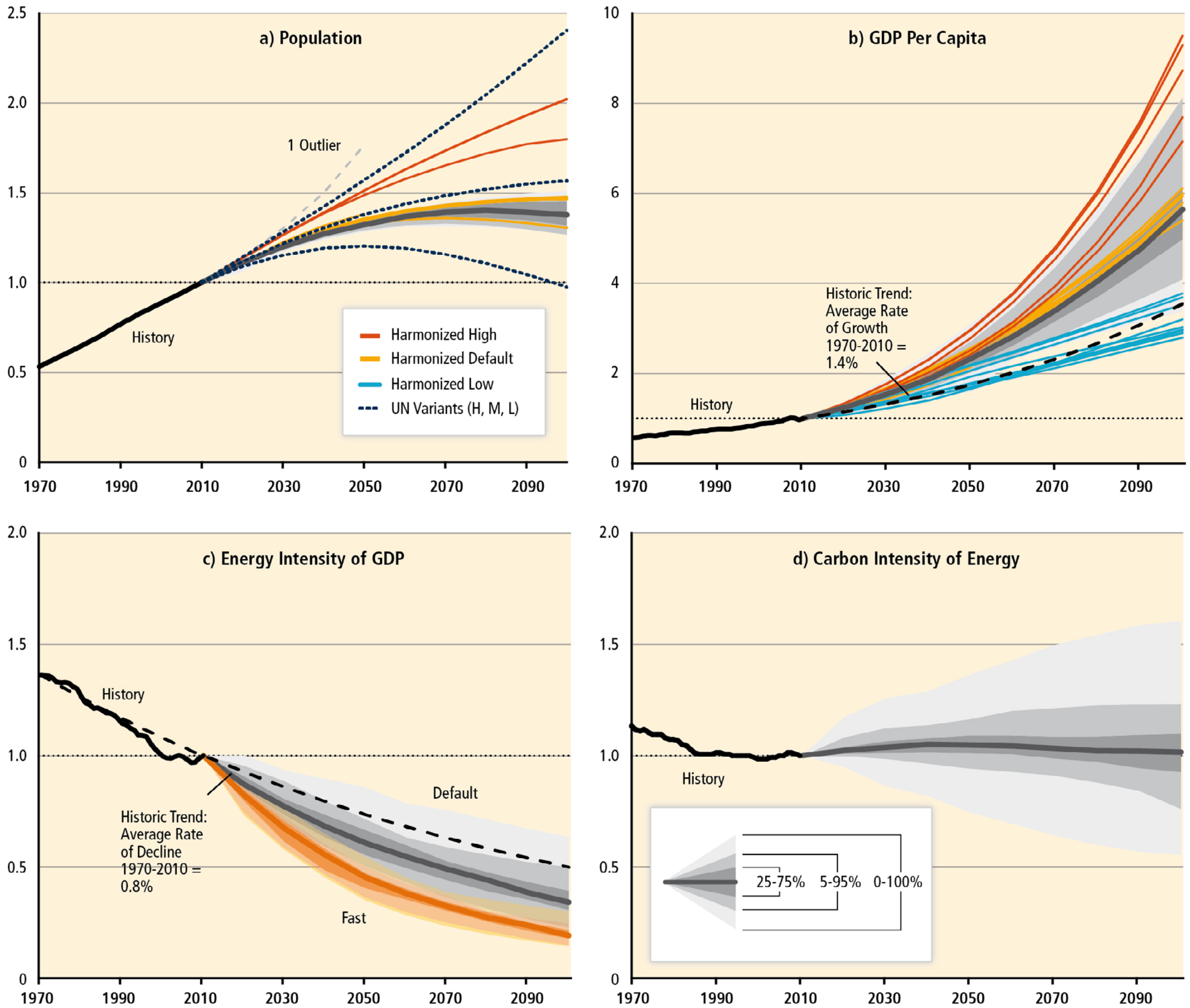
(AR5 WG3 Technical Summary)

Drivers for GHG emissions (I)



IPCC AR5, WG3 Technical Summary

Drivers for GHG emissions (II)



IPCC AR5, WG3 Technical Summary

Access to energy?

	Low		High	
	Optimistic	Pessimistic	Optimistic	Pessimistic
2009-2030: Energy poverty alleviation emissions (GtCO2)	2.9	2.9	17.8	17.8
2030-2060: Use of additional energy infrastructure (GtCO2)	7.9	7.9	48.5	48.5
2060-2100: Retirement of additional infrastructure (GtCO2)	5.3	10.5	32.3	64.7
2009-2100: Total emissions (GtCO2)	16.1	21.3	98.7	131
Additional temperature increase (degree C): mean and 10-90 percentile in square brackets	0.008 [0.004-0.011]	0.01 [0.006-0.014]	0.047 [0.027-0.067]	0.063 [0.036-0.089]

Table 3: Estimated additional emissions and temperature rise from an energy poverty alleviation program.

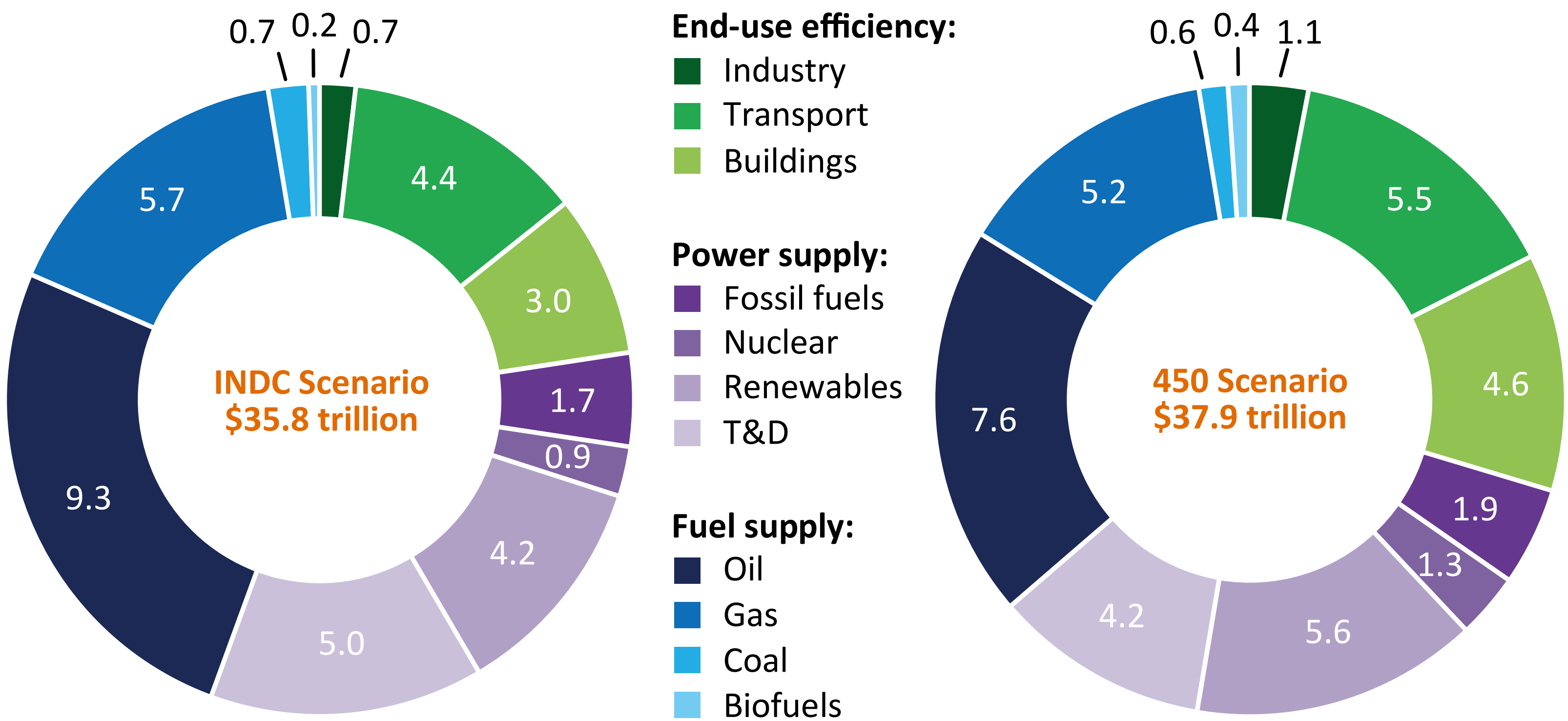
Chakravarty and Tavoni, 2013

Energy-related mitigation options

- Decarbonization of energy supply
- Final energy demand reductions
- Switch to low-carbon fuels
- Different by sector
  - Decarbonization of electricity generation is a key component: quicker and simpler
  - The transport sector is difficult to decarbonize, and opportunities for fuel switching are low in the short term
  - Large achievable potential in the building sector, but strong barriers

Emissions reductions required (I)

Figure 2.4 ▷ Cumulative global energy sector investments by sector in the INDC and 450 Scenarios, 2015-2030 (trillion dollars, 2013)

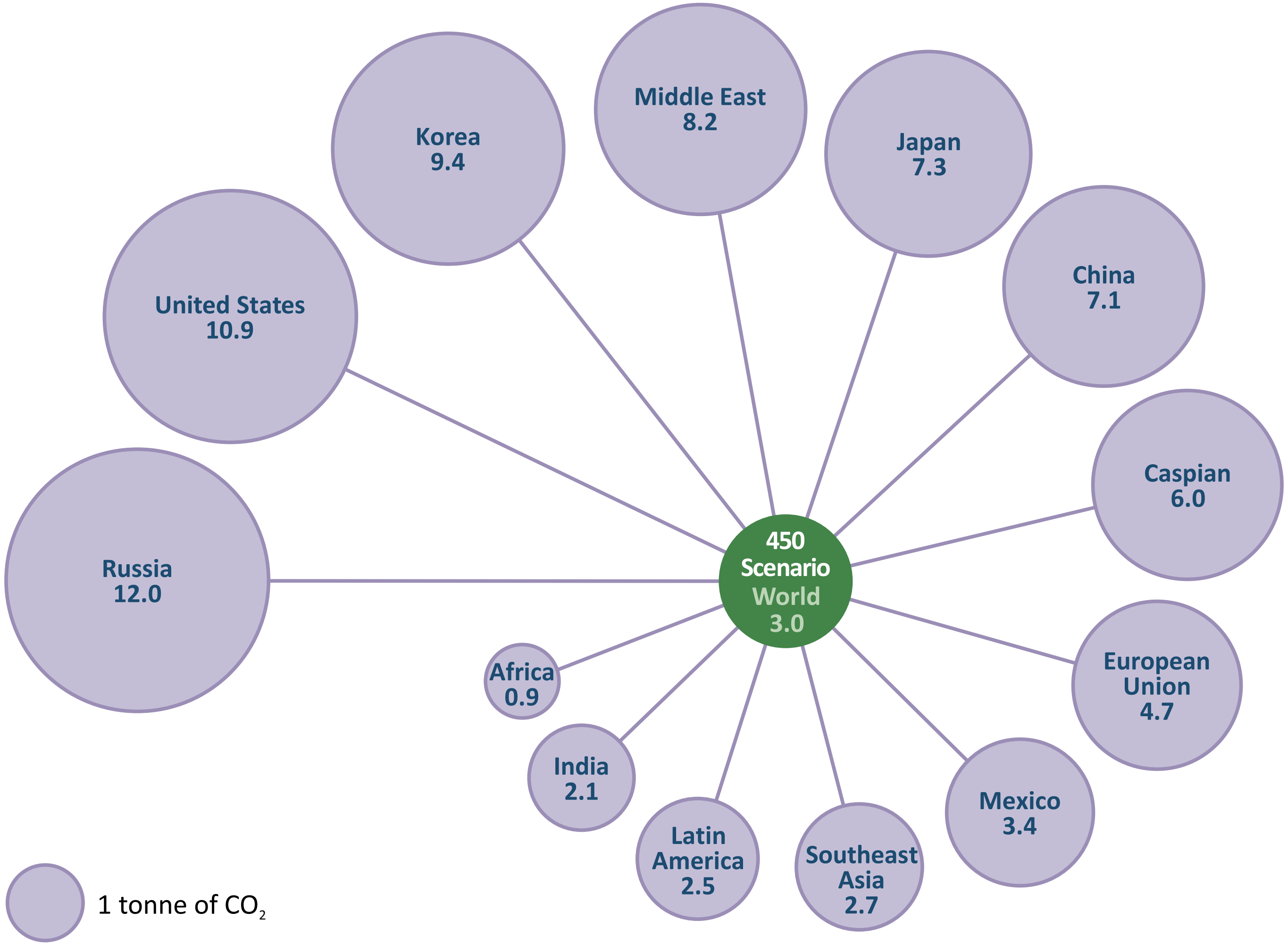


Note: T&D is transmission and distribution.

IEA WEO Special Report on Energy and Climate, 2015

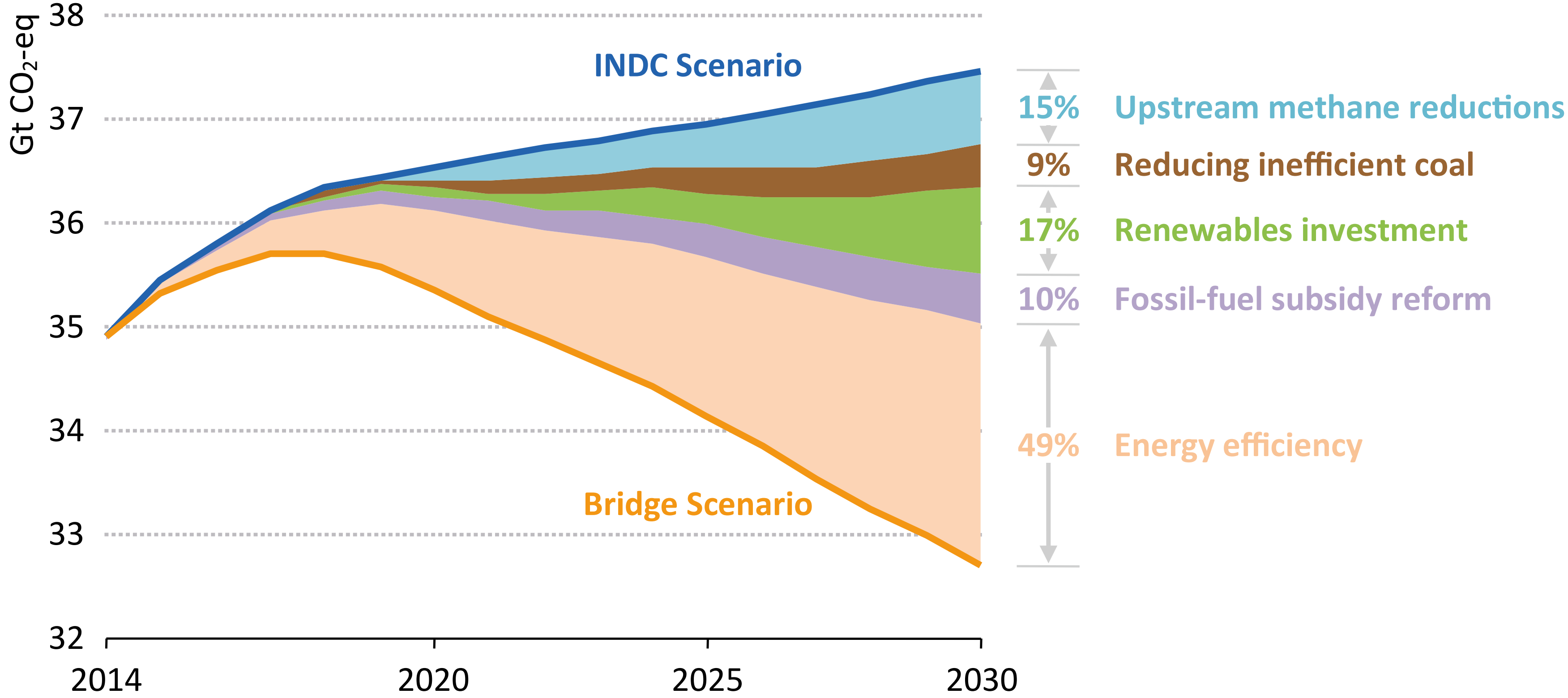
Emission reductions required (II)

Figure 2.5 ▻ Energy-related CO_2 emissions per capita by selected region in the INDC Scenario and world average in the 450 Scenario, 2030



Emissions reductions required (III)

Figure 3.2 ▷ Global energy-related GHG emissions reduction by policy measure in the Bridge Scenario relative to the INDC Scenario



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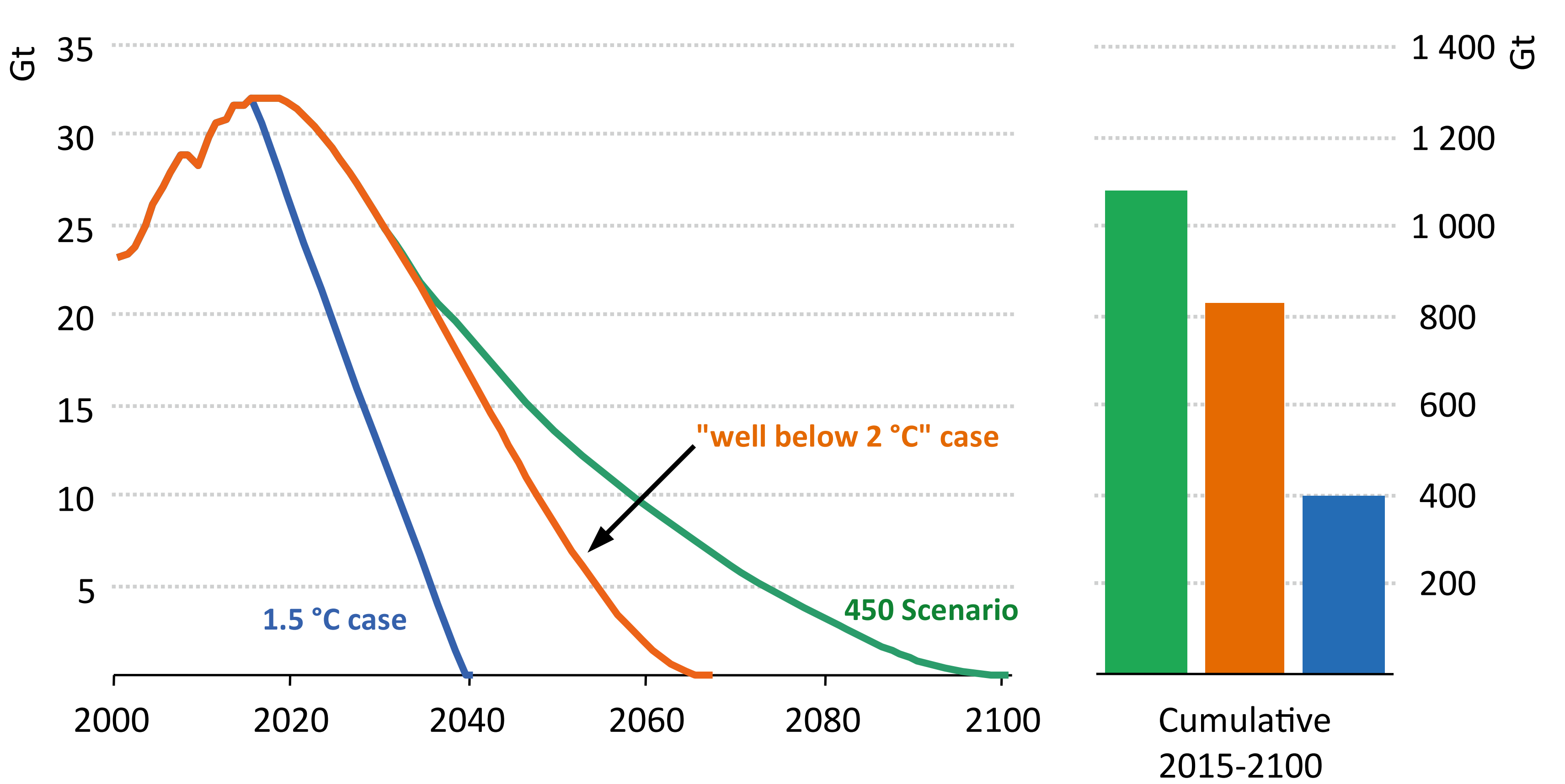
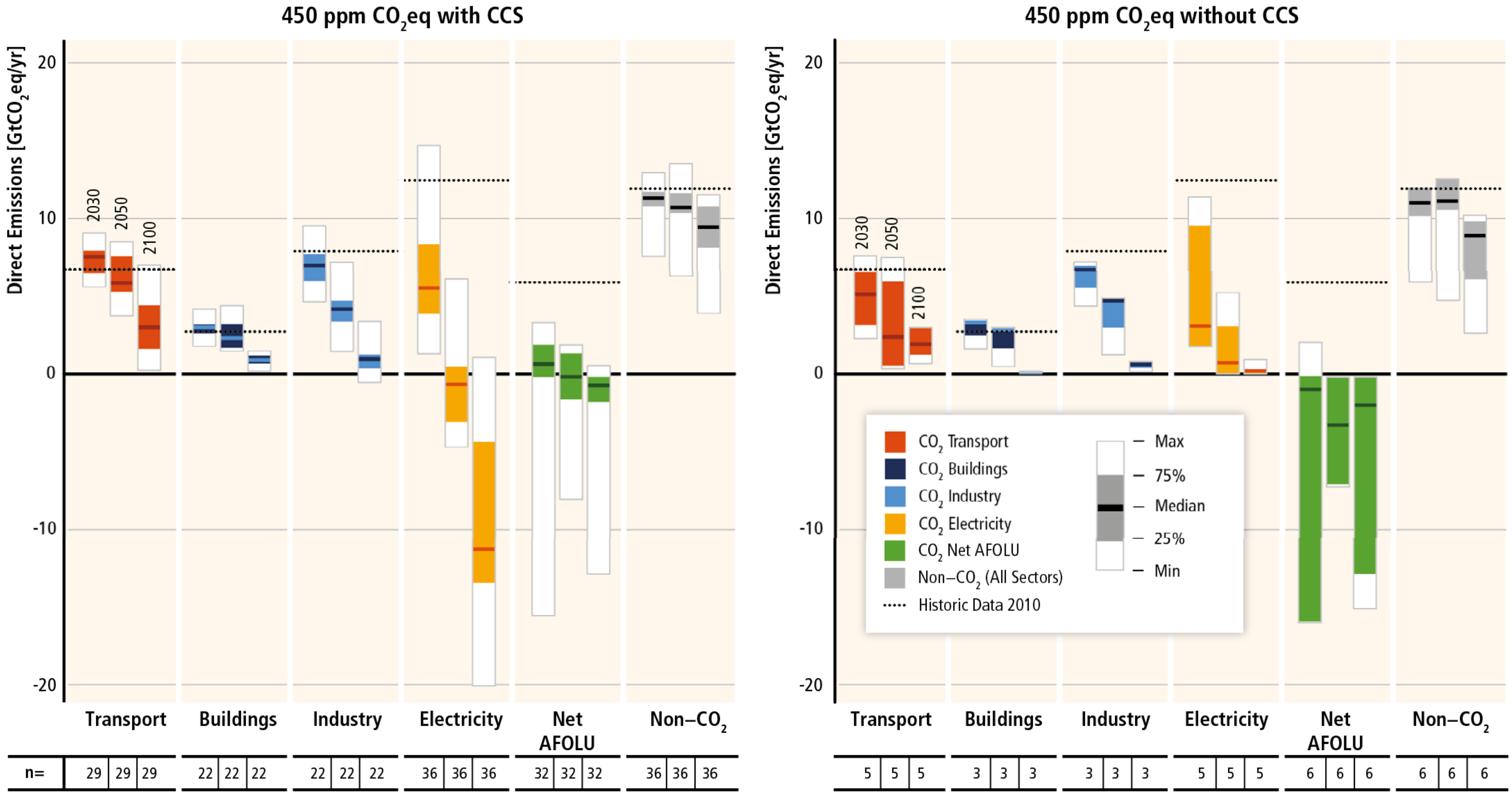
Deep decarbonization



Without net-negative emissions, energy sector CO_2 emissions fall to zero by 2040 for a 50% chance of 1.5 °C and around 2060 for a 66% chance of 2 °C

Mitigation potential



IPCC AR5, WG3 Technical Summary

But the future may not take us there

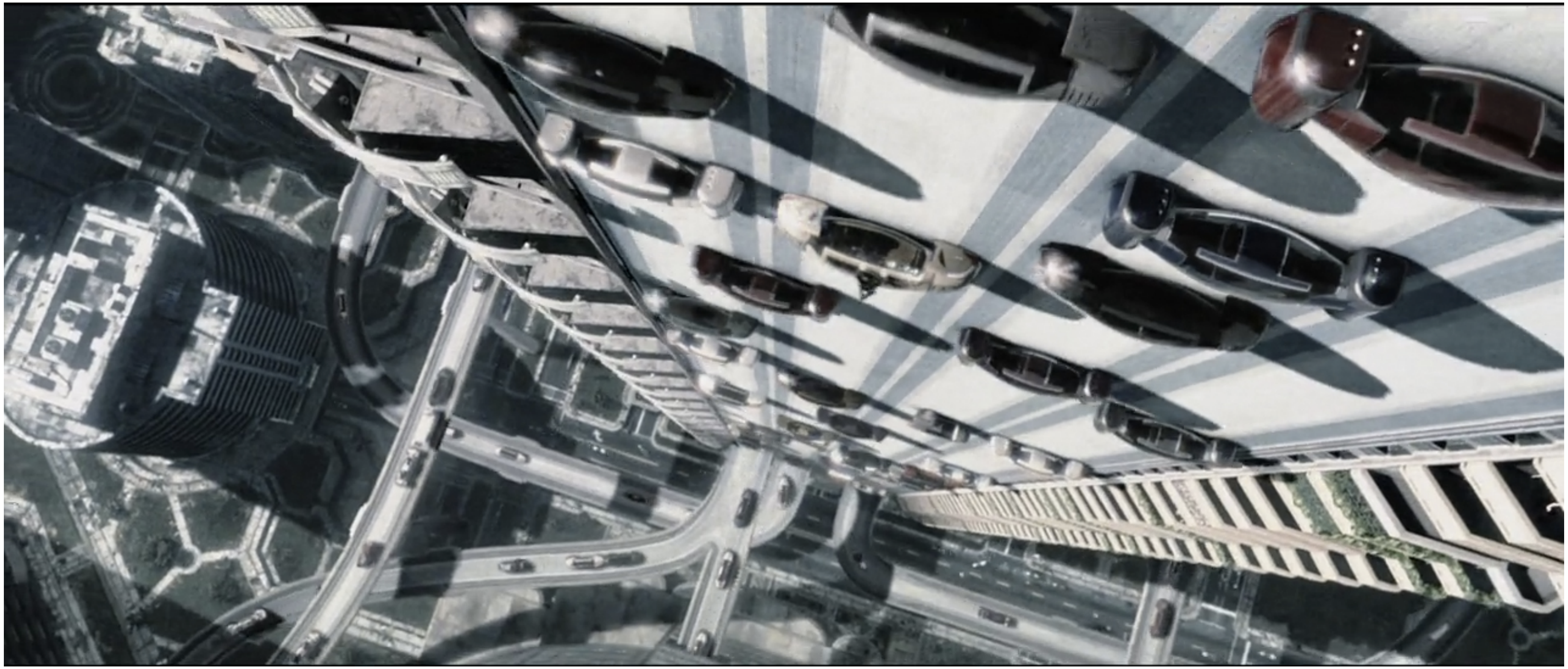
...for strictly logical reasons, it is impossible for us to predict the future course of history.

Sir Karl R. Popper

Many possible futures

Many possible futures

Many possible futures



Many possible futures

Many studies

EXXON Mobil

bp

World Energy Outlook 2016

Shell

IHS CERA

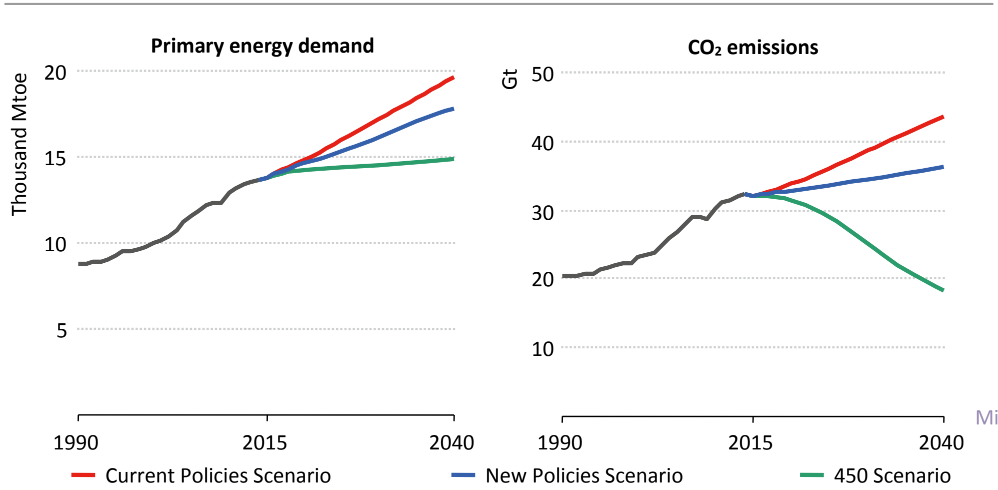
GREENPEACE

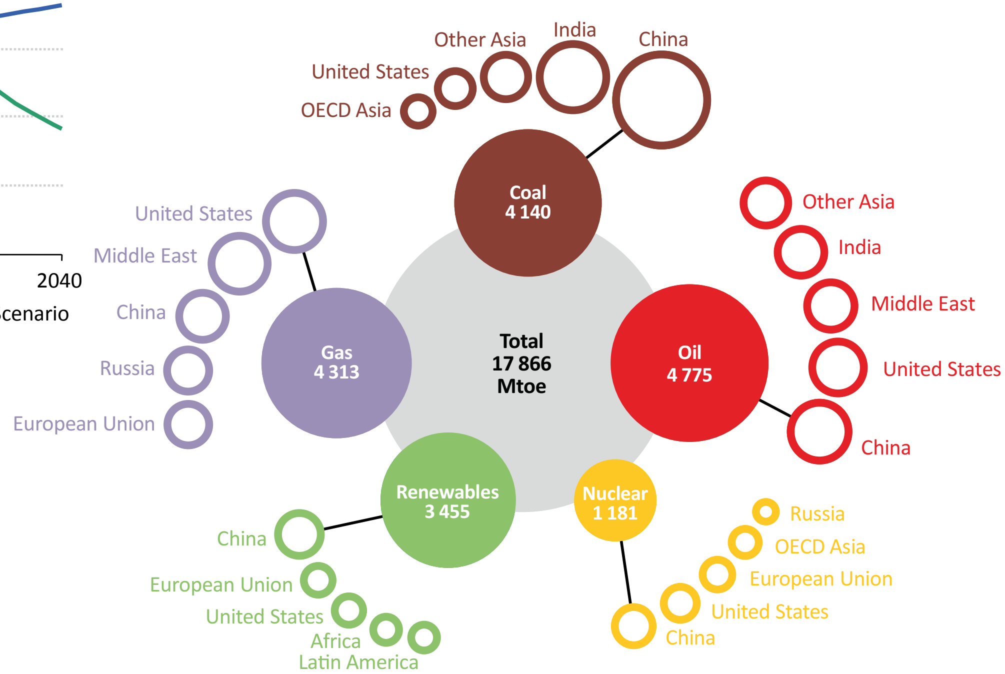
Bloomberg New Energy Finance

economics for energy

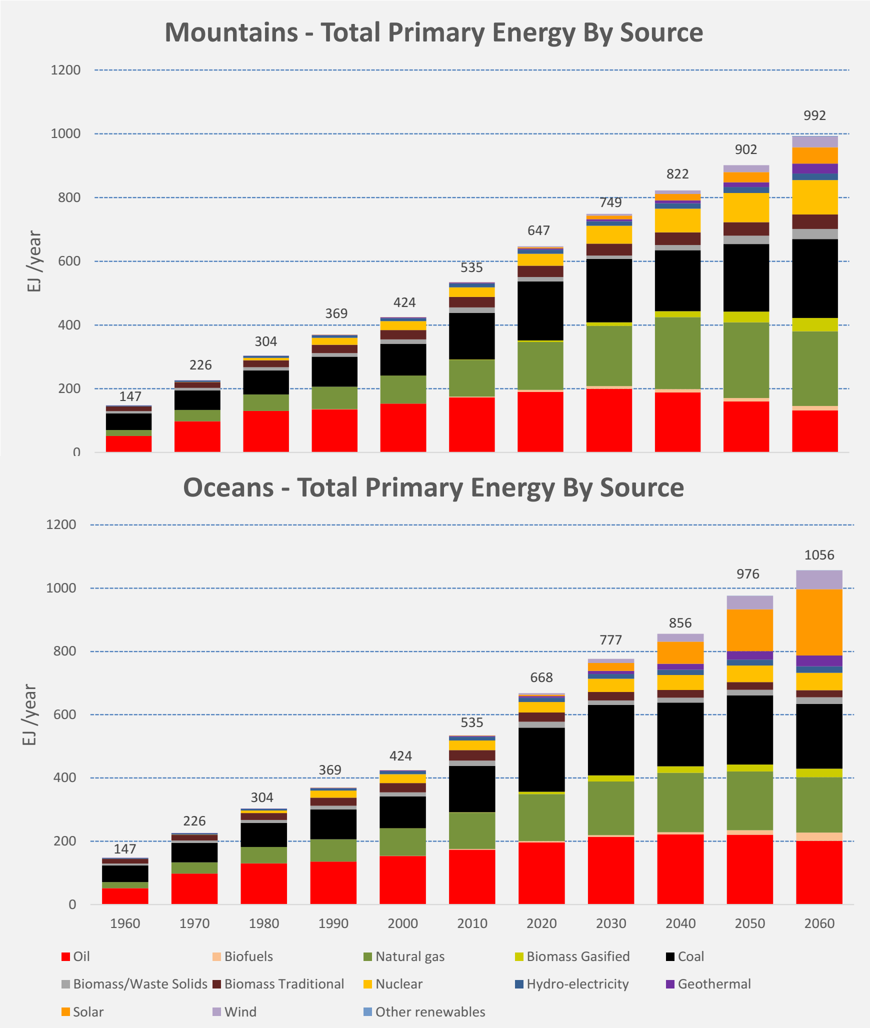
IEA WEO

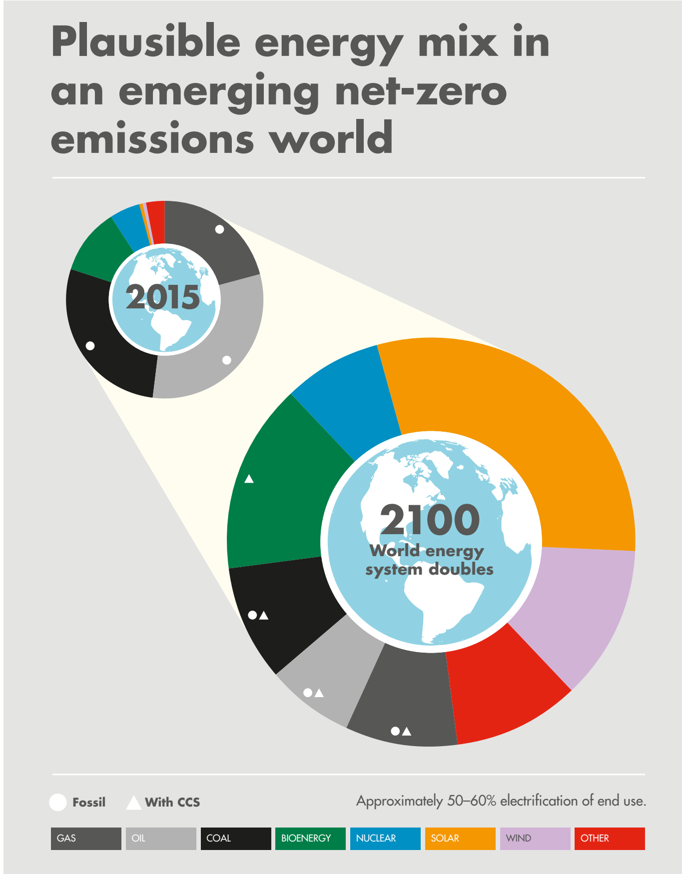
- Large investment needs to keep supply flowing, even more to decarbonize
- The Paris goal (1.5ºC) is almost unachievable



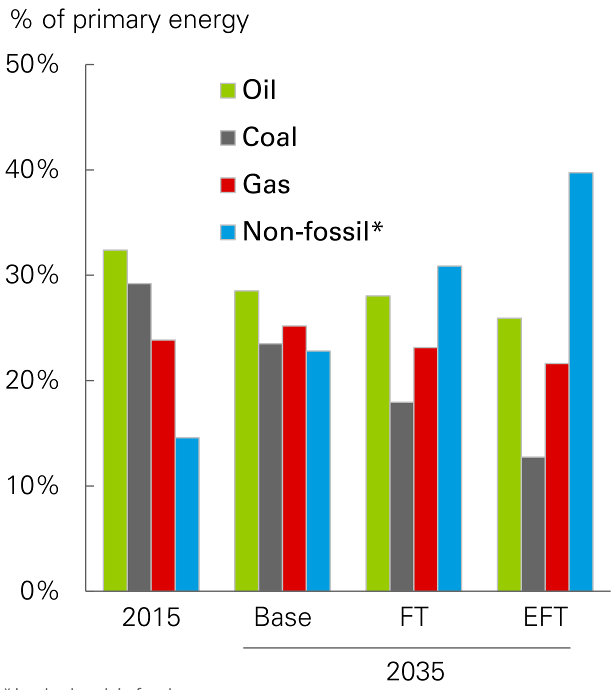


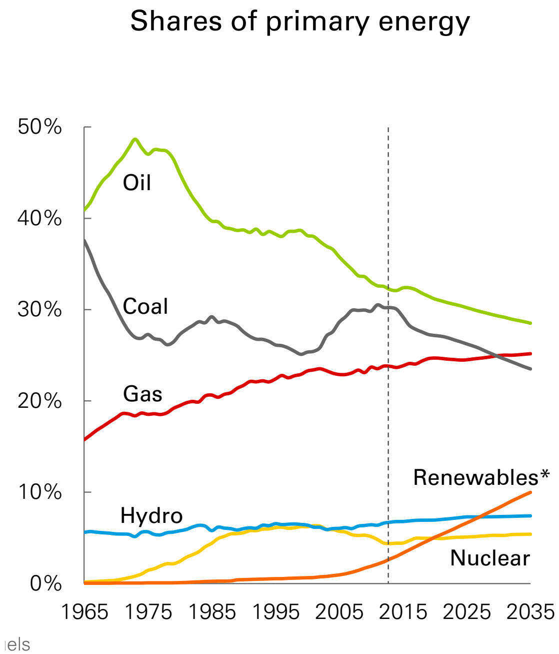
Shell

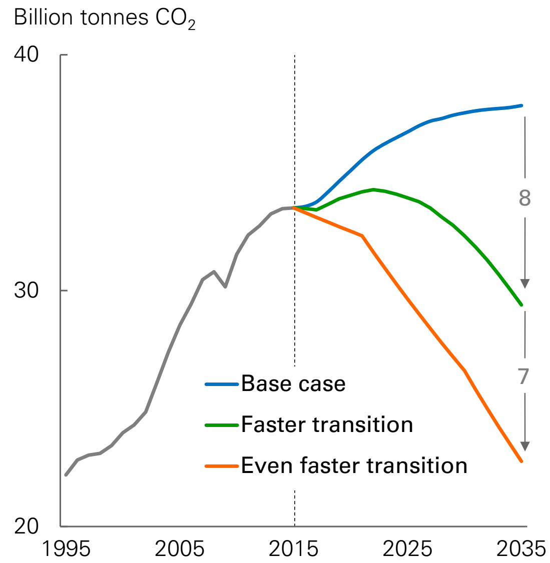

Mountains - Total Primary Energy By Source
EJ /year
1200
1000
800
600
400
200
0
147
226
304
369
424
535
647
749
822
902
992
Oceans - Total Primary Energy By Source
EJ /year
147
226
304
369
424
535
668
777
856
976
1056
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
Oil
Biofuels
Natural gas
Biomass Gasified
Coal
Biomass/Waste Solids
Biomass Traditional
Nuclear
Hydro-electricity
Geothermal
Solar
Wind
Other renewables

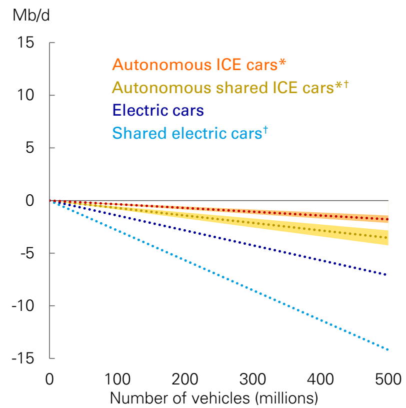

Plausible energy mix in an emerging net-zero emissions world
2015
2100
World energy system doubles
Fossil
With CCS
Approximately 50–60% electrification of end use.
GAS
OIL
COAL
BIOENERGY
NUCLEAR
SOLAR
WIND
OTHER

BP Outlook



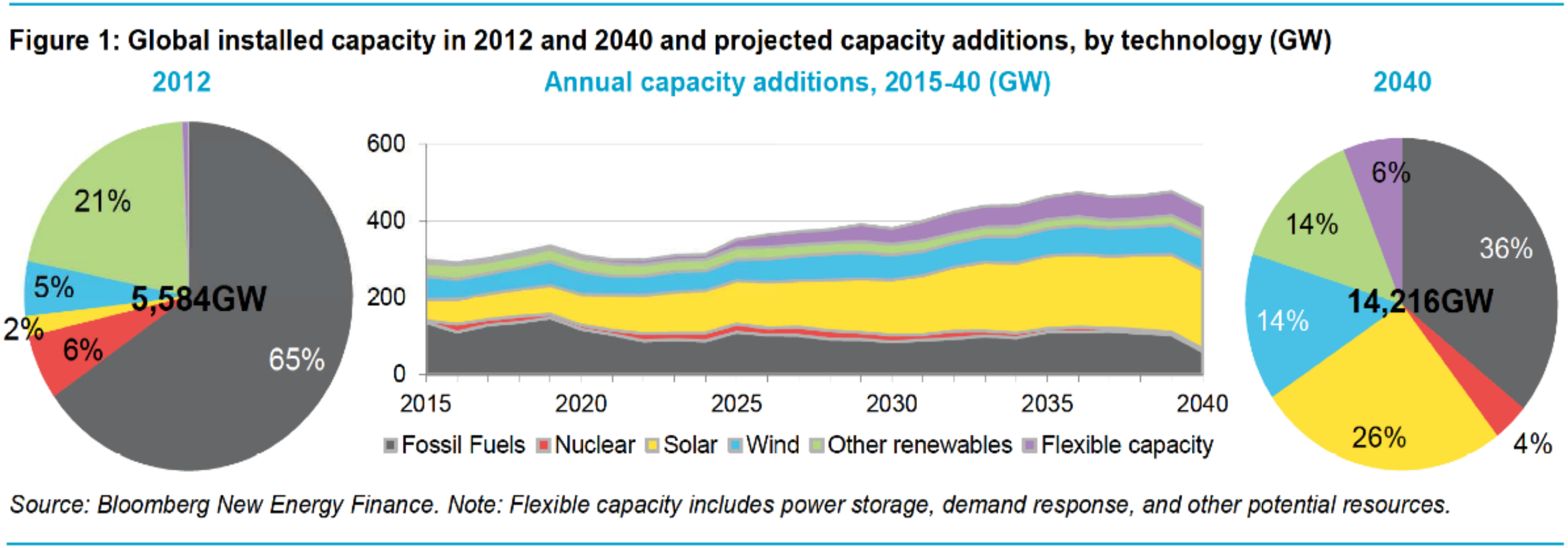






- Global resource abundance
- Increased car ownership – but electric cars remain anecdotal
- Oil demand for cars keeps growing
- Resources are not the problem
- Demand revised down, RES revised up

Bloomberg NEF



- Renewables rule
- Thanks to technological development
- Decentralized in developed countries, centralized in developing ones

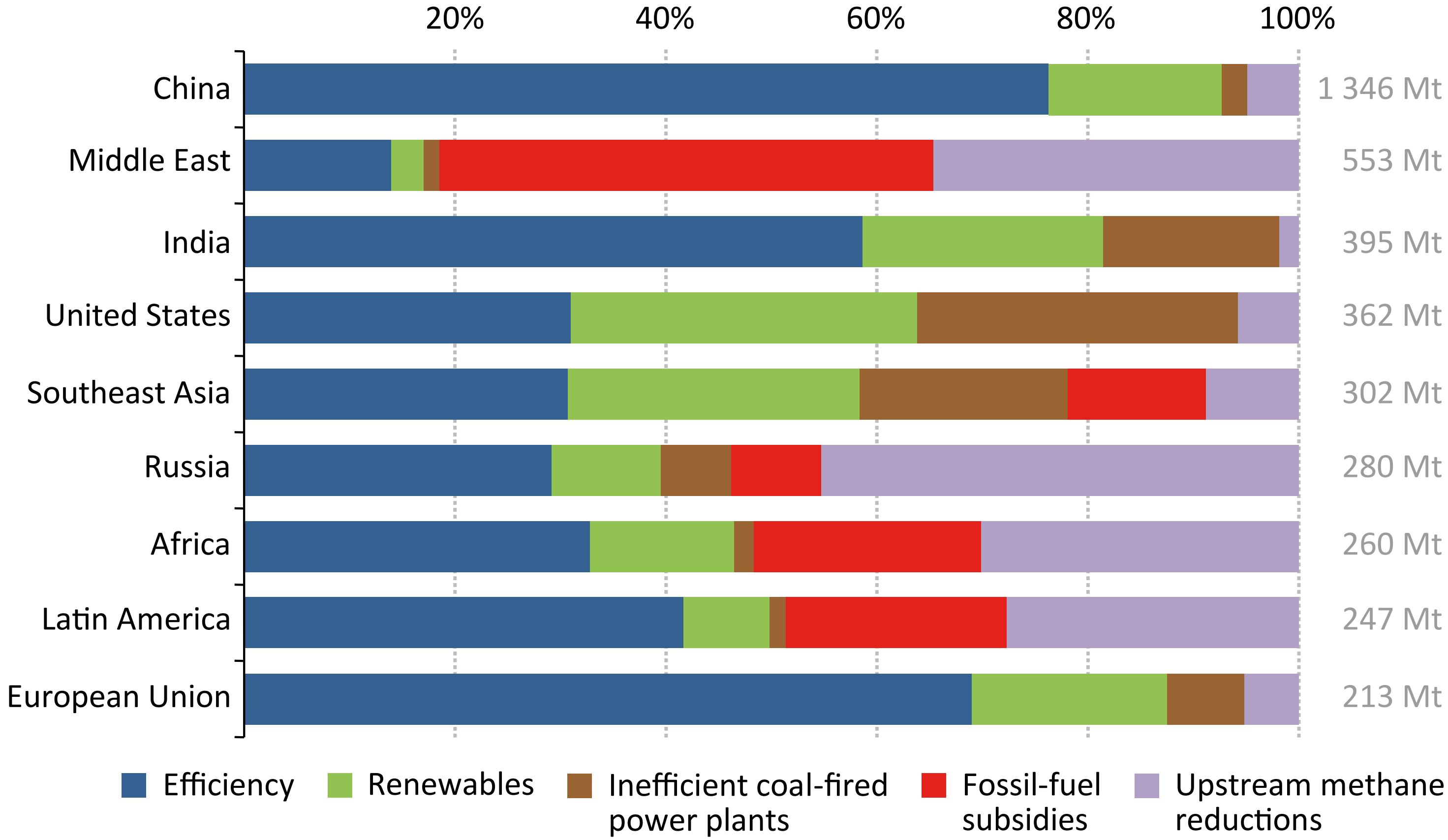
Large differences in building blocks

	Faster transition	Even faster transition	IEA 450	MIT 2º Base	IHS Markit 'Solar Efficiency'	Greenpeace 'Revolution'
CAGR (%)* 2015-2035						
Carbon emissions	-0.7%	-2.0%	-2.0%	-2.0%	-2.8%	-3.2%
Total energy	0.9%	0.8%	0.4%	0.5%	-0.7%	-0.1%
Energy intensity	-2.4%	-2.5%	-3.0%	-2.9%	-4.0%	-3.5%
Carbon intensity	-1.5%	-2.7%	-2.3%	-2.5%	-2.1%	-3.5%
Share of total energy, 2035						
Oil & gas	51%	48%	48%	46%	51%	39%
Renewables†	16%	23%	17%	29%	19%	38%
Share of abatement vs. 2015						
Power sector	>100%	89%	77%	74%	58%	35%

Large differences among regions (I)

Large differences among regions (II)

Figure 3.4 ▷ Energy-related GHG emissions reduction in CO_2-eq terms by policy measure and region in the Bridge Scenario relative to the INDC Scenario, 2030



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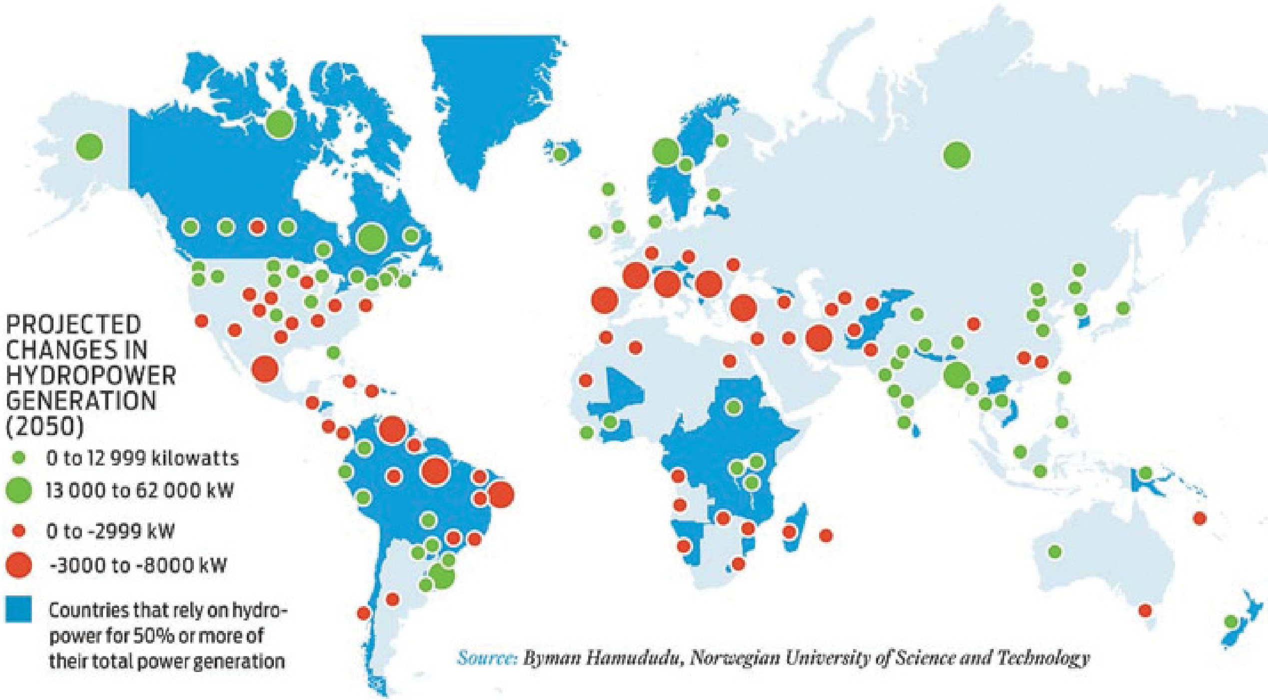
And climate changes: hydro

Box 3.1. Projected Changes in Hydropower Generation

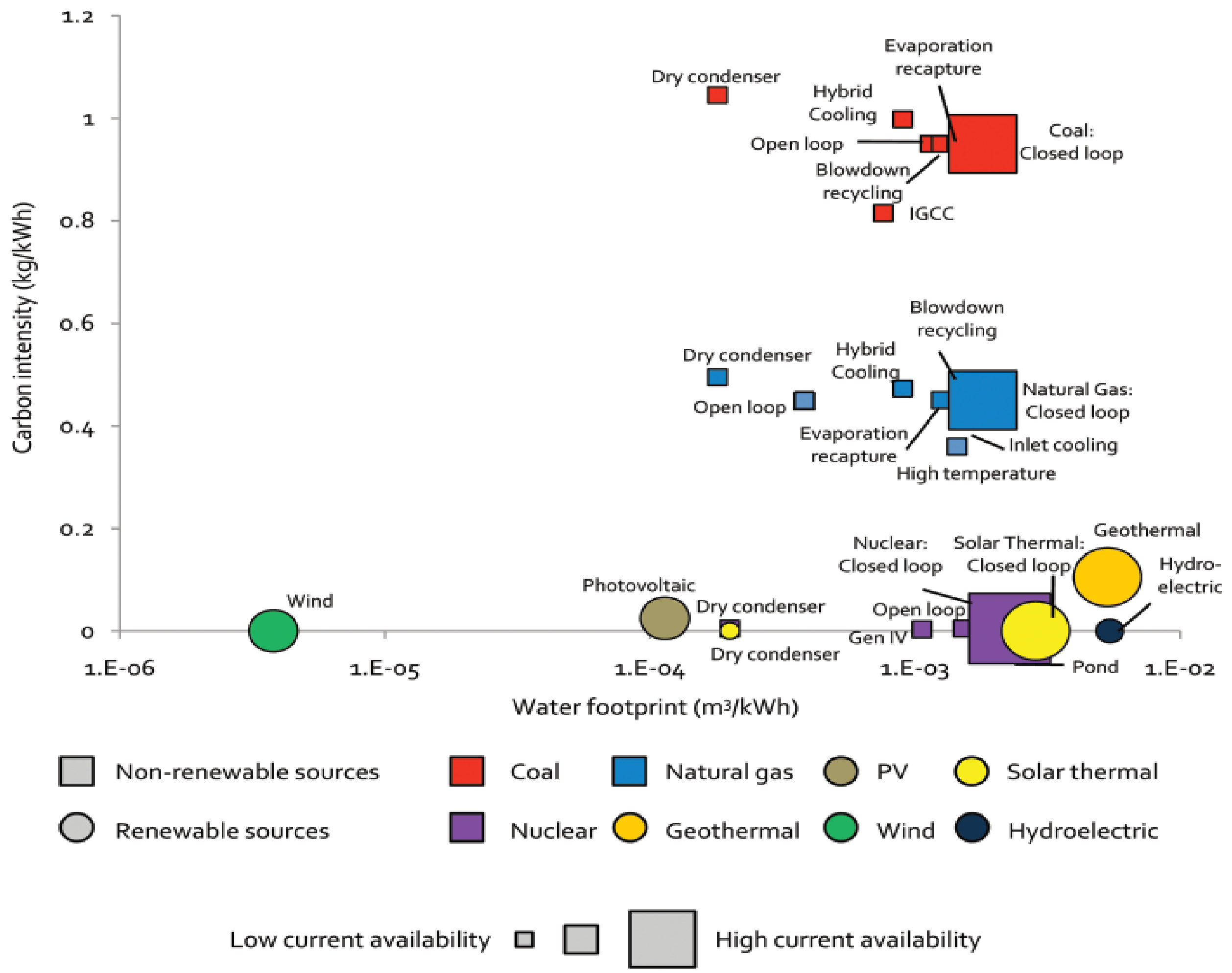
Modeling by the Norwegian University of Science and Technology examined climate impacts on river flows and hydropower generation to 2050. Systems at highest risk had both a high dependence on hydropower generation for electricity and a declining trend in runoff. South Africa is quoted as one example with a potential reduction of 70 GWh per year in generation by 2050. Afghanistan, Tajikistan, Venezuela, and parts of Brazil face similar challenges.



Source: Hamududu and Killingtveit, 2010.

And not all technologies use the same water

Figure 3.4. Effect of Emerging Technologies on Carbon and Water Intensity of Electricity Sources



Source: Lux Research, 2009.

Common themes

- The economy grows fast (3-4% pa)
- Energy demand continues growing (30-35% by 2040)
  - In non-OCDE countries
- Electricity grows faster
- Fossils maintain their rule
  - Decarbonization is not fast enough
  - Increasing role of gas and renewables
    - Renewables increase due to technological advances
  - But climate goals cannot be achieved
- Geopolitical changes

economics for energy

Some points for discussion

- Many scenarios are plausible
  - But demand growth is critical
- Gas vs Coal: Leaks and atmospheric emissions
- Electrification seems the cheaper way
- The role of nuclear
- The role of CCS
- Transport: NatGas vs Biofuels vs Electricity
- Do we need more storage?

economics for energy

And some additional questions

- How to deal with bridge technologies (and the associated infrastructure)?
- How to deal with networks (and their fixed costs)?
- Markets vs Regulation?

Thanks for your attention

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