Major Issues for Sustainable Energy Development

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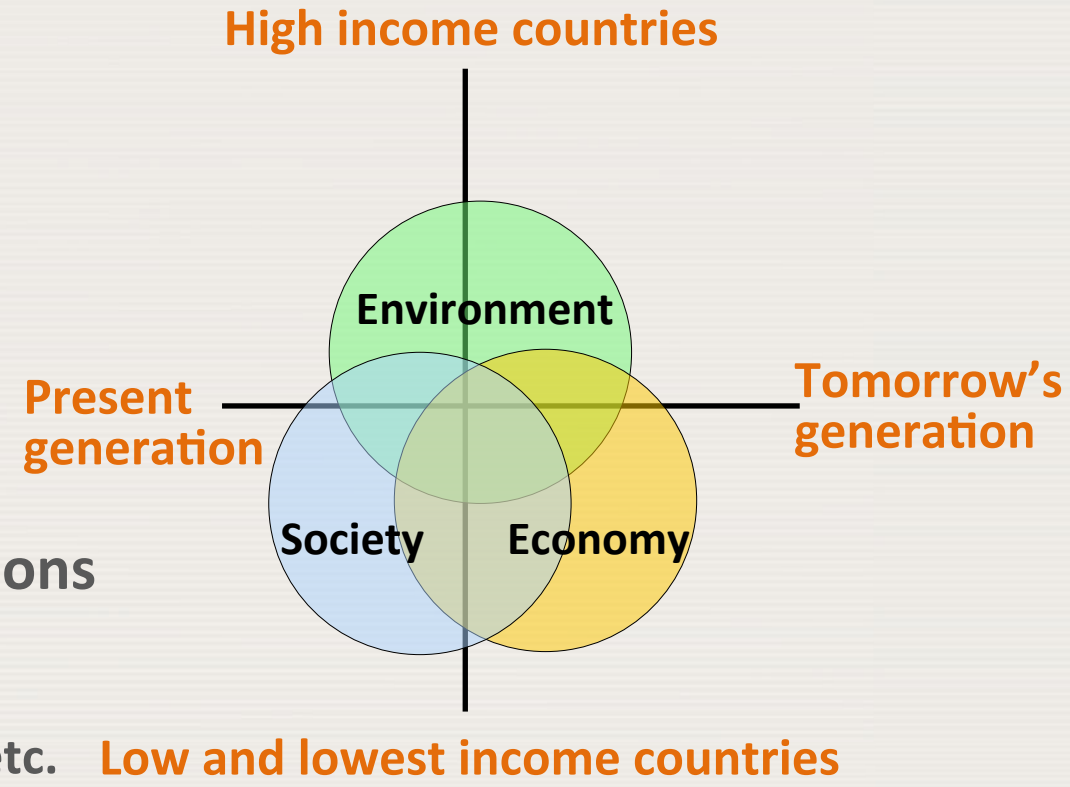
The energy tri-lemma

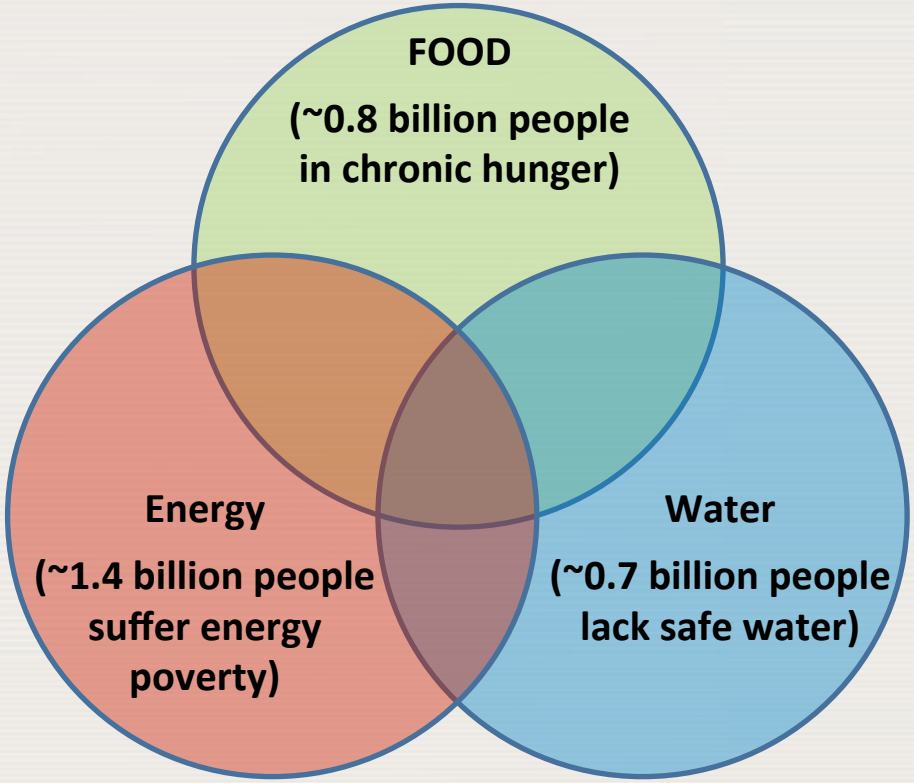
- Energy security
  - Supply security
  - Reliability
  - Access
- Competiveness
  - Costs of energy services
  - Affordability
- Environmental considerations
  - Climate change
  - Local and regional pollution
  - Water, land-use, materials, etc.



1. All these factors (and more) determine the sustainability of a particular technology, fuel or infrastructure (on a life cycle basis)!
2. Decision makers continuously face, and deal with, trade-offs between them

But energy is but one sustainable development issue….

- Energy, water and land-use (food) are intimately interlinked
- All affect the climate and are affected by the climate
- Therefore, issues related to water, energy or land use cannot be dealt with in isolation – only in an integrated manner with trade-offs explicitly considered
- Still, most water, energy and land-use planning, decision and policy making occurs in separate and disconnected institutional entities

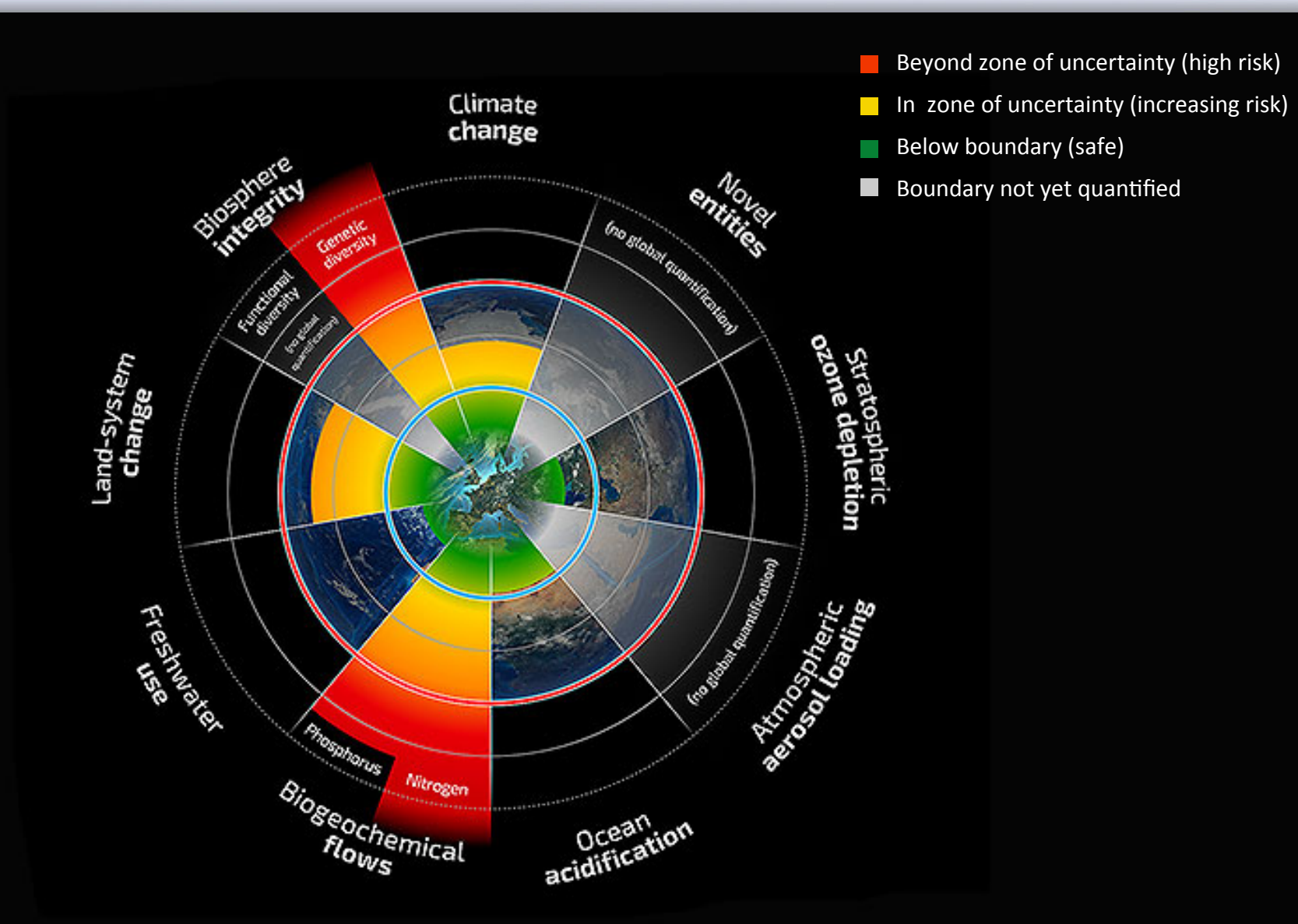


Source: Sharif, 2017

Agenda 2030 for Sustainable Development

- Clean and affordable energy services is the enabler for essentially all 17 SDGs - but that progress on energy occurs to the detriment of other goals and objectives is the challenge (and vice versa)

Planetary boundaries

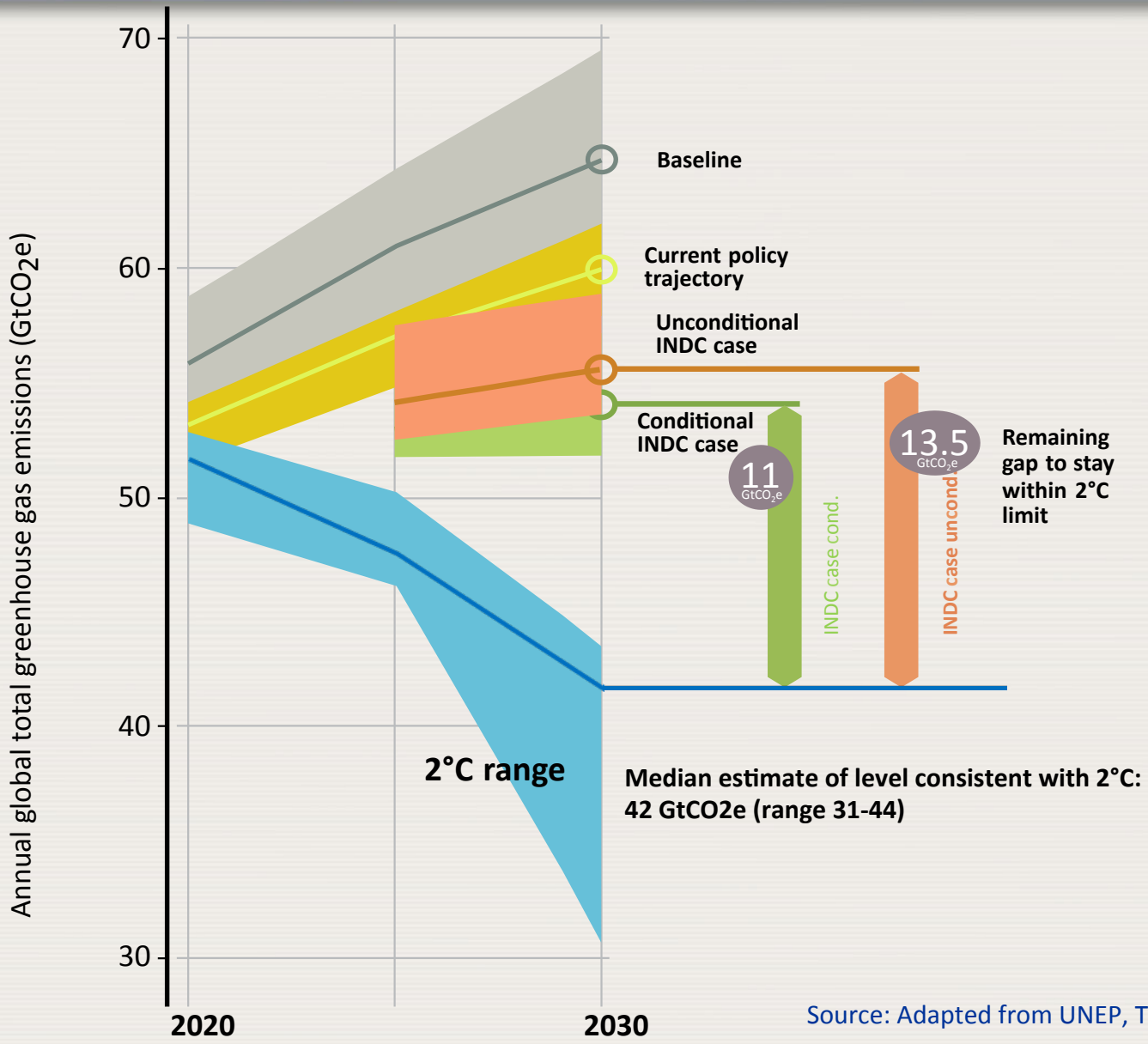


Source: J Rockström, 2016

Risk of climate destabilization – the world is on a warming track

- Paris Agreement (PA)
- Prevention of 'dangerous' anthropogenic interference with the climate system
  - Today taken to limit global mean temperature increase below 2^{o}C
  - Global emissions would have to peak within a few years
- The action window is rapidly closing
- Nationally Determined Contributions (NDCs) are the vehicle to deliver the climate objectives
- Under the PA, every country submits a national plan, i.e., the NDCs, how it is going to tackle its greenhouse gas emissions
- What we have seen so far, NDCs are necessary but not sufficient to not deliver the needed climate results

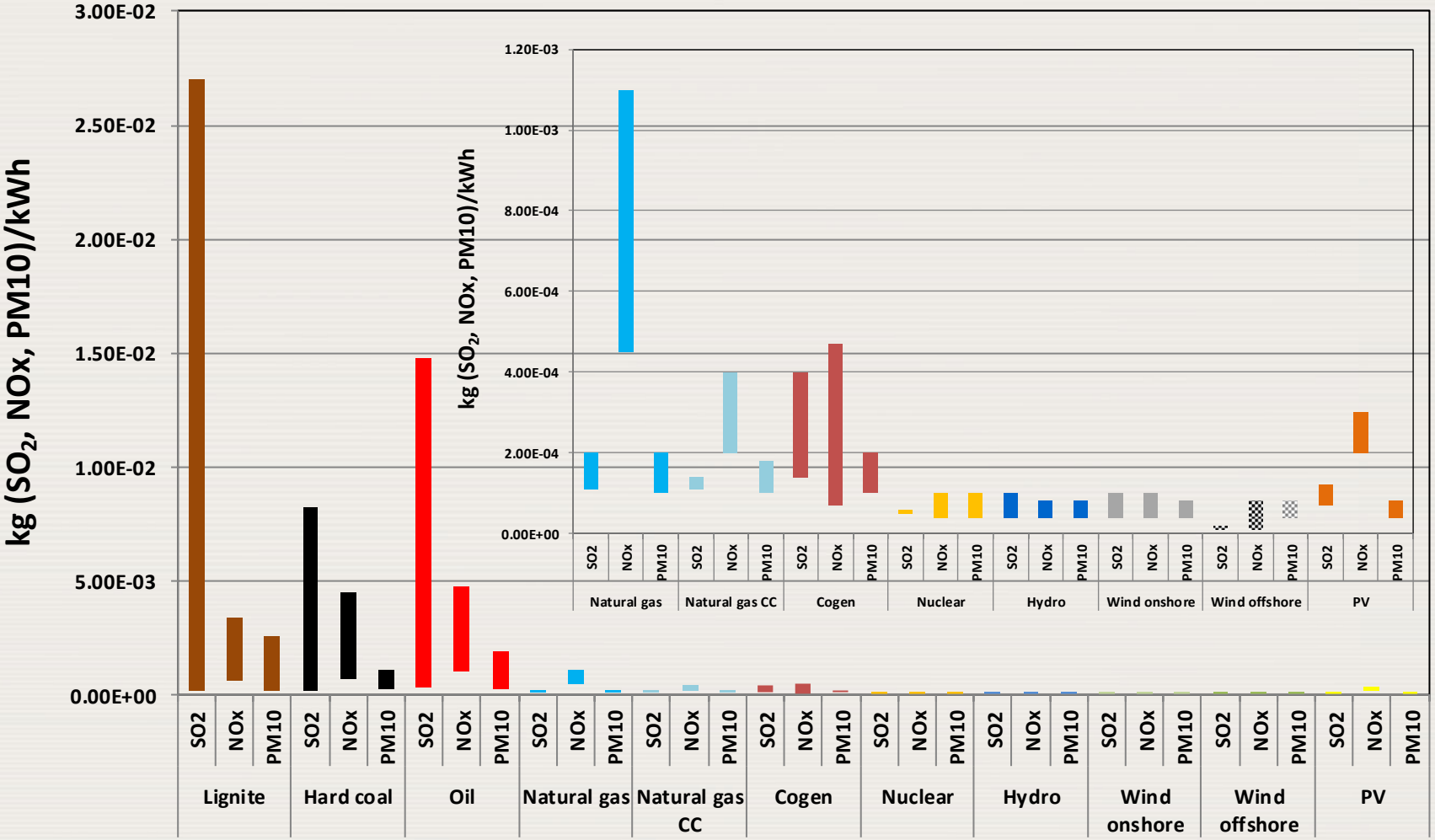
The Emissions Gap Report 2015/6



Source: Adapted from UNEP, The Emissions Gap Report 2015 -2017

Air pollution

Air pollution from selected electricity chains

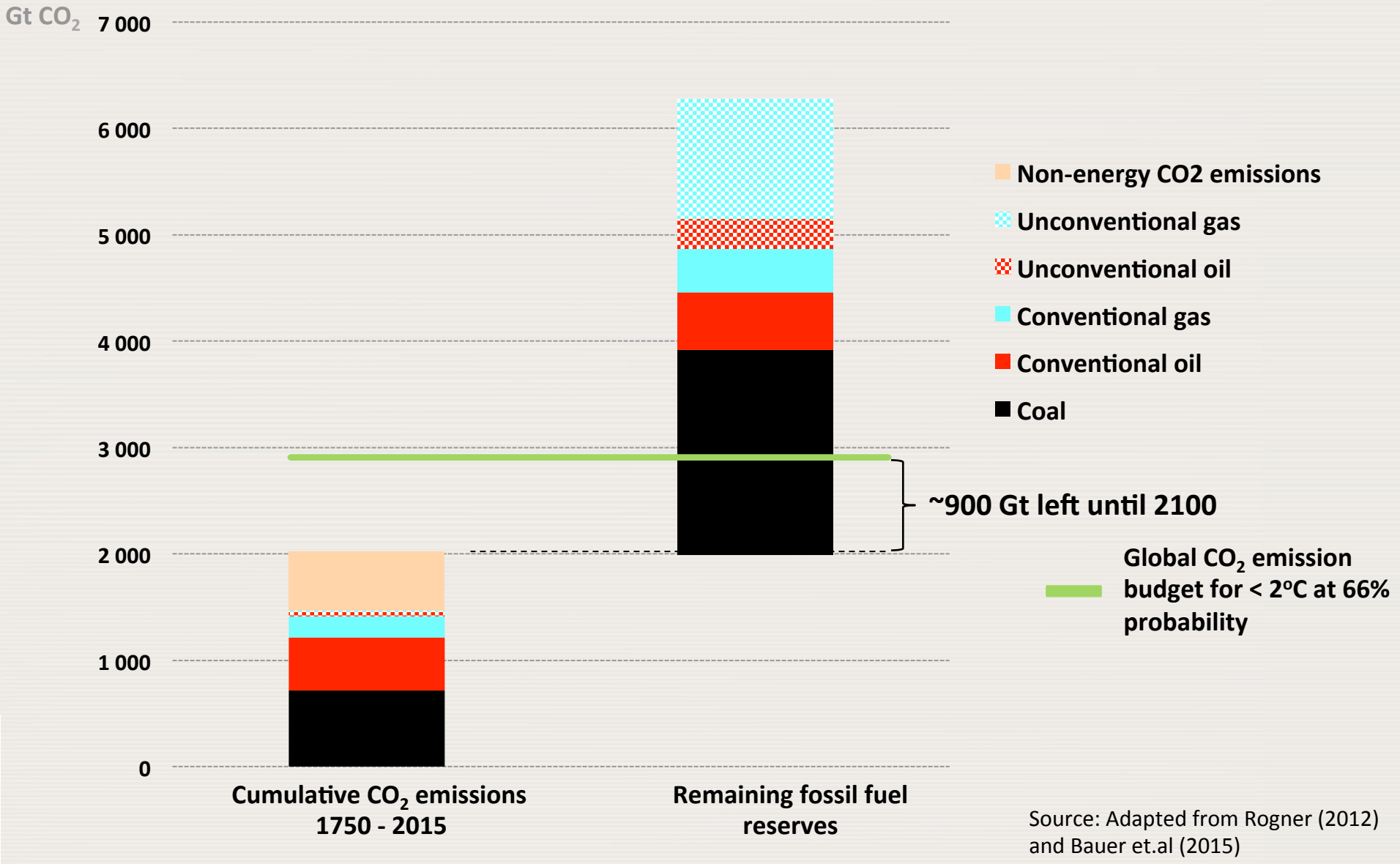


Source: Adapted from NEA (2007)

Key issues (non-exhaustive)

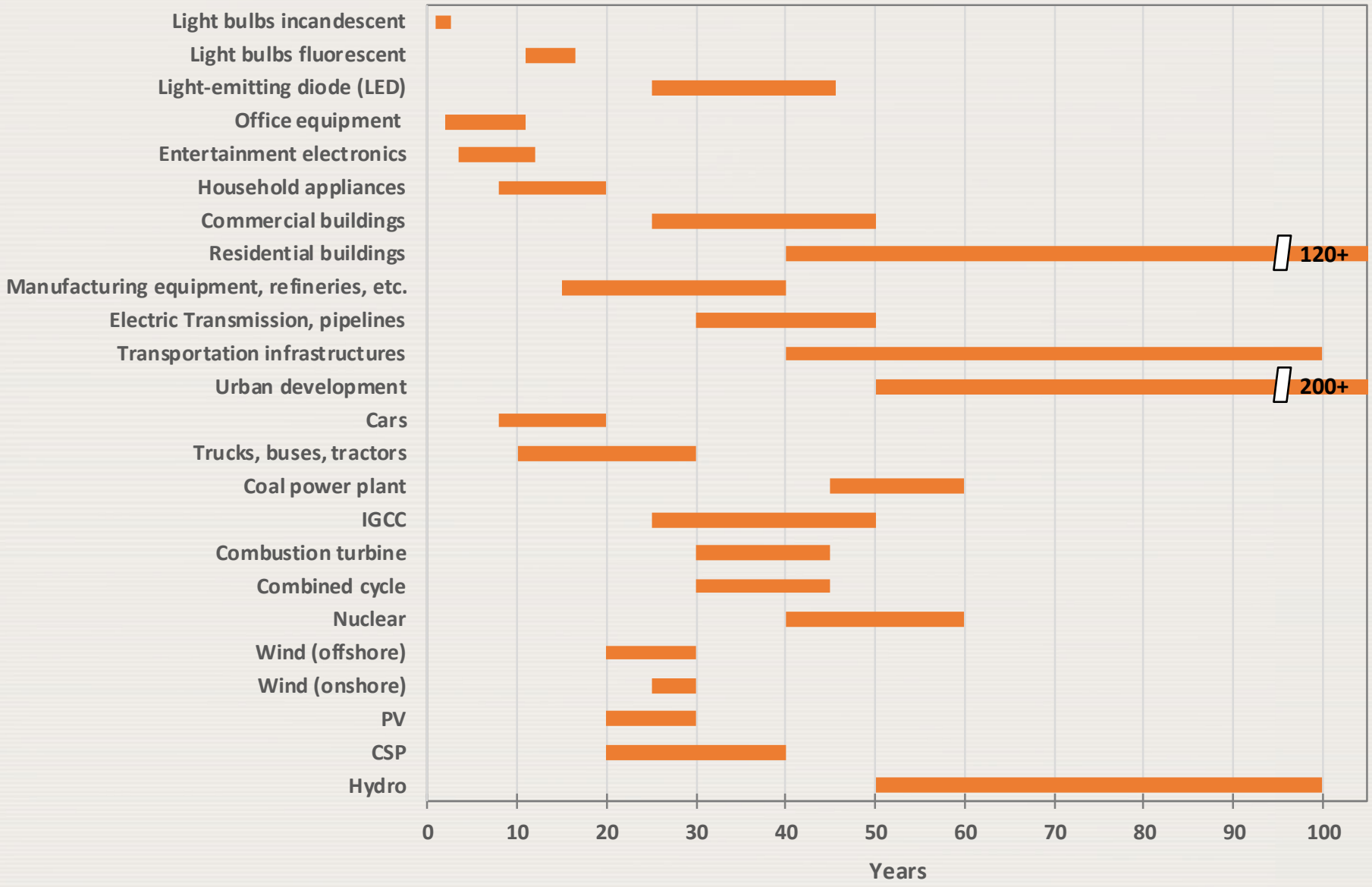
- Issue 1: Fossil fuels are still plentiful
  - often accessible to low and lowest income countries
  - subsidized
- Issue 2: Longevity of energy infrastructures
- Issue 3: Policies often are technology prescriptive rather than technology neutral and performance oriented
  - one size does not fit all
  - all countries are different
- Prices do not reflect full social costs
- Issue 3: Finance - the Achilles heel of system transformation
  - Finance flows consistent with pathways towards low greenhouse gas emissions and climate-resilient development (adaptation)
- Issue 4: Adaptation and equitable burden sharing

Fossil reserves, carbon contents & emission budget

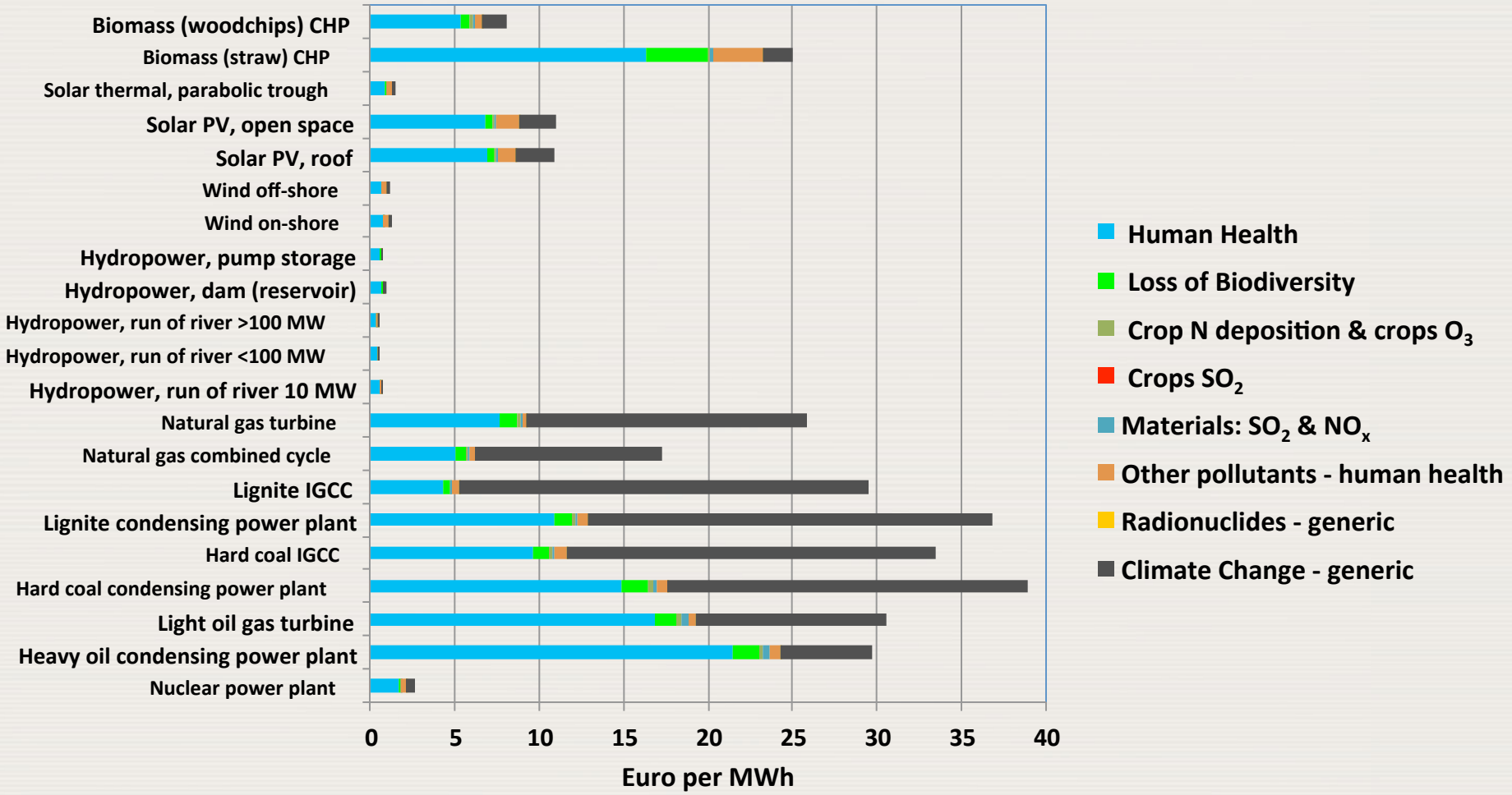


Source: Adapted from Rogner (2012) and Bauer et.al (2015)

Longevity of energy technologies and infrastructures

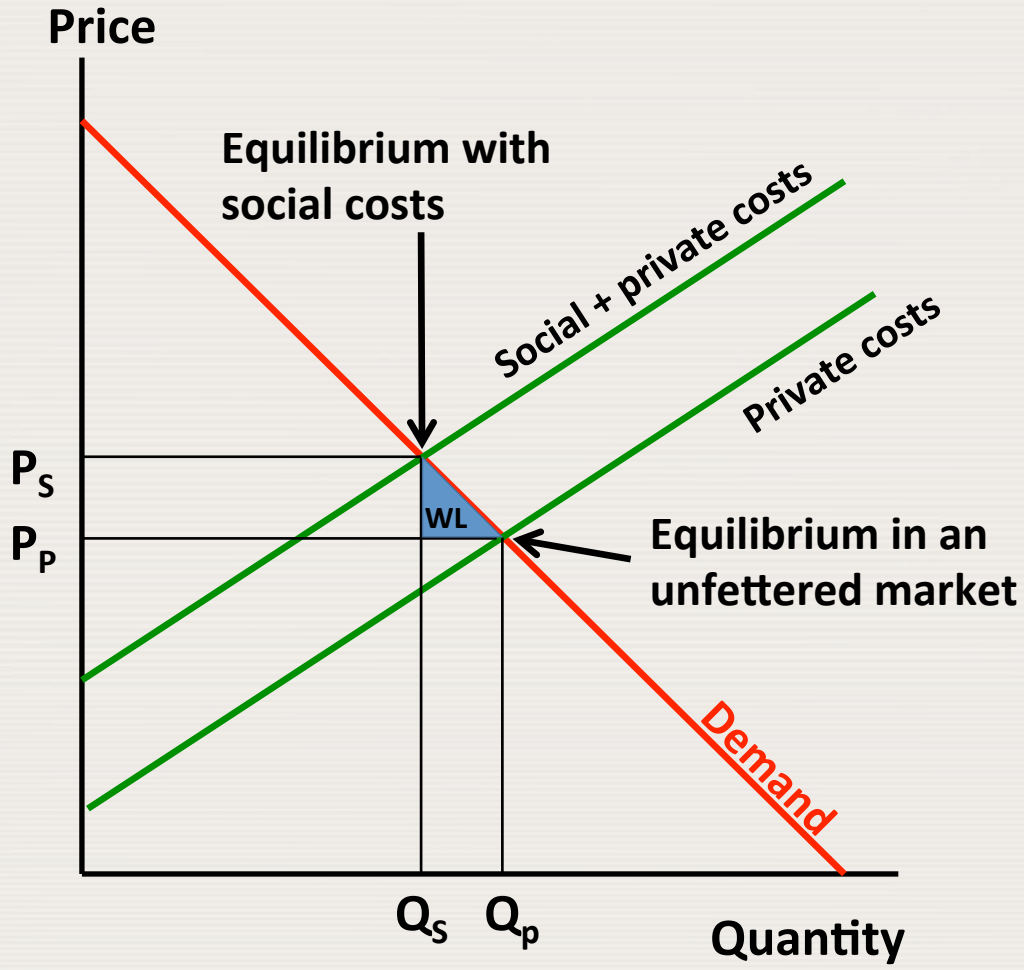


Externalities - electricity generation



Source: EU CASES Project (Markandya et al. 2011)

Contemporary challenges: Externalities



What is an externality?

A cost or benefit that is 'external' to the transaction...

Any examples?

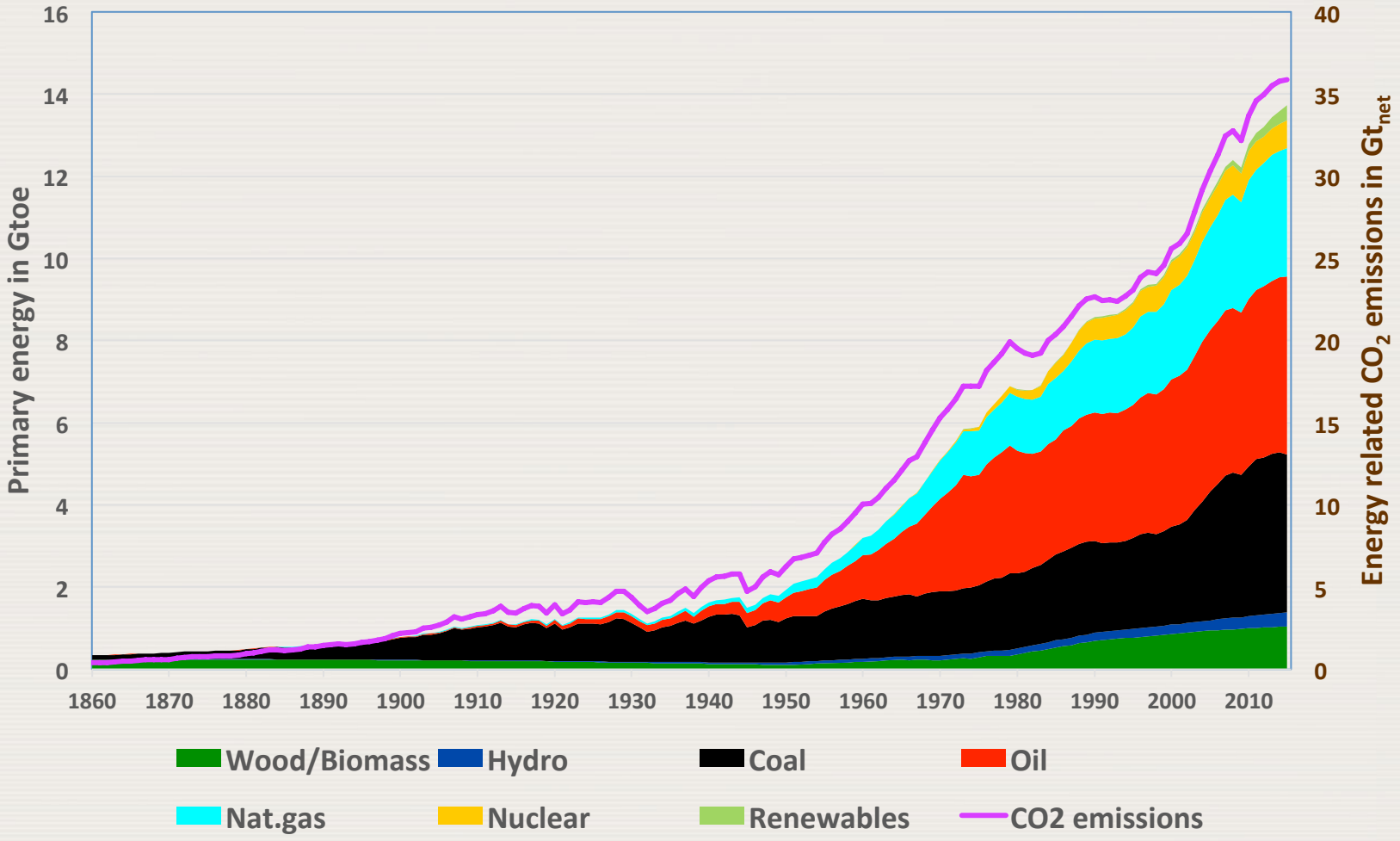
OK, so we damage the environment... how much are you willing to pay to:

- avoid the damage?
- fix the damage?
- live with the damage?

Energy system transformation

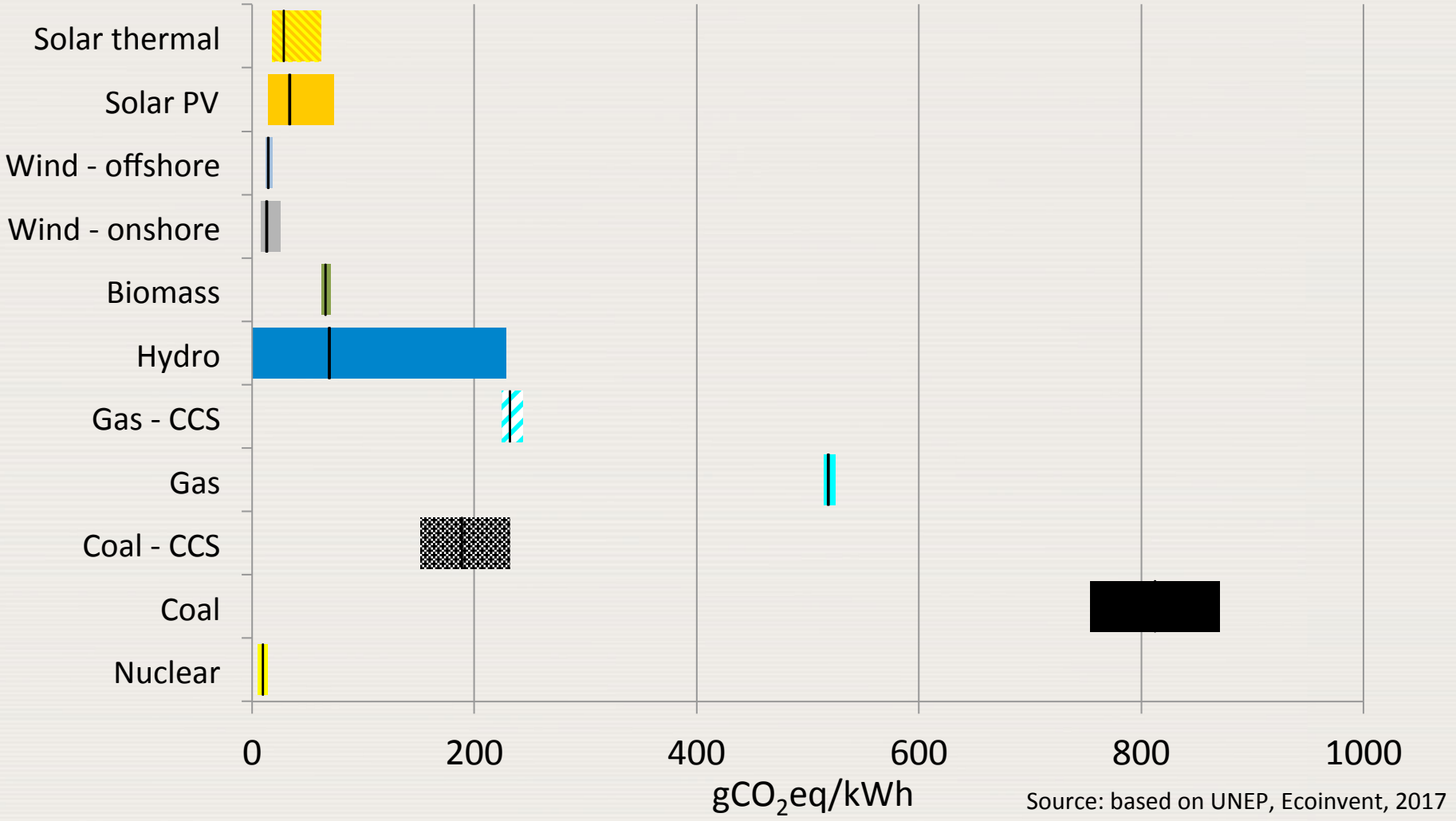
- Both the 2030 Agenda and the PA call for *fundamental (energy) system transformation* towards future energy systems that are
  - low GHG emitting
  - resilient and adaptive to climate change impacts
  - integral part of an overall socio-economic transition process
  - energy service delivery rather than selling kWh or MJ
  - more with less – reduce, recycle, reuse
  - make use of market mechanisms
  - account for externalities
  - cognizant of the energy-water-food nexus
- International cooperation and technology transfer
  - trade
  - shared regional infrastructures

Primary energy use and carbon emissions



Source: Adapted from IIASA and IEA databases

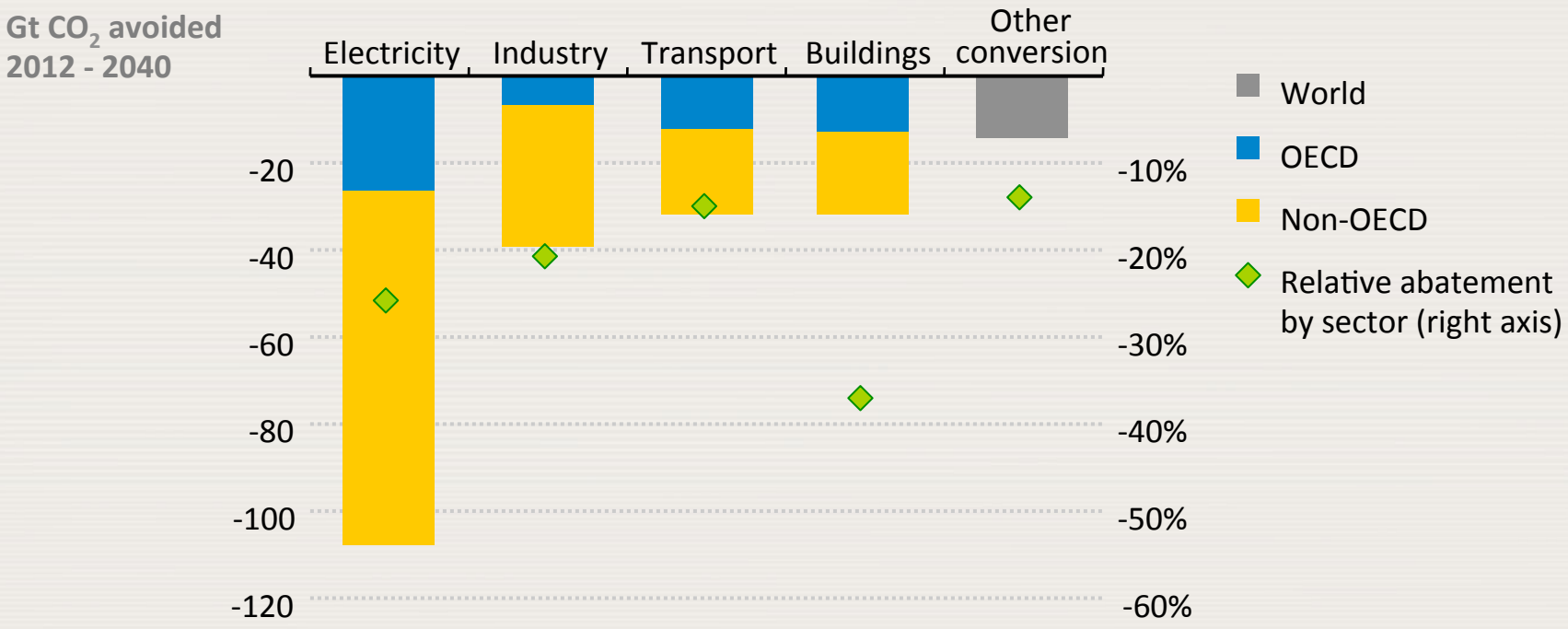
Mitigation – Role of different electricity generating technologies



Source: based on UNEP, Ecoinvent, 2017

Electricity generation offers the largest possibility of abatement in the short-to-medium term

Cumulative CO_2 emissions reduction by sector and region in the 450 Scenario relative to the New Policies Scenario

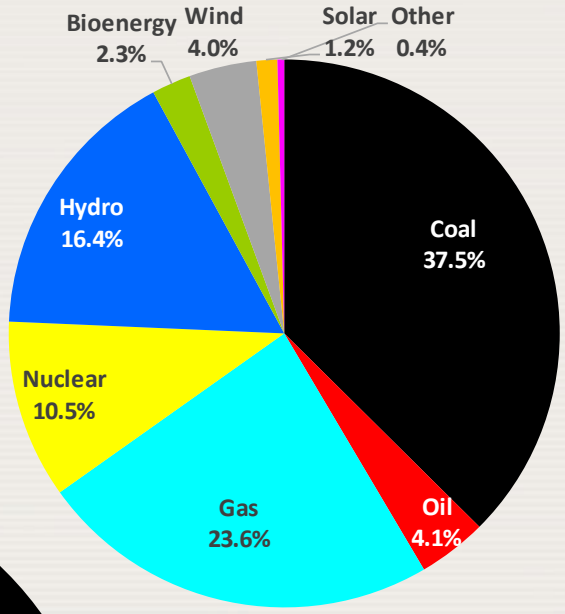


Decarbonizing electricity generation through 2040 by about 25% would take the world half-way towards limiting the temperature increase to 2°C

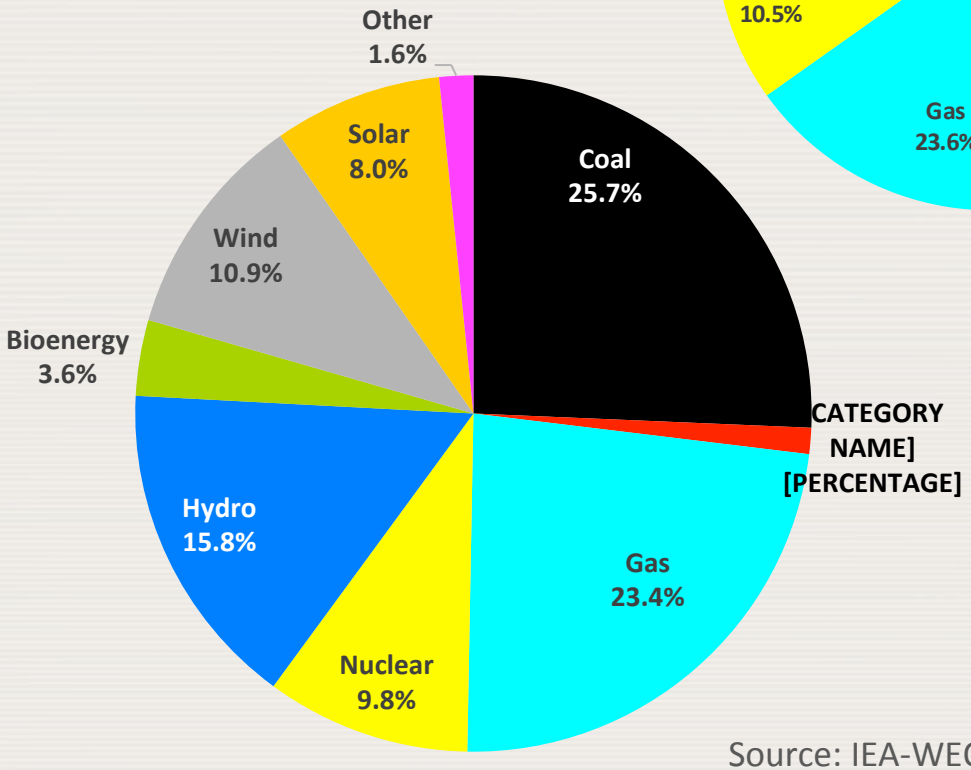
Source: IEA WEO 2014

Global electricity in 2040: New Policy Scenario (NPS) versus Sustainable Development Scenario(SDS)

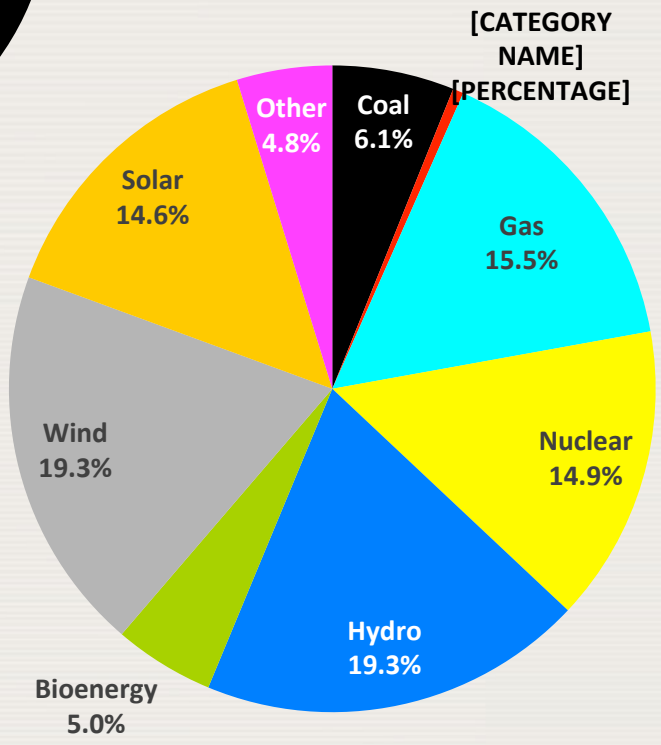
Generation 2016:
24 770 TWh



Generation NPS 2040:
39 290 TWh

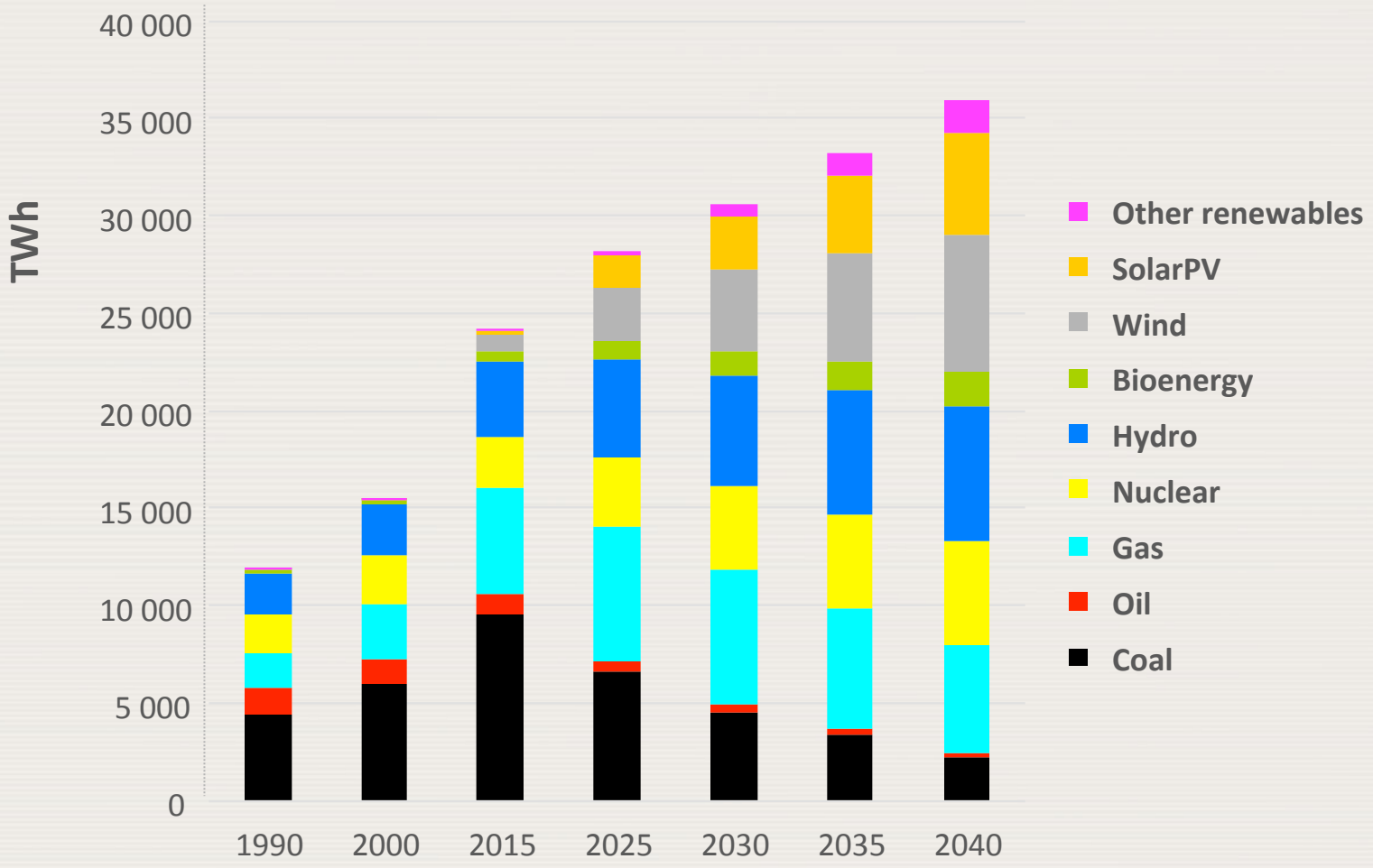


Generation SDS 2040:
35 981 TWh



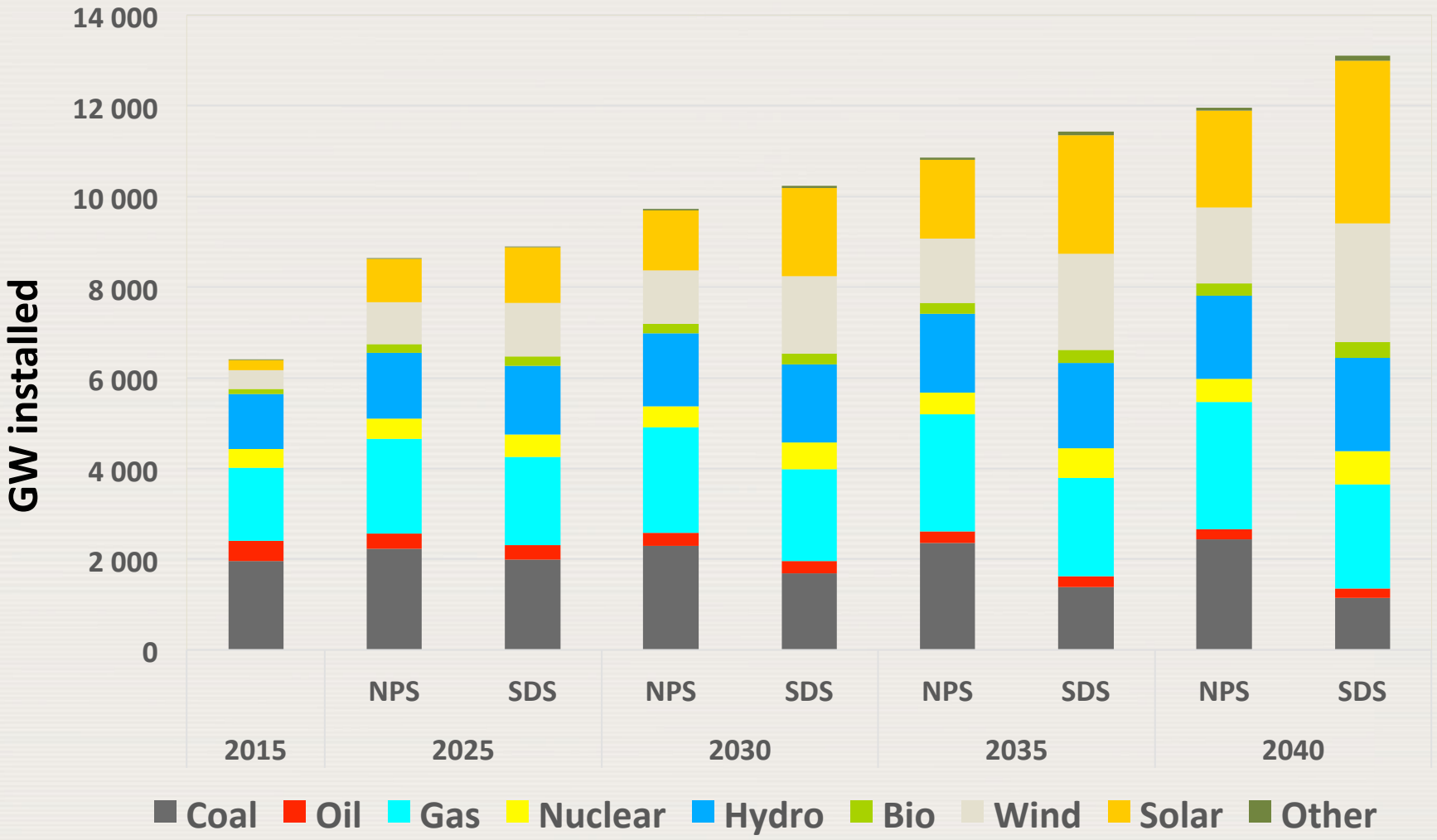
Source: IEA-WEO, 2017

Global electricity generation in a 2°C future



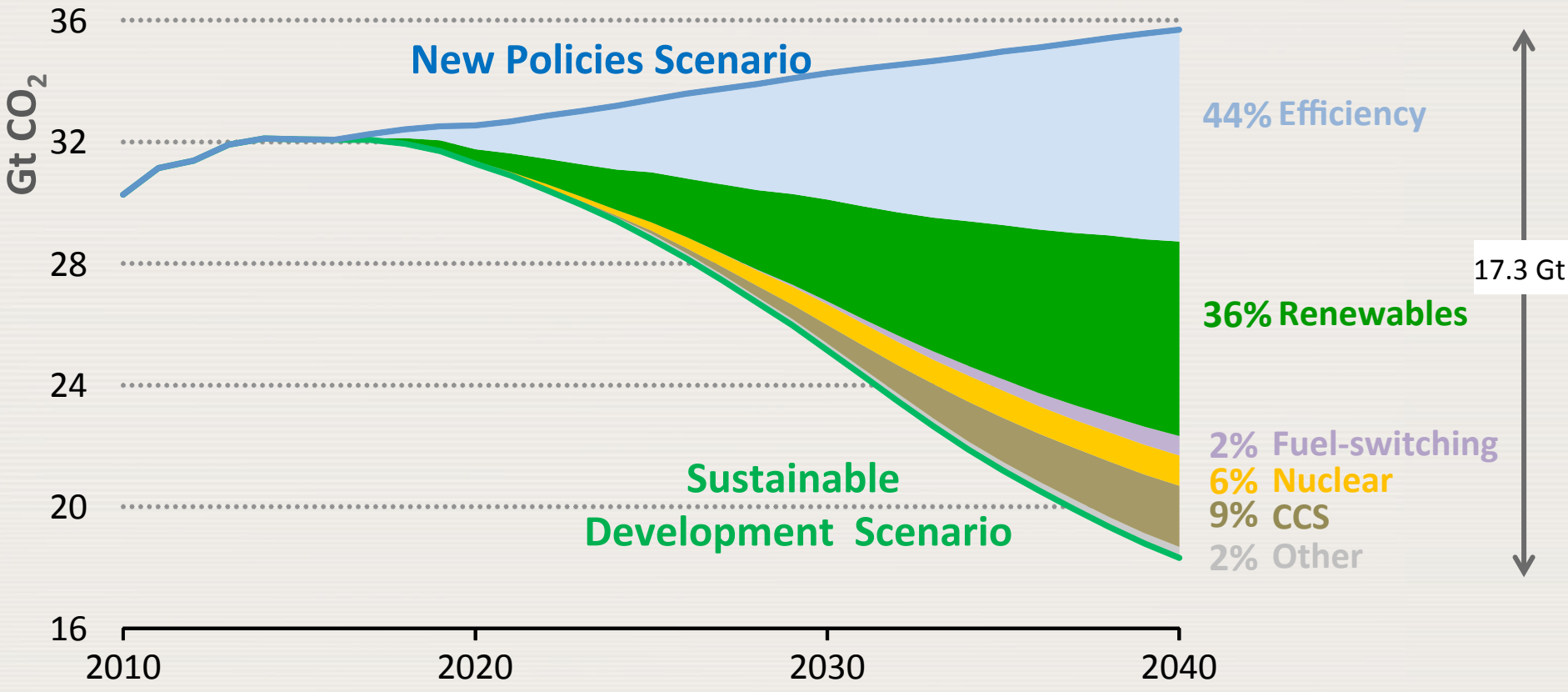
Source: IEA-WEO 2017

World electricity generating capacity by fuel and energy-related CO_2 emissions



A 2 °C pathway is still further efforts away

Global CO_2 emissions reductions from NPS to SDS



Energy efficiency and renewables account for 80% of the cumulative CO_2 emissions savings in the Sustainable Development Scenario

Source: IEA-WEO 2017 – Figure 3.15 p. 139

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

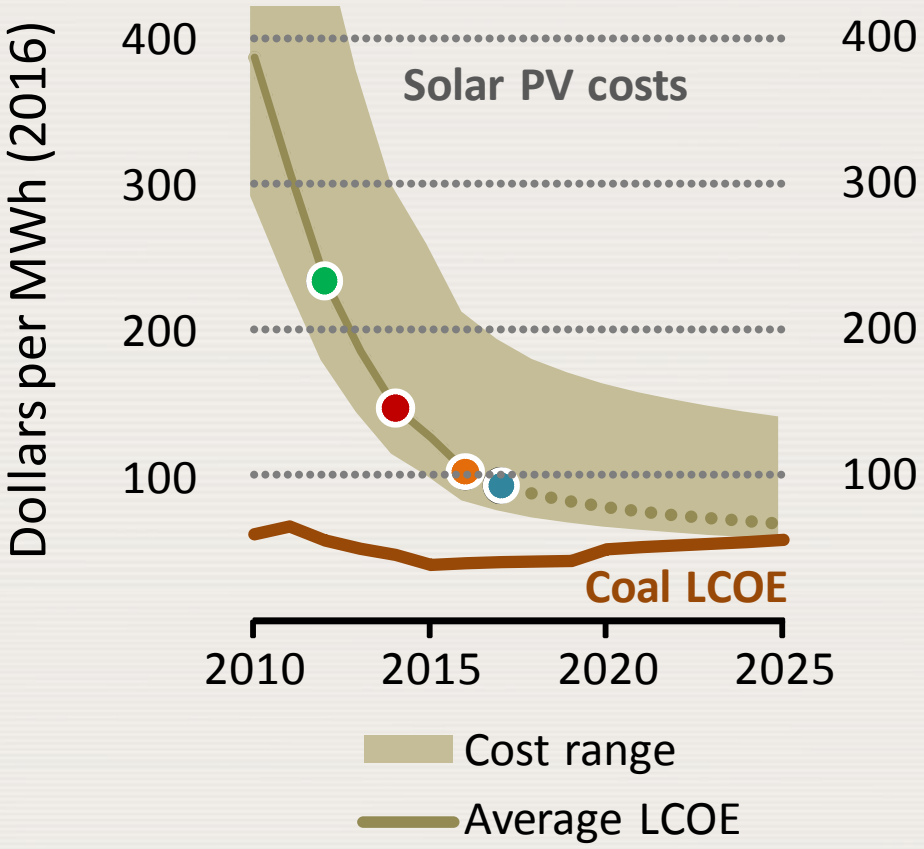
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

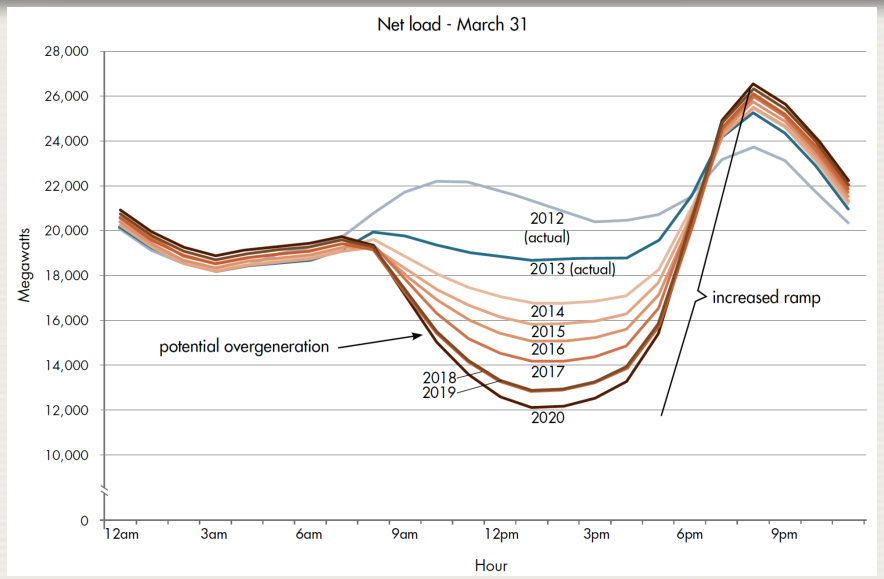
7.3 By 2030, double the global rate of improvement in energy efficiency

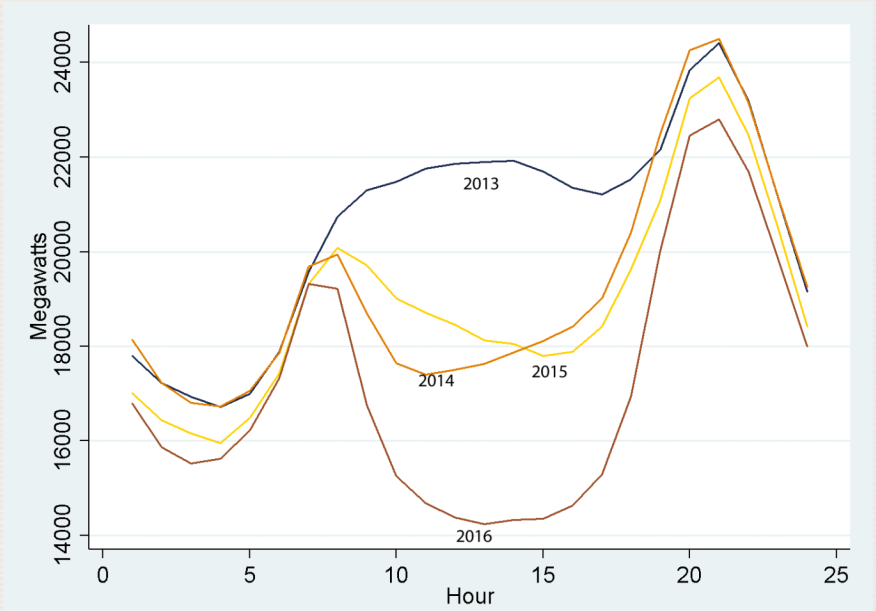
7.a By 2030, enhance international cooperation *to facilitate access to clean energy research and technology*, including renewable energy, energy efficiency and *advanced* and cleaner fossil-fuel technology, and *promote investment in energy infrastructure and clean energy technology*

7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries and small island developing States

Solar and wind are now the cheapest electricity around—unless you need to store it







Different generating cost levels

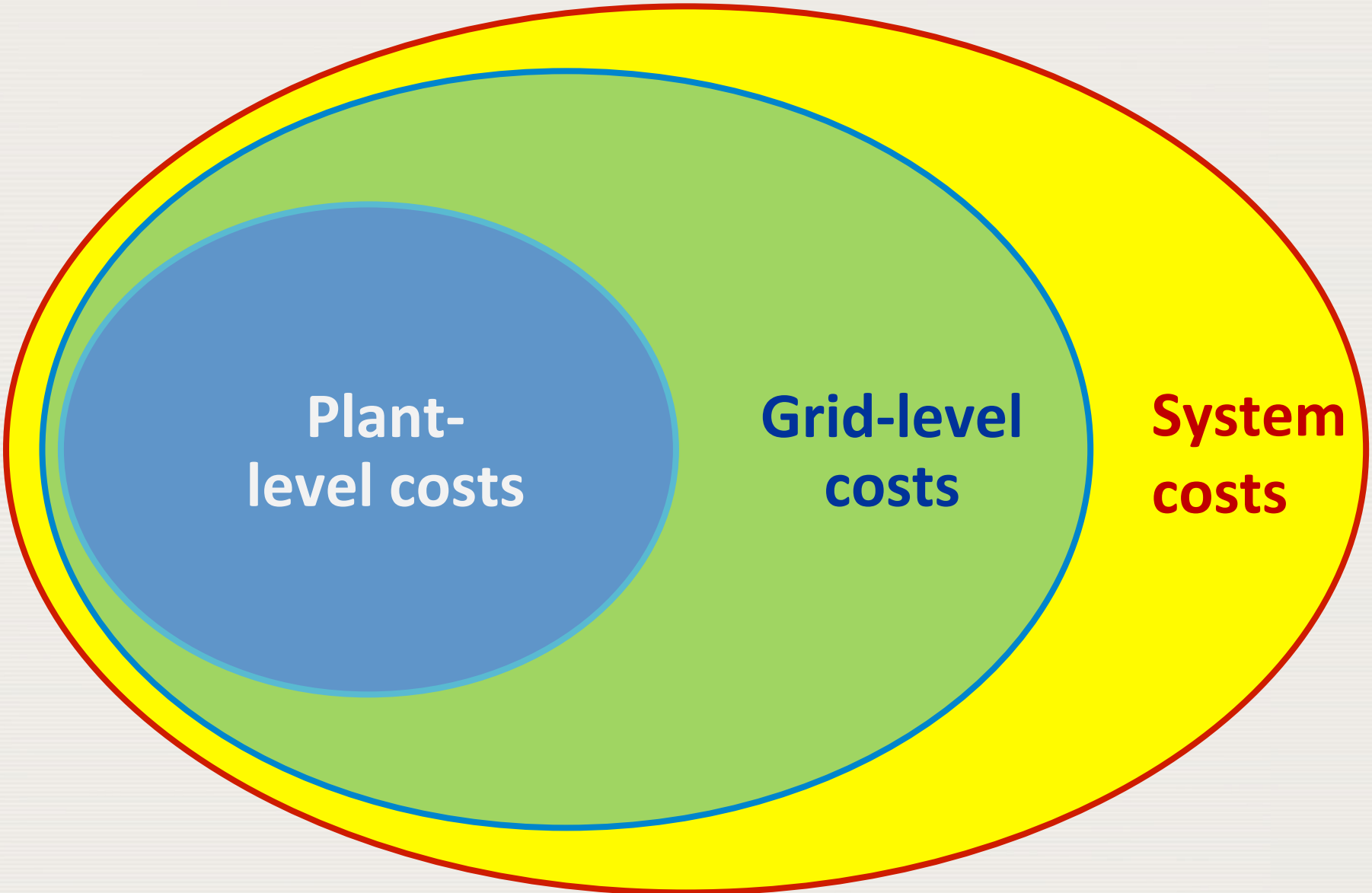
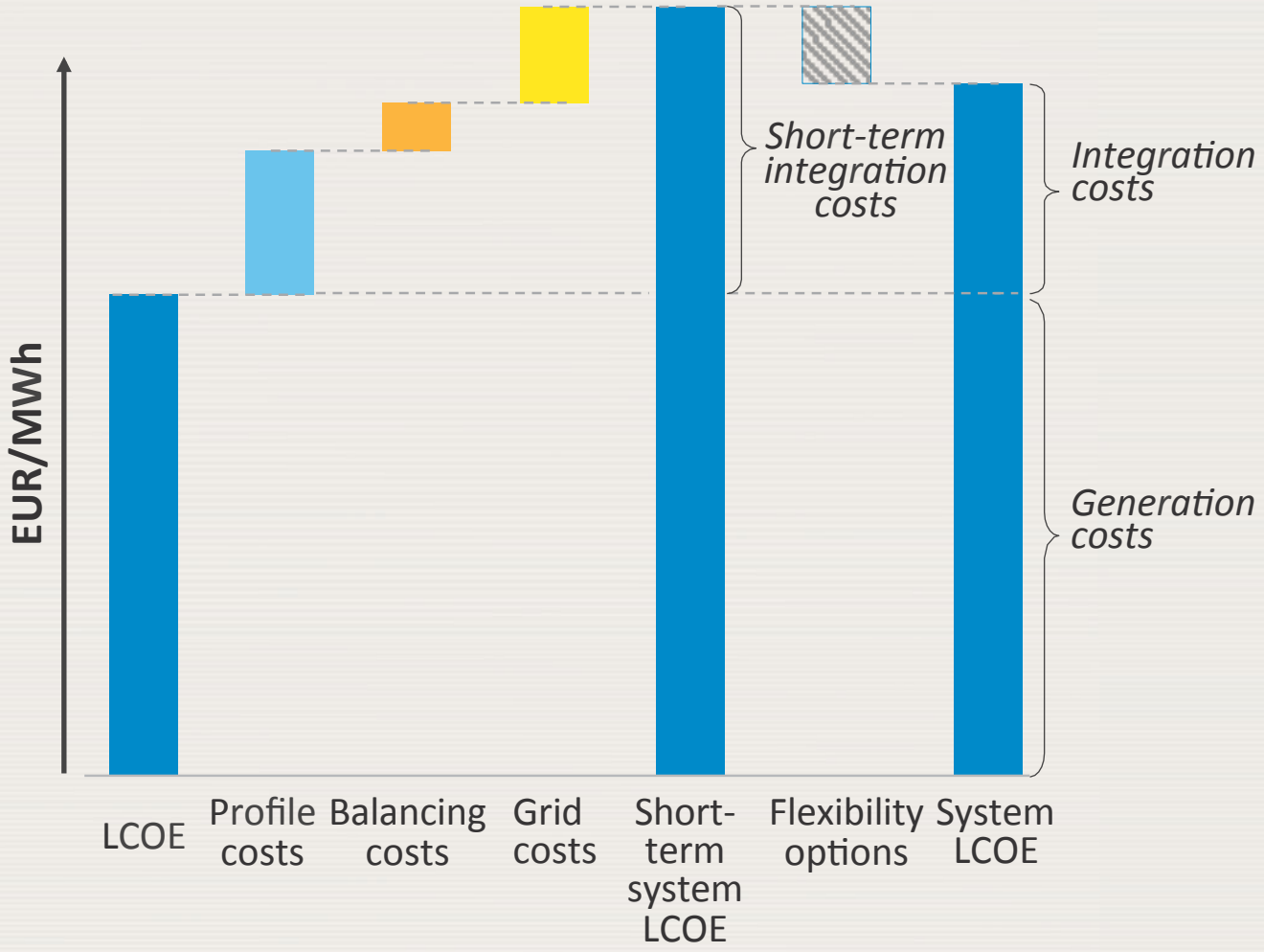


Illustration of electricity system costs

- *Profile (variability) cost:* Costs caused by the variability in the output of intermittency of wind, solar, etc. (back-up cost)
- *Balancing (uncertainty) cost:* Costs of uncertainty in the output of intermittent generation (frequent and close to real time changes in plant schedules, higher reserves)
- *Grid-related (location) costs:* Costs associated with the transmission and distribution of intermittent electricity from remote locations



LCOE = Levelized costs of electricity

Cities hold the key…..

- 54% of global population live in cities – and growing…
- Cities account for
  - ~85% of global GDP
  - ~67% of global primary energy demand
  - ~75% of GHG emissions
  - ~2% of global land cover
- A net increase of urban population of 2.4 billion by 2050
- So far international sustainable development efforts predominantly focus on rural issues (electrification, income generating activities, empowerment, access to markets, education, etc.) → high priority for poverty eradication
- Cities offer above average opportunities for integration, recycling and efficiency improvements with substantial reductions in energy intensities

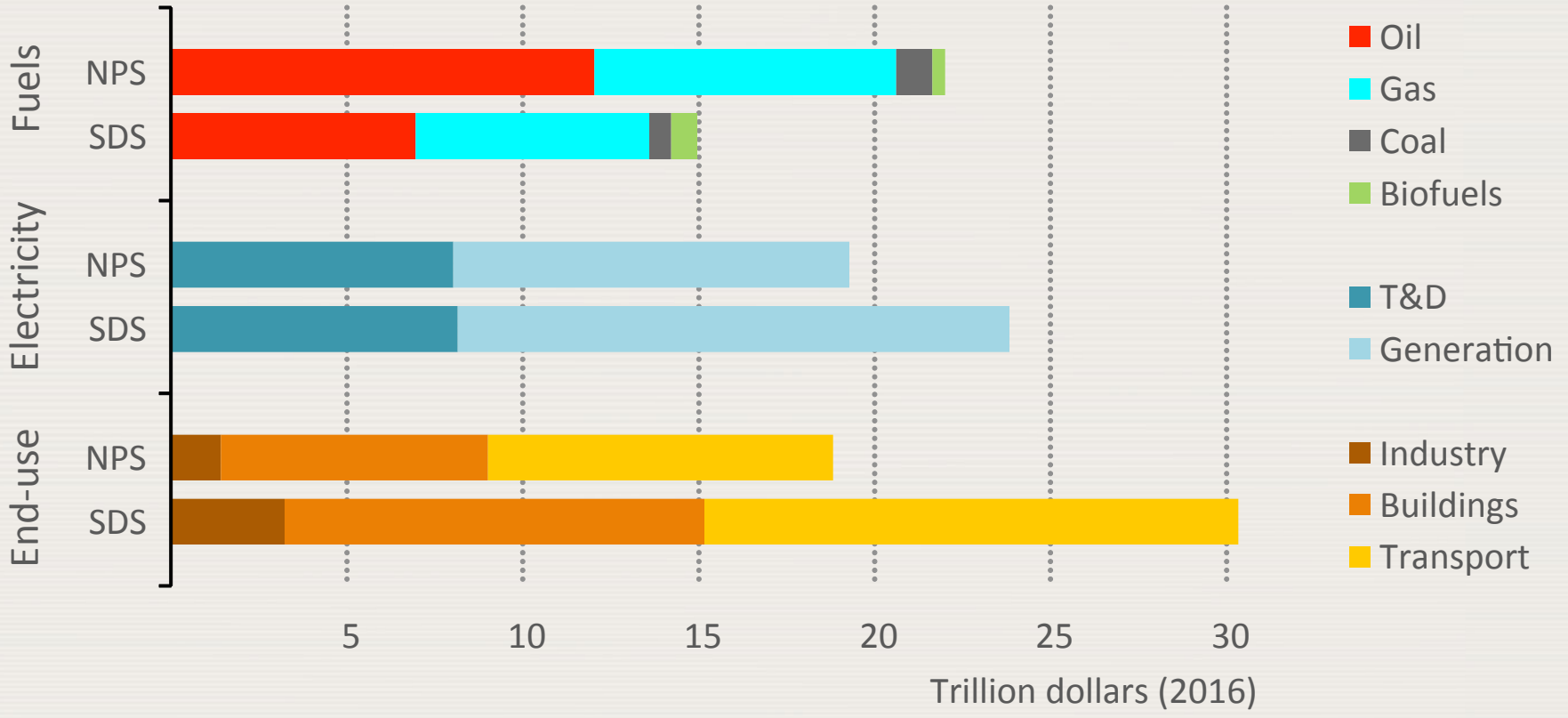
Finance

- Sustainable energy reorders the balance between upfront investment costs and operating costs throughout the energy system
  - Efficiency improvements
  - Renewables
  - Carbon capture & storage
  - Nuclear power
  - Energy storage
  - Transmission
  - Smart grids
  - Electric mobility
  - Urban structures
  - Integration
  - Increased resilience
  - ……

  all are generally upfront cost-heavy but offer low or lowest operating outlays

- New business models, finance, enabling institutions, good governance and policy are required

Cumulative global energy investment by scenario, 2017-2040



Source: Adapted from IEA-WEO 2017

Trade-offs between the three dimensions

- The environmental, economic and social sustainability pillars are co-equal, because:
  - each is indispensable, and
  - all interconnected
- Trade-offs between the three pillars are inevitable
- Trade-offs influenced by value judgments
- Energy technology options are not the snag to system transformation – available finance is
- Energy systems modeling helps
  - identify trade-offs
  - assess the options
  - Chart roadmaps for systems transformation
  - Informs policy and decision making

A long and bumpy road ahead .....