Conférence de l'Institut Coriolis pour l'Environnement de l'École polytechnique

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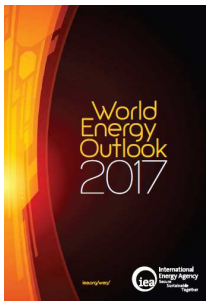
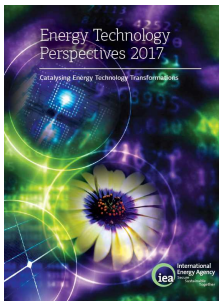
World Energy and Economic Impacts of Climate Policies: illustration

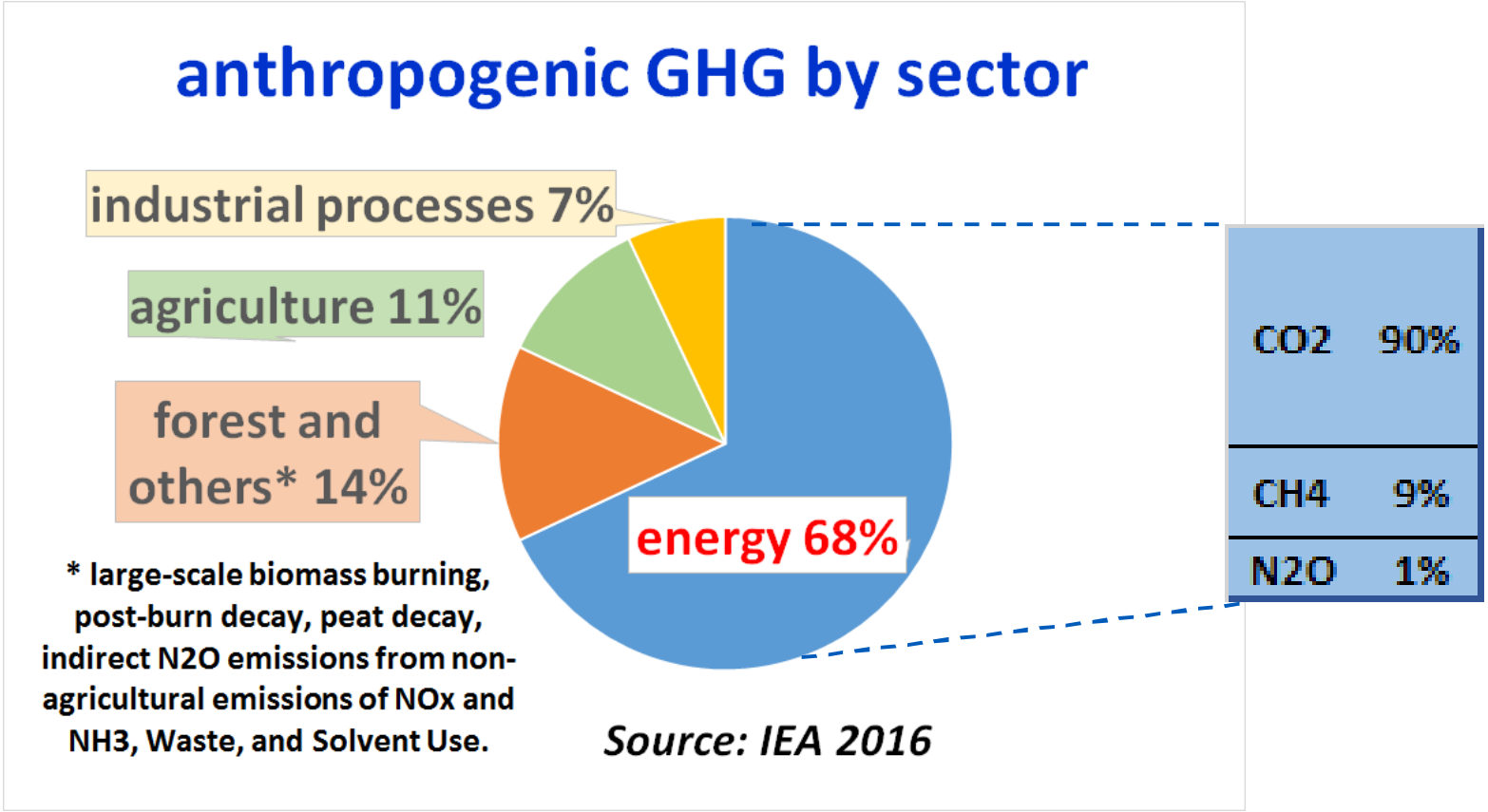
based on International Energy Agencies complementary scenarios in

- **World Energy Outlook (WEO) 2017**
  - 2016 - 2040
- **Energy Technology Perspectives (ETP) 2017**
  - 2016 – 2060





Focus on CO2 emissions associated with the energy sector



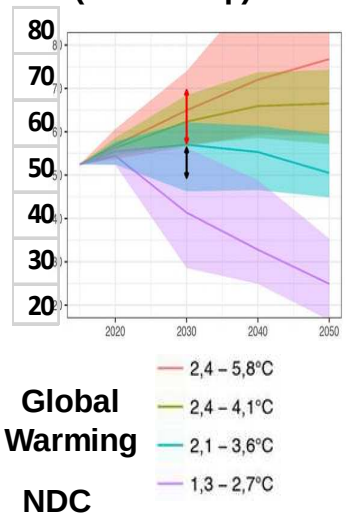
- **Electricity: 40 % of CO2 emissions related to energy (25 % of all GHG)**
  - ↳two thirds of global power generation from fossil fuels

From Paris Agreement to Energy-CO2 Emission Pathways

To reach the "well below 2°C" target of the Paris Agreement: (i) peak emissions as soon as possible; (ii) rapid emissions reduction thereafter; (iii) global carbon neutrality in the 2nd half of century (anthropogenic sources ≤ sinks)

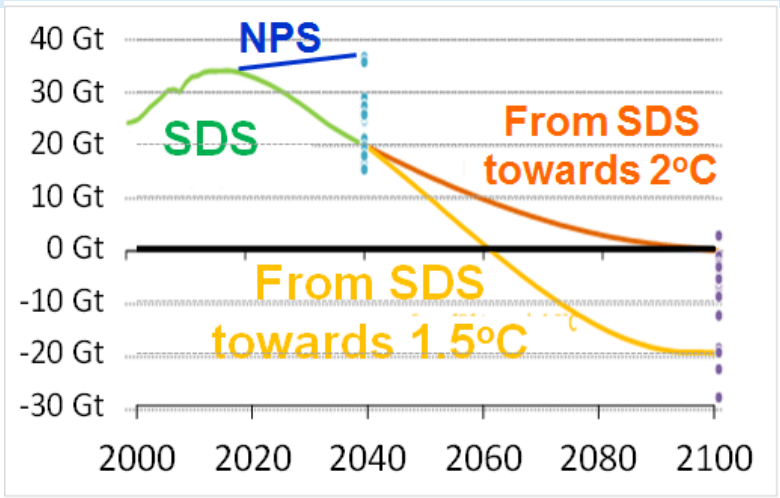
- **WEO Sustainable Development Scenario (SDS)**: CO2 emissions peak before 2020
  - show a steep decline through the Outlook period: consistent with (i) and (ii).
  - Emissions in 2040 at the lower end of a range of decarbonisation scenarios,
  - the long-term trajectory is crucial to determining the final T outcome
- **ETP scenario "beyond 2°C"**: similar to SDS, with carbon neutrality reached in 2060
- **WEO New Policies (NPS) and ETP Reference (Ref): consistent with NDC**
  - peak emissions delayed: towards 2°C–3°C versus steeper reduction & negative emissions

GHG Emissions (GtCO2 eq.)



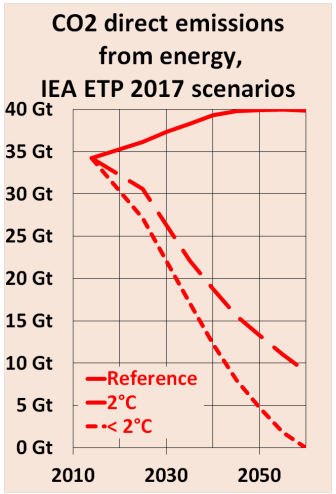
WEO NPS & SDS relative to other decarbonisation scenarios (projecting global T rise of around 1.7-1.8°C)

Energy & process-related CO2 emissions



Dots: emissions in 2040 & 2100 from all RCP 2.6 scenarios in recent Shared Socioeconomic Pathways (SSP) database (IIASA, 2017).

IEA ETP 2017: three scenarios to 2060

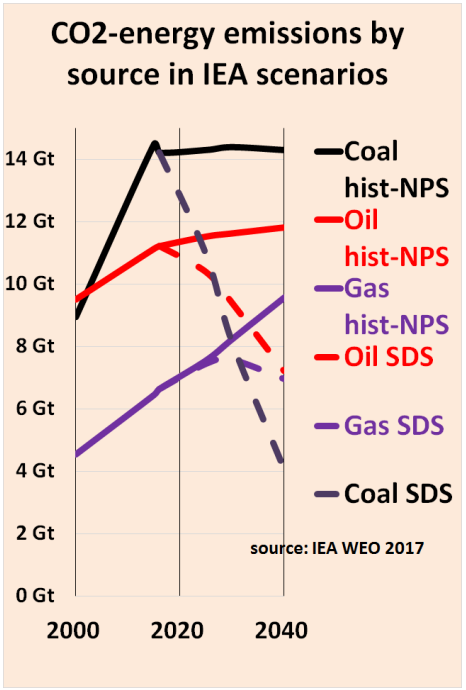


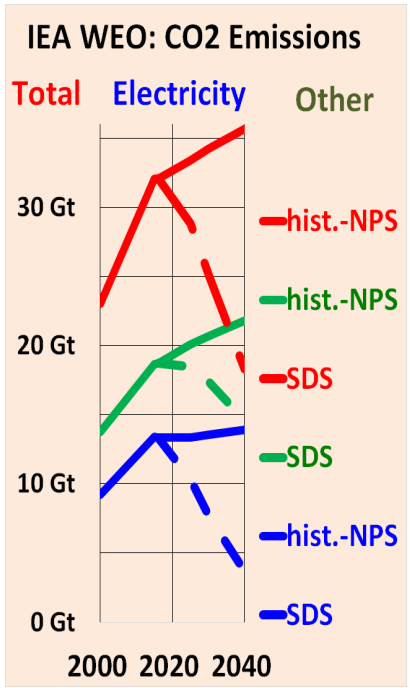
Energy-CO2 emission pathways: inflection or disruption

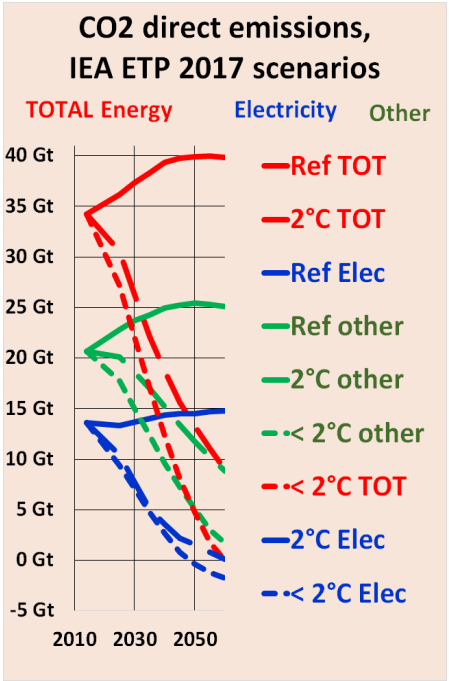
- Electricity from fossil fuels: mainly coal & gas
- Other uses from fossil fuels: oil for transportation, oil, gas (and coal) for heating uses

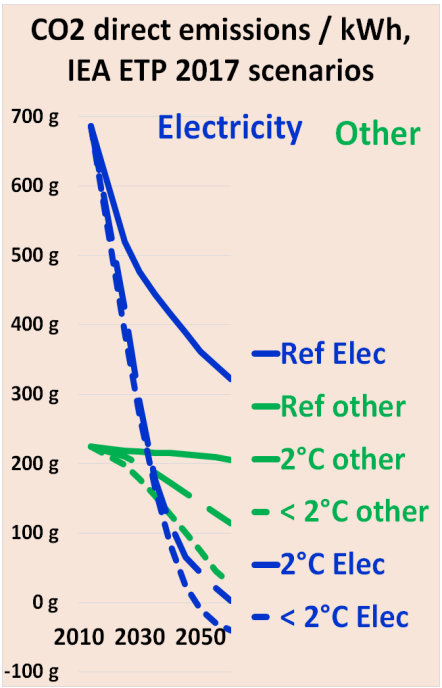
- WEO NPS and ETP Reference (consistent with NDC) reflect major "inflection" policies
  - trends between 2016-2060 versus trends between 2000-2016

- WEO SDS and ETP 2° or ETP beyond 2° are really "disruptive" ("tipping points"?)









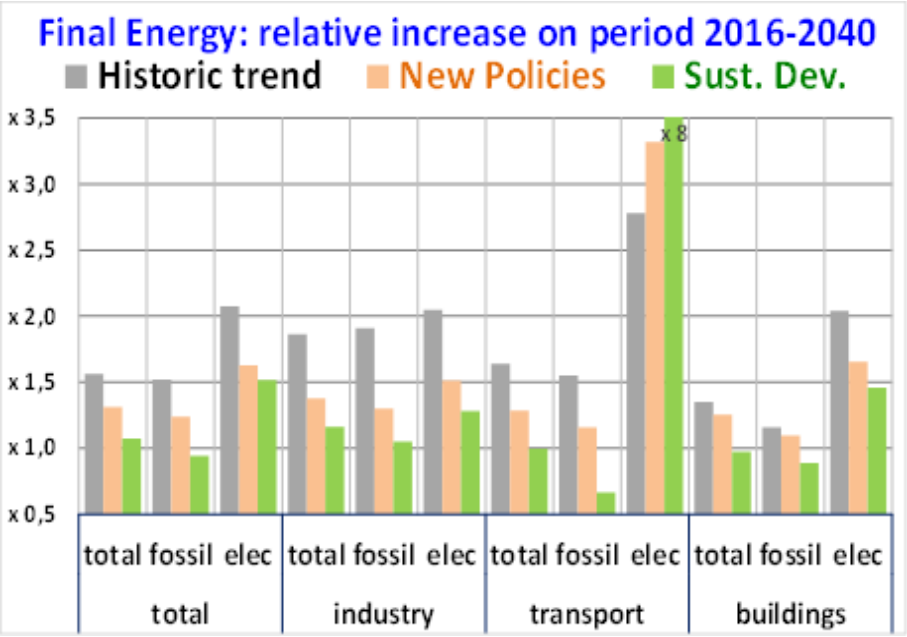
source : IEA WEO 2017

source : IEA ETP 2017

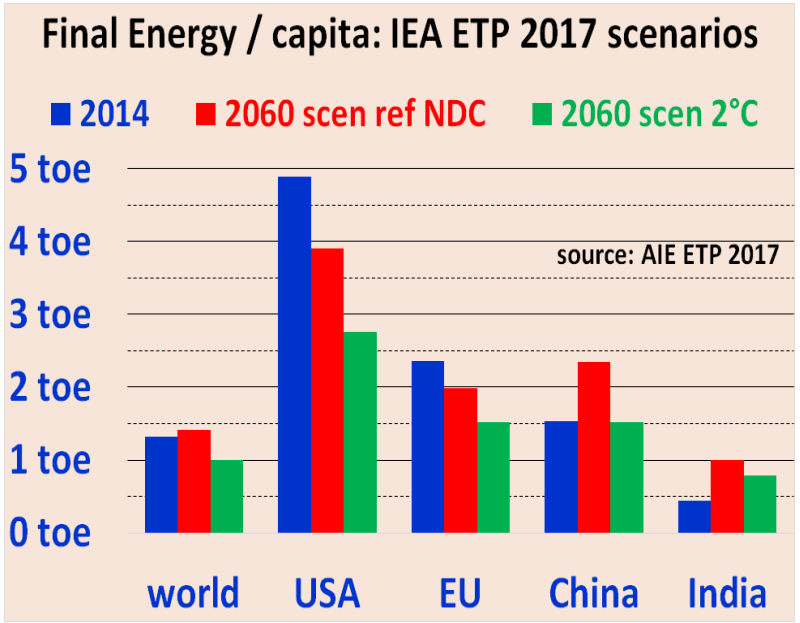
Energy consumption pathways: inflection and disruption

- WEO NPS and ETP Reference (consistent with NDC) reflect major "inflection" policies – trends between 2016-2060 versus trends between 2000-2016
- WEO SDS and ETP 2° or ETP beyond 2° are really "disruptive" ("tipping points"?)

World



source : IEA WEO 2017

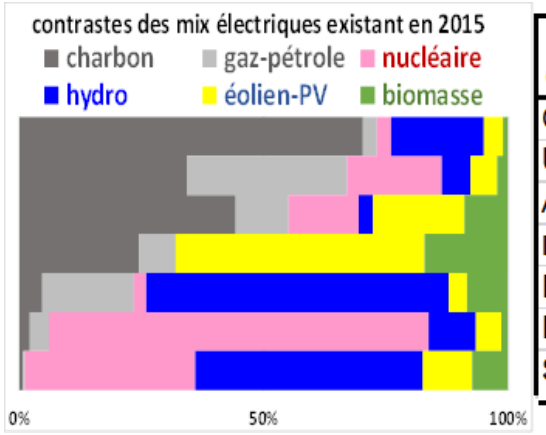


source : IEA ETP 2017

Electricity is a key factor for a low carbon economy

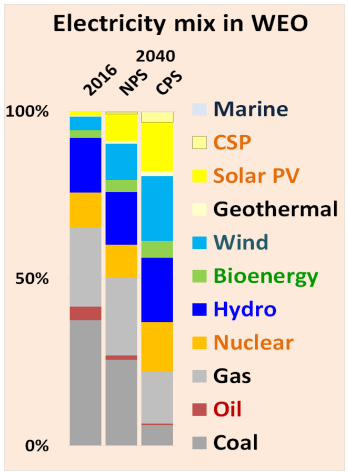
Today, with existing technologies, electricity matters for CO2 emissions

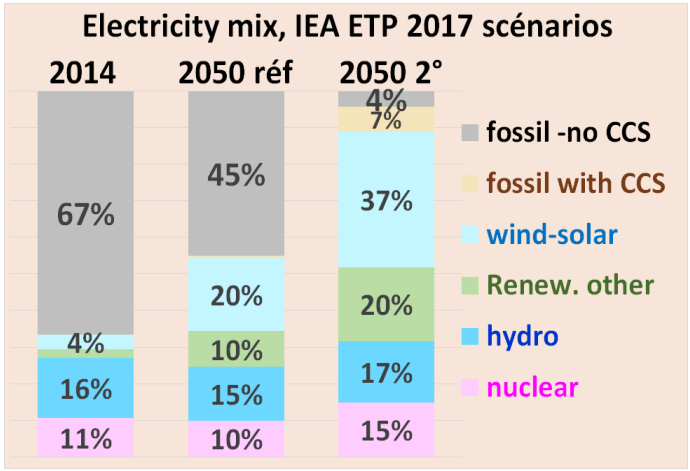
Countries with existing decarbonized electricity emit significantly less CO2 per inhabitant

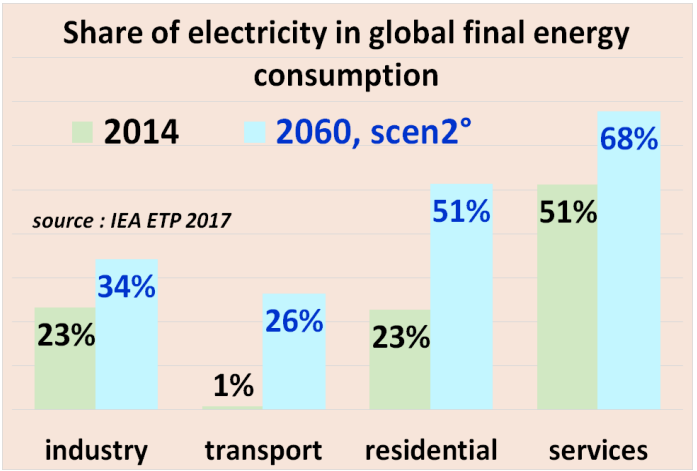


Emissions de CO2/hab 2015	
Chine	6,6 t
USA	16 t
Allem.	8,9 t
Danemark	5,6 t
Brésil	2,2 t
France	4,4 t
Suède	3,8 t

- **Global Electricity mix nearly CO2-free in climate scenarios**
  - Global CO2 direct emissions per kWh generated (public heating incl.) in WEO
    - 540 g (2016), 350 g (NPS 2040), 100 g (SDS 2040)
- **Decarbonisation requires all the best available technologies: there is no silver bullet**
- **Higher share of decarbonised electricity in energy end-uses**





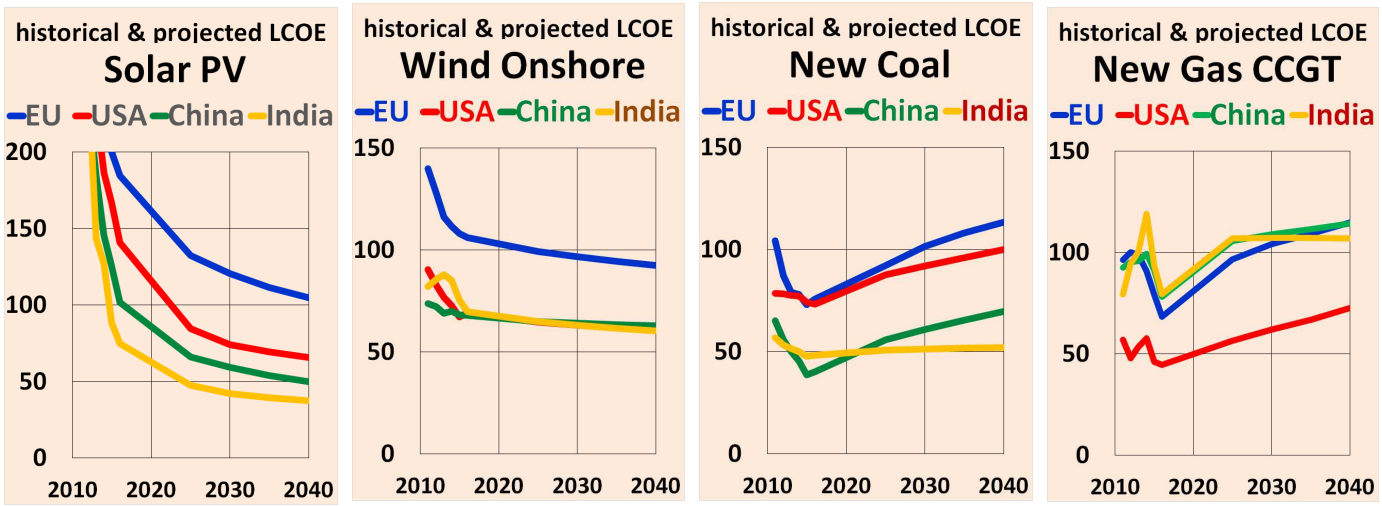


Costs of scenarios (1)

- includes prospects for cost decreases on renewables and storage
- includes prospects for cost increase on fossil fuels (carbon pricing)

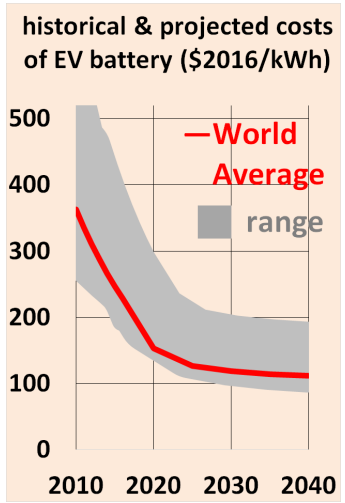
Levelised Cost of Electricity (LCOE) with standard financing, in $$_{2016}$/MWh

source : WEO fig 6,21



EV batteries

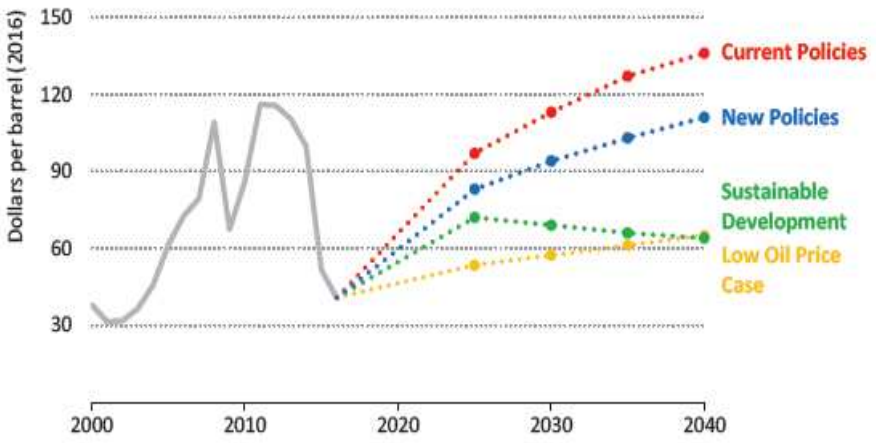
source : WEO fig 1,8



- Coal refers to subcritical and supercritical designs. CCGT = combined-cycle gas turbines.
- Operating costs incl. the costs of fuel, variable operation & maintenance & CO2 where priced
- LCOEs for gas & coal based on projected fuel prices for a range of capacity factors (50-80%).
- Solar PV and Winc: historical capital costs & capacity factors provided by IRENA
- LCOE with standard financing: WACC (in real terms) of 8% in the USA & EU, 7% in India.
- Low-cost financing reduces the cost of capital by 3%

Costs of scenarios (2)

WEO Figure 1.5: Average IEA crude oil import price by scenario and case



"Oil prices vary widely by scenario, reflecting the different ways in which resources, costs and policies could affect the supply-demand balance"

Table 1.1 ▷ CO2 price in selected regions by scenario ($2016 /t)

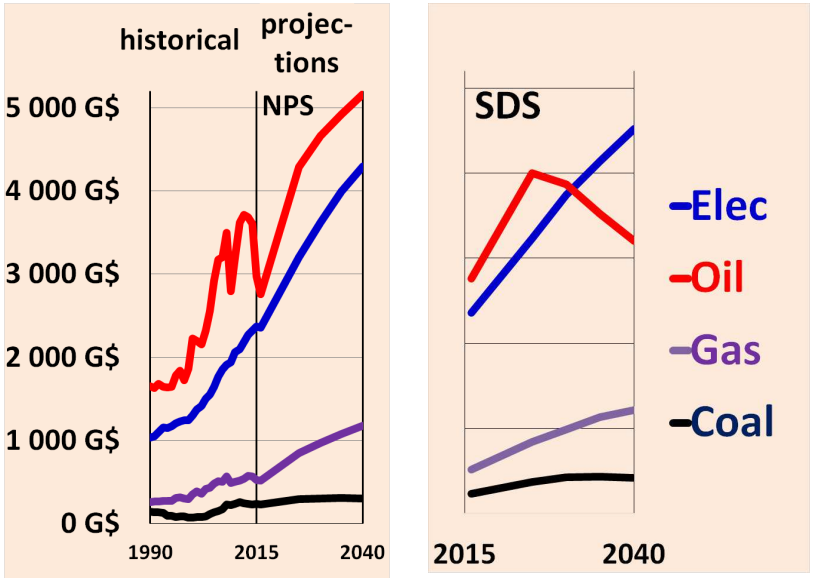
	Region	Sector	2025	2040
NPS	South Africa	Power, industry	10 $	24 $
	China	Power, industry, aviation	17 $	35 $
	Canada	All sectors	25 $	45 $
	European Union	Power, industry, aviation	25 $	48 $
	Korea	Power, industry	25 $	48 $
SDS	Brazil, China, Russia, South Africa	Power, industry, aviation*	43 $	125 $
	Advanced economies		63 $	140 $

* Coverage of aviation is limited to the same regions as in the New Policies

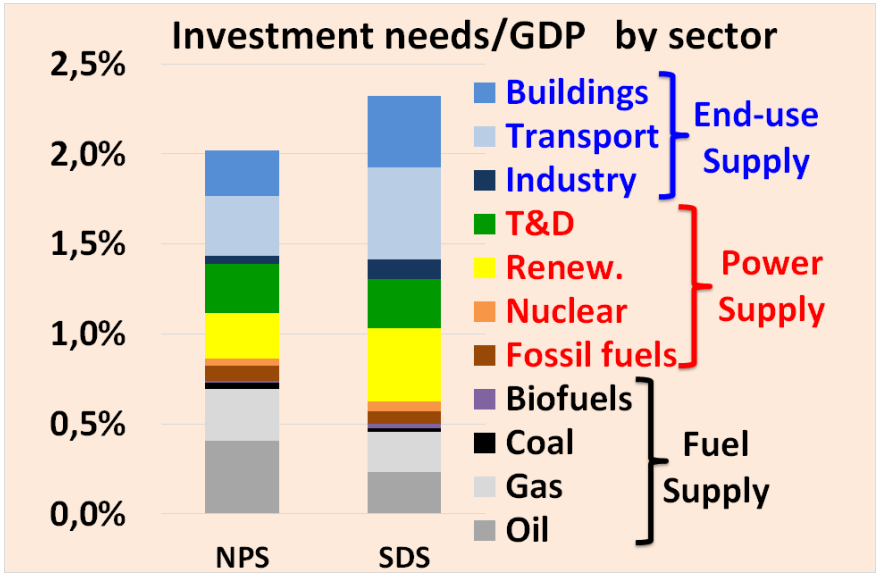
Costs of scenarios (3)

- **Low global cost of public policies both in NPS and SDS**
  - Fuel energy expenditure growth is lower than GDP growth in NPS, and even lower in SDS
    - total expenditure/ GDP ($2010 current exch. rate): 5% (2000), 8% (2016), 6% (2040 NPS), 5% (2040 SDS)
  - investment needs in SDS vs NPS (financing cost not included): less than 0,5 % of GDP :
    - Stern Review 2007 ("cost of inaction > cost of action") would be right ?
- **Very demanding hypothesis: public policies are successful in both scenarios**
  - plausible or likely alternatives: global financing cost > 0, higher T&D costs (cf Germany?), higher costs for building insulation and renovation (cf France?)
    - costs could easily be more than a few percent of GDP: socially acceptable?

Global end-user energy expenditure by fuel



source : WEO 2017 fig 2.19



source : WEO 2017 fig 3,20