The World Energy Outlook 2014

Every year, the International Energy Agency (IEA) presents their 'world energy outlook' (WEO) in which they model several possible futures for our energy system. This article presents some interesting outcomes from the edition of 2014. First general trends are discussed, followed by a detailed analysis for each different fuel.

In the WEO, there are 3 main scenarios. The *Current Policies Scenario* (CPS) only takes all policies that are already formally adopted into account, but assumes that no new policies to reduce the environmental impact of the energy system come into force. The *New Policies Scenario* (NPS) is the central scenario in this edition of the WEO. It assumes that the good intentions are translated in several policies that become effective in the next years. In this scenario, the global average temperature increases by 3.6°C. The *450 scenario* (450) is a scenario where there is a reasonable chance to limit the global increase in temperature to 2°C. Unless otherwise stated, the graphs and numbers are those from the NPS. The WEO 2014 models all scenarios up to 2040. Note that a scenario is NOT a forecast. It merely is a possible future which is calculated based on certain assumptions.

General trends

As can be seen in figure 2.2, the total primary energy consumption (= total resources used) in 2040 amounts to 18290 million ton oil equivalent (MTOE). About one fourth of this comes from each 'basic' resource: coal, oil, gas and low carbon (nuclear and renewable). This means a large increase in the usage of RES (= renewable energy sources, such as wind and solar PV) is expected. In the EU, the share of low carbon primary energy amounts up to 40% in 2040. Figure 5.1 shows how these resources are used in the different scenarios. (The numbers of the graphs are the same as those of the WEO itself)

Figure 2.2 ▷ Fuel shares in world primary energy demand in the New Policies Scenario

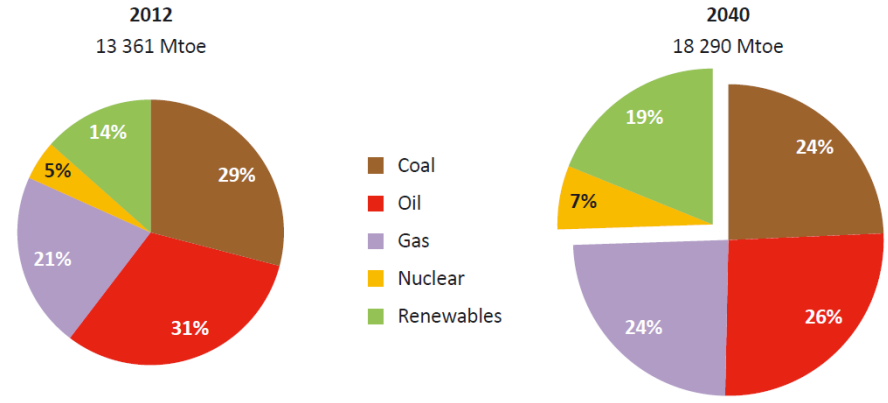
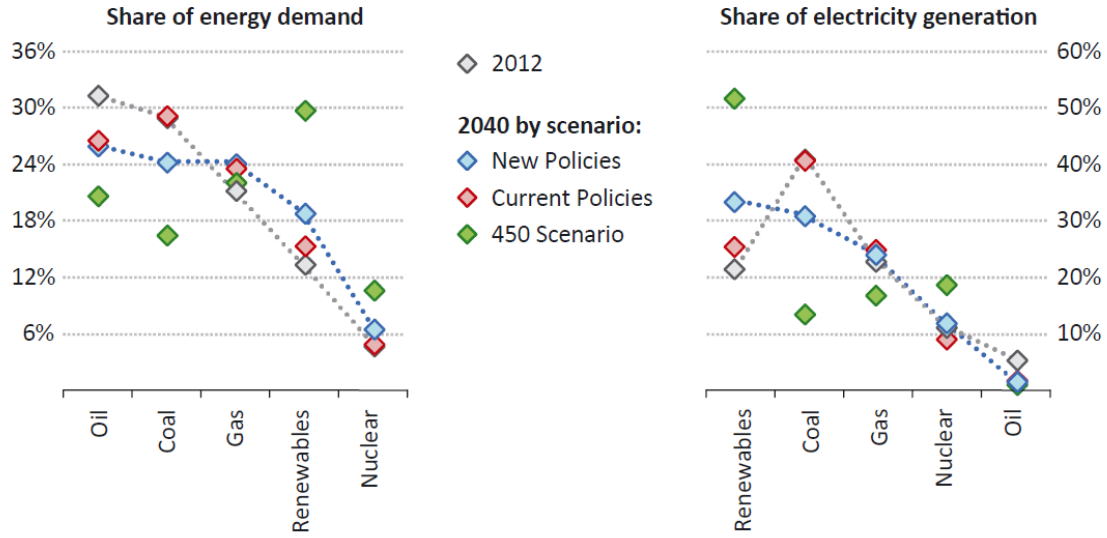
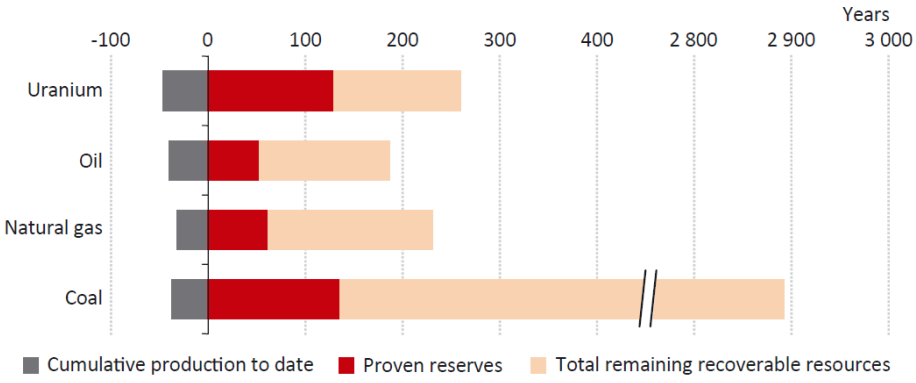


Figure 5.1 ▷ Share of world energy demand and electricity generation by fuel and scenario



The next question is whether there are enough resources to satisfy this need. As several studies revealed, no shortage of any resource in the near future is expected. The figure below shows the so-called R/P ratio for the different resources, where R are the resources and P the current production. Note that this does not in any way mean that we have resources for R/P years, as the production levels change every year (to satisfy the increasing demand), new exploration means that R can increase (the R/P ratio has actually increased for several years).

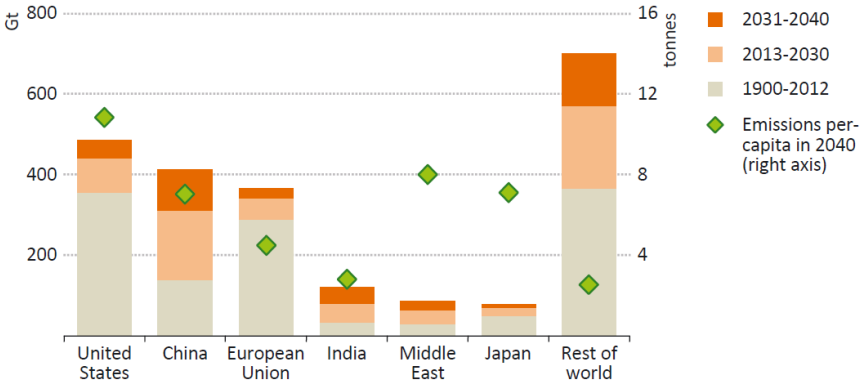
Figure 2.13 ▷ Lifetimes of fossil-fuel and uranium resources*



* Expressed as number of years of produced and remaining resources based on estimated production rates in 2013. For uranium, proven reserves include reasonably assured and inferred resources (see Chapter 11 for more details).
Sources: BGR (2013); O&GJ (2013); USGS (2012a); USGS (2012b); BP (2014); NEA/IAEA (2014); IEA estimates and analysis.

Figure 2.20 shows the CO_2 emissions for the NPS. The absolute cumulative emissions (= sum of all emissions up to that year) are the highest in the US. For the moment, the EU is second, but by 2040 China will have emitted more CO_2 than the EU. The emissions per year and per capita in 2040 are also highest in the US, followed by the Middle East, Japan, china and the EU. The global average in 2040 equals 4.2 ton per capita per year.

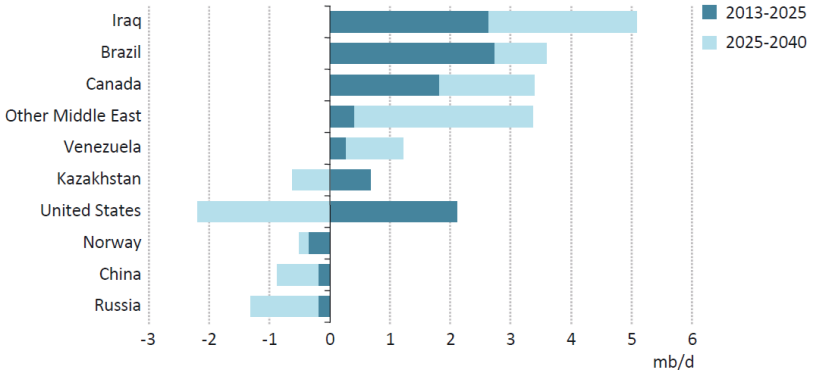
Figure 2.20 ▷ Cumulative energy-related CO_2 emissions by region in the New Policies Scenario



Fossil fuels

The oil production is expected to increase (for each barrel reduced demand in the OECD, the demand in non-OECD countries increases by 2 barrels). Until 2020, non-OPEC countries increase their output but then it falls back and the market share of OPEC increases as can be seen in figure 3.10. To satisfy this increasing demand, vast investments in production capacity are needed and because of the long lead times of such projects, these investments should be done in the near future.

Figure 3.10 ▷ Change in oil production by selected region in the New Policies Scenario



Natural gas has an important environmental value as it replaces coal in China, oil in the Middle East and allows flexible production to balance the variations of RES in the EU. A large increase in the usage of unconventional gas (tight gas, shale gas etc.) is predicted. Gas scarcity is expected to decrease, as more and more countries start to produce gas and the trade of LNG (liquefied natural gas), which can be transported as needed, increases. In the EU, the share of Russian gas is expected to decrease as a result of this increased LNG and because of the 'southern gas corridor', a pipeline from the gas fields in the Caspian region and the Middle East to Europe. The recent agreement between Russia and China doesn't threaten the EU gas supply, as it concerns gas resources in East Siberia, which will either be developed for the Chinese market or they will stay in the ground (they are too remote for the EU market).

Coal is the most CO_2 insensitive fossil fuel. Therefore, decreasing the emissions at coal fired power plants is key to reduce the greenhouse gas emissions (GHG's). There are two main ways to achieve this: CCS and increased efficiency. In the NPS, 70GW (3%) of coal fired power plants are equipped with CCS by 2040 (carbon capture and storage, a technology where the GHG's are filtered out of the flue gasses and stored in large repositories). In the 450 scenario, 580GW is equipped with CCS,

pointing at the importance of the technology to reduce the emissions. Also the fact that the new US environmental standards 'effectively mean' that all new coal fired power plants in the US must be equipped with CCS, hints at the potential of CCS.

Increasing efficiency is another important way to reduce emissions, as more electricity can be produced from the same amount of coal (and thus the emitting the same amount of GHG's). If all coal fired power plants reached supercritical efficiencies (43 to 47%) by 2040, the GHG emissions would decrease by 17% compared to the NPS (in the NPS, many power plants still have low efficiencies).

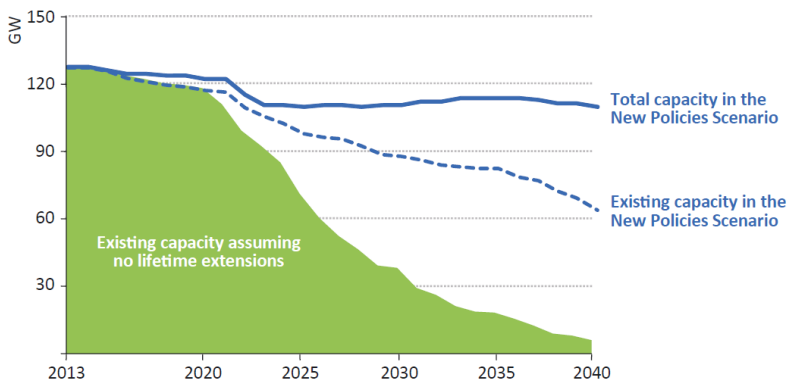
An obstacle for transforming to a low carbon energy system, are the fossil fuel subsidies. Fossil fuel subsidies are defined as "Any government action directed primarily at the energy sector that lowers the cost of energy production, raises the price received by energy producers or lowers the price paid by energy consumers". In 2013 an astonishing $548 billion was spent to artificially lower the end-user prices in several countries ('only' $121 billion was globally spent on subsidies for RES). The average spending on fossil fuel subsidies in the 40 countries who have such subsidies, amounted to over 5% of the GDP, more than is spent on education or health in several of these countries. These fossil fuel subsidies often block investments in low-carbon sources and the consumption of fossil fuels increases due to the lower price paid by customers.

Nuclear

The WEO has a special focus on nuclear energy (each edition focuses on one fuel). Globally, nuclear energy is the second largest source of low-carbon energy, second to hydro energy. In the OECD, nuclear energy is even the largest source. Today, 392GW of nuclear capacity is installed. In the NPS, this increases to 624GW in 2040, in the 450 scenario even to 862GW. The IEA suggests that governmental policy is the single most significant determinant for the prospect of nuclear power.

In the EU, the amount of nuclear energy is expected to decrease. However, new power plants are still needed due to the fast retirement of old power plants. Figure 11.9 shows the capacity in the EU (the green area is the capacity if no lifetime extensions are granted, the dashed line assumes certain lifetime extensions and the difference between the dashed line and the full line are new nuclear power plants). As can be seen, if nothing is done, the nuclear capacity is reduced to 6GW in 2040, which would create a huge problem for the security of supply. The cost of closing and dismantling nuclear reactors (decommissioning costs) is currently uncertain; values of $1 to $2 billion per reactor are reported.

Figure 11.9 ▷ EU nuclear power capacity in the New Policies Scenario and retirement profiles under different lifetime extension assumptions



Also the investment for a new nuclear power plants is substantial. These investments are unlikely to happen in competitive markets as the risks seem to be too high. Especially the risks for future price and policy changes are problematic due to the large sunk investment involved in nuclear power plants. In fact, the IEA doesn't expect any investments in new nuclear power plants in competitive markets unless the risk is mitigated by governmental subsidies (e.g. a guaranteed price of electricity).

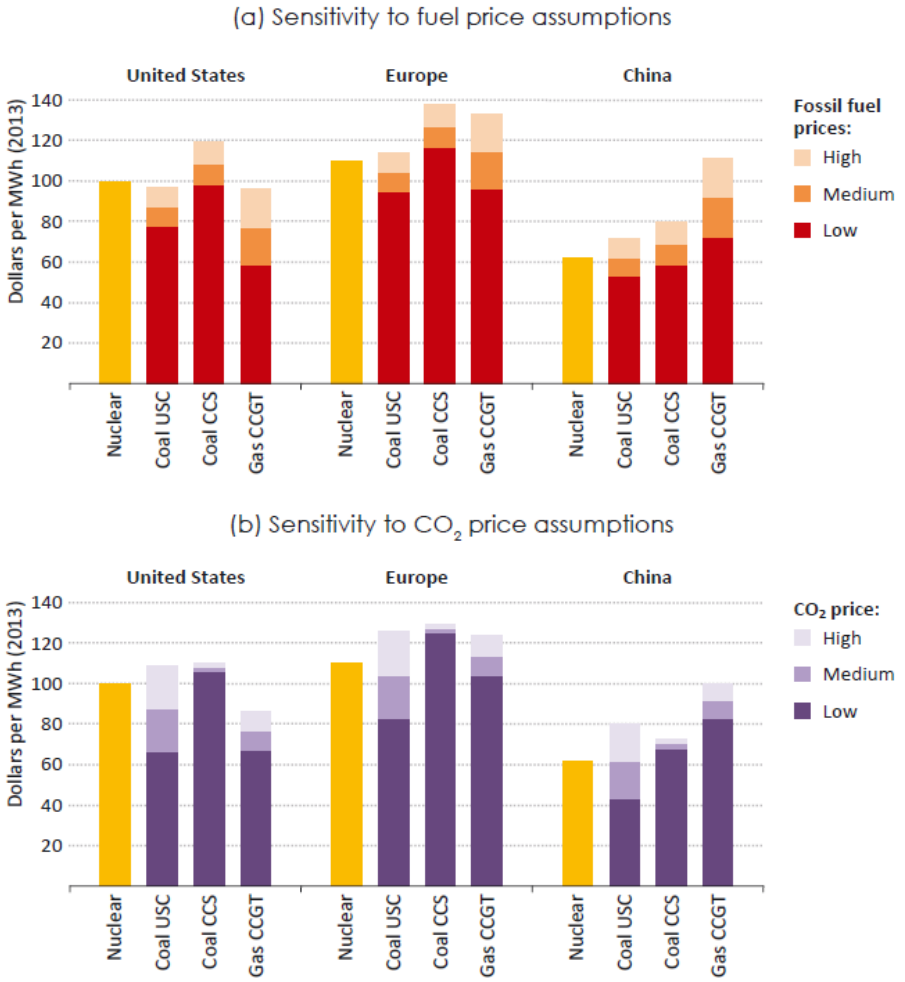
Table 10.5 and figure 10.9 compare nuclear power to other electricity generation technologies. It can be concluded that nuclear energy has many advantages (good security of supply at a constant price, low GHG emissions, etc) but also faces several drawbacks (financial risk, public opposition, radioactive waste, etc). The low nuclear scenario discusses what happens if the usage of nuclear power is lower than modeled in the NPS. It turns out that this has averse implications for energy security, economic aspects and climate trends (e.g. 5% more emissions in the EU), but less radioactive waste is produced.

Table 10.5 ▷ Relative attributes of power generation technologies

	Nuclear	Coal steam	Gas CCGT	Wind onshore and solar PV
Investment cost	Very high	Moderate	Low	Moderate-high
Construction time*	4-10 years	4-5 years	2-3 years	0.5-2 years
Operational cost	Low	Low-moderate	Low-high	Very low
Operational characteristics	Baseload, limited flexibility	Baseload, moderate flexibility	Mid-load, high flexibility	Variable output, low load factor
CO_2 emissions	Negligible	High-very high	Moderate	Negligible
Key risks	Regulatory (policy changes), public acceptance, market	Regulatory (CO_2 and pollution), public acceptance, market	Regulatory (CO_2), market	Regulatory (policy changes)

* Construction time is the time between the start of a reactor's construction and its connection to the grid.

Figure 10.9 ▷ Generating costs for selected new power plants under different fuel price and CO_2 price assumptions

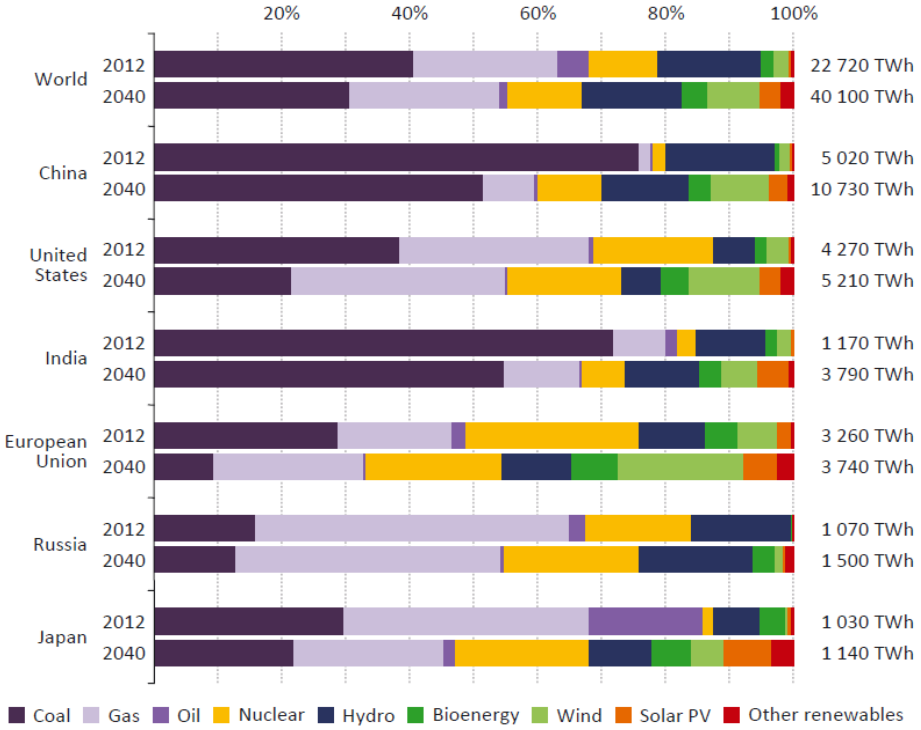


The IEA also shortly discusses the accident at Fukushima. They mention some studies that concluded that no discernible radiation-related health effects are expected and that the accident was 'man-made and foreseeable' and resulting from 'inadequate safety requirements'.

Electricity

The (global) electricity sector will see a huge increase in the deployment of RES (RES generation triples to 2040) and also the usage of gas and nuclear energy increases. Figure 6.9 shows the shares of the different fuels in the electricity production in different regions. Especially in the EU, where the share of RES reaches 46% in 2040, this leads to several challenges, both technical (e.g. balancing the variability of RES if their share is higher than 10% poses several technical problems) and economical (e.g. solar PV becomes competitive on a price parity basis only in a few locations).

Figure 6.9 ▷ Share of electricity generation by source and selected region in the New Policies Scenario



To guarantee the security of supply, significant investments in new thermal power plants are needed (to back up the RES in cases of low wind or sun). It is the opinion of the IEA that under the current market rules, these investments won't happen and that a reform of the wholesale market is needed to guarantee the security of electricity supply. This is because of several reasons, amongst others because of:

- The increased usage of RES undermines the profit of thermal power plants (by decreasing the price of electricity and by reducing the amount of operating hours of thermal plants)
- The current wholesale prices or around $70/MWh are insufficient to cover all fixed costs (they estimate that about $90/MWh is needed)
- The regulatory risks is too high

The IEA notices that although many governments stepped back from direct influence over electricity markets when liberalizing them, many of them have now stepped back in the market typically to promote the deployment of low-carbon sources.

Or as they phrase it in another section of the WEO: "today's difficulties in competitive markets often stem from government interventions in the market designed to redress perceived imperfections, such as the failure of markets to deal with the external costs attributable to environmental or social damage. But markets in which prices are set both by competition and by regulation are very uncertain sources of financial return to those investors whose plant does not enjoy preferential treatment"

The expected prices of electricity in the EU are much higher than in the US or China as can be seen on figures 6.12 (prices in 2020) and 6.14 (prices in 2040). Prices in China are a little bit higher than in the US.

Figure 6.13 ▷ Total power generation costs by selected region in the New Policies Scenario, 2020

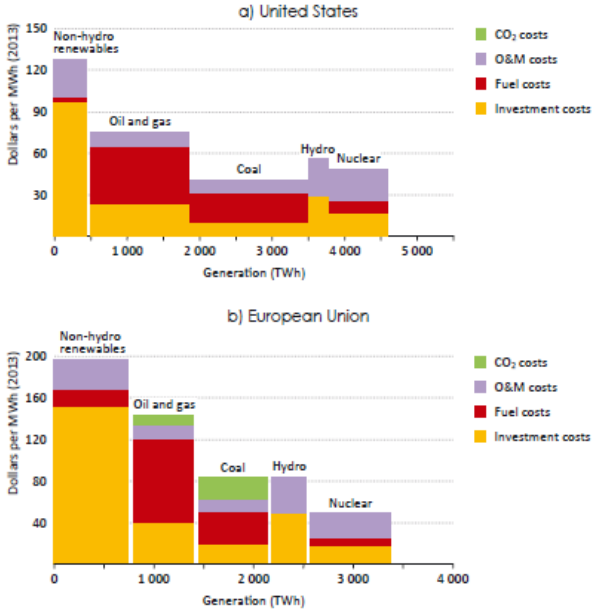
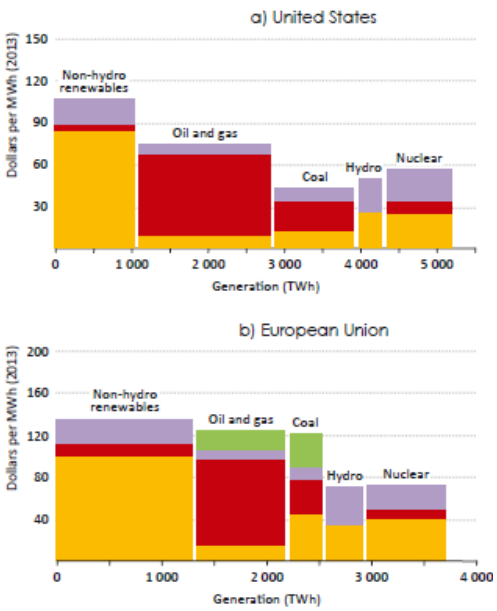


Figure 6.14 ▷ Total power generation costs by selected re New Policies Scenario, 2040



One way to mitigate this price different is by increased energy efficiency. Also the impact on GHG emissions savings is spectacular, only 1/3 of the potential of energy efficiency is exploited in the NPS but still this is responsible for half the emissions saved compared to the current policies scenario. Many investments in energy efficiency are economically sound, which further contributes to the (sometimes underestimated) potential of energy efficiency.

Conclusion

As mentioned at the beginning, the NPS describes a future if most policies to reduce the GHG emissions proposed today become effective. As can be seen in the previous analysis, this already poses significant challenges on different domains: technical (e.g. balancing the variability of RES), economical (e.g. profitability of generators) and regulatory (e.g. reducing uncertainty on investments). Even if all these challenges are faced, the temperature increases by 3.6°, which is considered to be too much.

The 450 scenario is much more challenging (e.g. the massive amount of nuclear power and CCS needed). Greenhouse gas emissions are a global issue, and Europe can't solve it by itself. Therefore, climate agreements like the Kyoto protocol are essential. All hopes are pinned on the next conference in Paris in November 2015. The IEA will release a special report in mid-2015 to inform the international climate negotiations.

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