11th IEEJ/CNPC Research Meeting

IEEJ Outlook 2018

– Prospects and Challenges up to 2050–

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Overview of the current global energy market

- Although the trend of Asia as leading **the global energy market remains unchanged**, developments in the **US and China**, which accounts for **40%** of the energy market, must be carefully monitored.
- **World coal demand dropped for two years** in a row (**US and China** largely) while **oil and gas grew**. China's coal consumption declined for the third consecutive year (2016, BP).
- Discussions on **Peak Oil** (supply) of the 2000s are now changing to **Peak Demand**. Note the recent movements that aim to ban the sale of internal combustion engine vehicles.
- **CO_2 emissions dropped in 2015** but **increased again in 2016**. **India and ASEAN** showed big increases despite the declined observed in the **US and China**.
- Paris Agreement calls for "**Long-term low greenhouse gas emission development strategies**" **by 2020**. This Outlook expands its estimation period to 2050.

Scenarios in this Outlook

#Reference Scenario

Reflects past trends with current energy and environment policies.
Does not reflect any aggressive policies for low-carbon measures.

#Advanced Technologies Scenario

Assumes the introduction of powerful policies to enhance energy security and address climate change issues.
It promotes utmost penetration of low-carbon technologies.

#Oil Demand Peak Case

Assumes a more rapid introduction of electric drive vehicles than in the reference scenario, to analyze the possibilities of oil demand peak.

<Climate Model Analysis>

#Reference: Emissions path with continuing past trends
#Minimizing Cost: Emissions path with minimizing total cost
#Halving Emissions by 2050: Emissions path reflected RCP2.6 in AR5 by IPCC

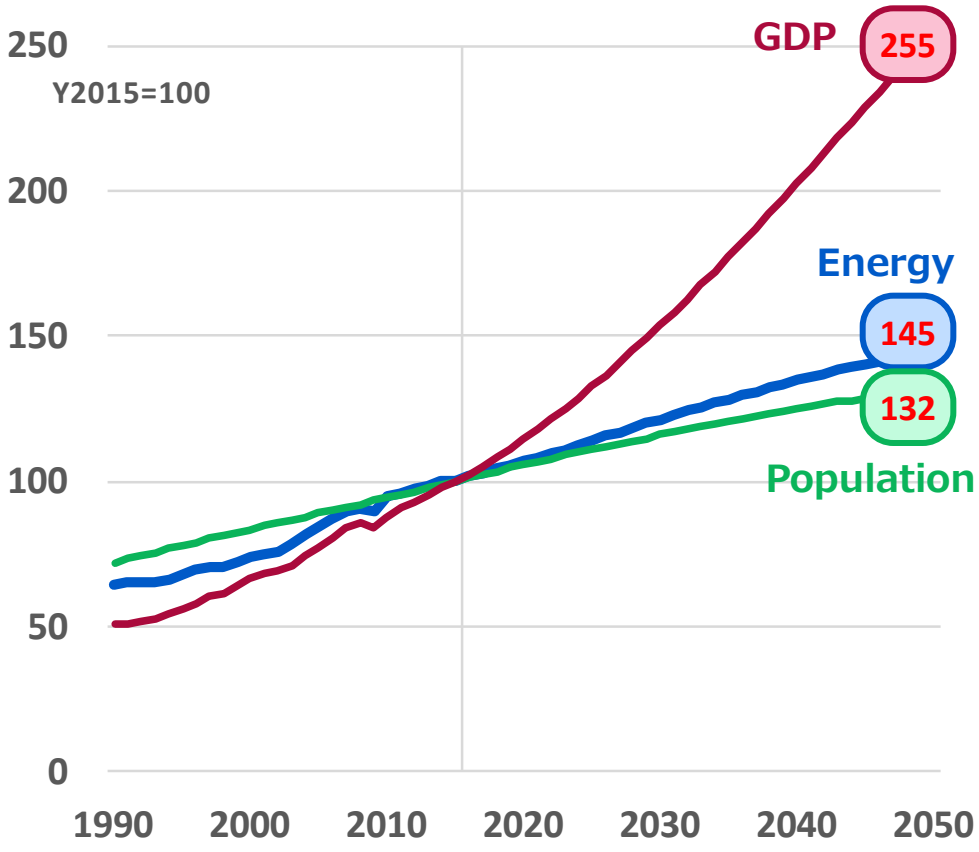
Examples for Technology

		Reference	Advanced Technologies	Peak Oil Demand
Energy efficiency	Vehicle technology (ZEV*1 sales share)	9% in 2030 20% in 2050	21% 43%	30% 100%
Energy efficiency	Coal-fired power generation (CCT share in newly installed capacity)	30% in 2030 90% in 2050	70% 100%	Same as Reference
Carbon free technology	Installed capacity PV Wind Nuclear	(2015 to 2050) 0.2 to 1.5 TW 0.4 to 1.9 TW 0.4 to 0.6 TW	(2050) 2.5 TW 3.0 TW 1.0 TW	
Thermal power generation with CCS (Only countries and regions with CO_2 storage potential excluding aquifers)		none	Newly installed after 2030	

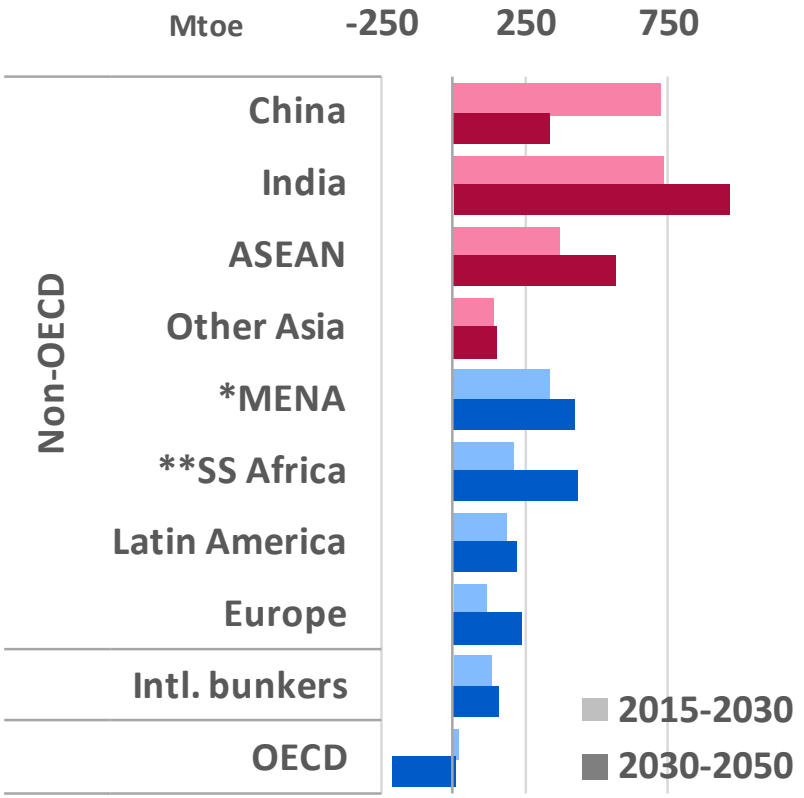
Energy Outlook up to 2050

Energy market shifting to southern Asia

❖ Global Population, GDP and Energy



❖ Growth in Primary Energy

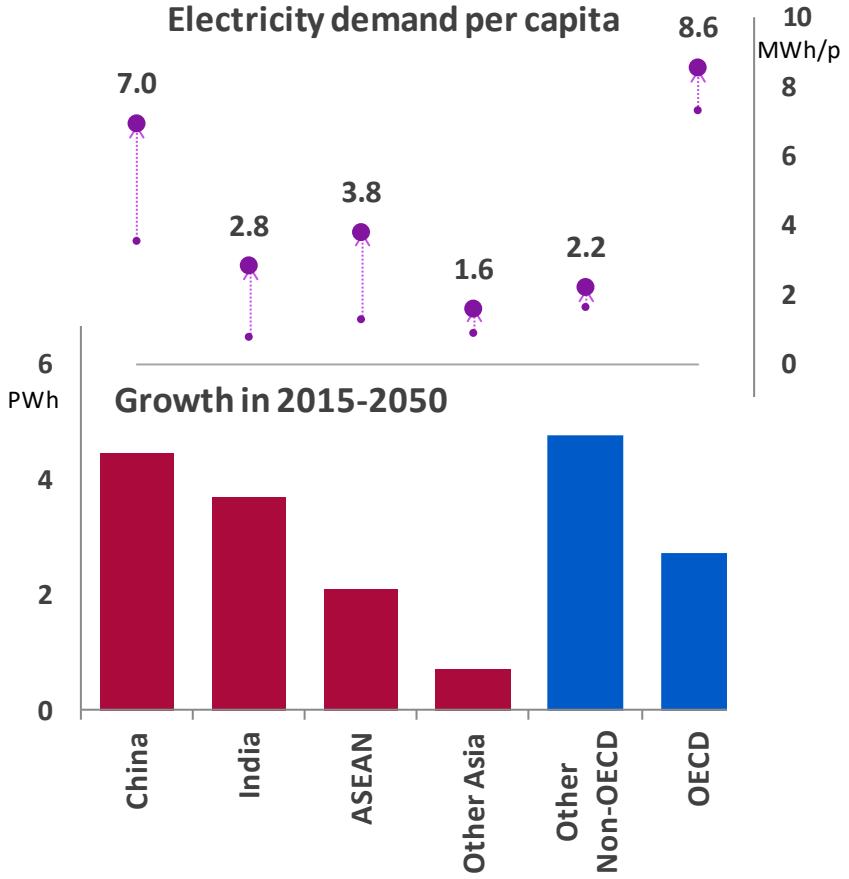


＊Middle East and North Africa, **Sub-Saharan Africa

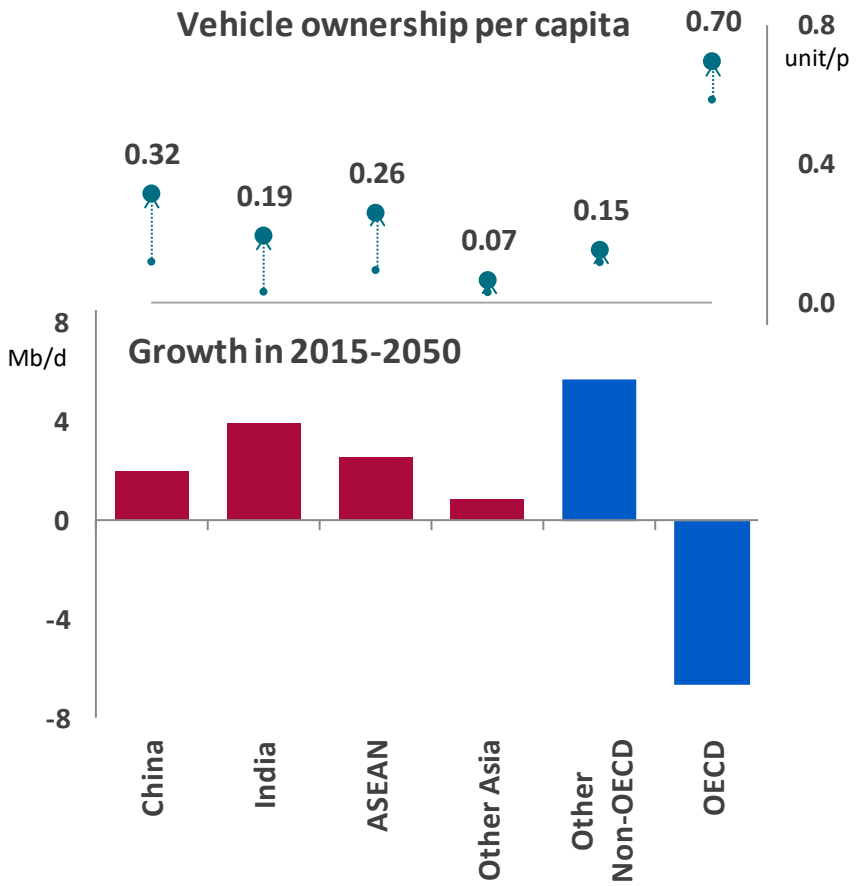
Despite large improvements in energy efficiency/intensity, global energy demand continues to increase. Two thirds of the energy growth comes from non-OECD Asia. As China peaks during the 2040s, the center of gravity of the market shifts within Asia towards the south.

Demand led by fuels for Generation & Transport

❖ Electricity



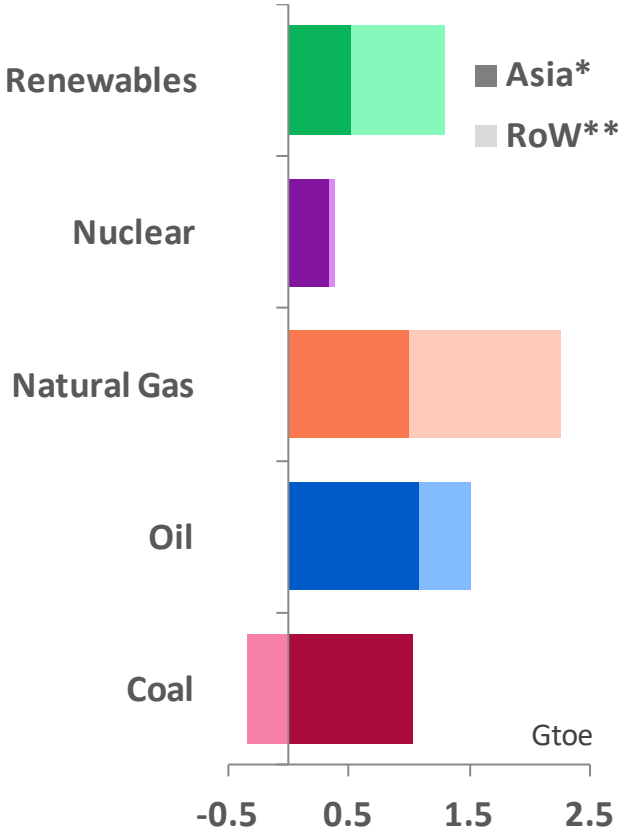
❖ Oil fuels for vehicles



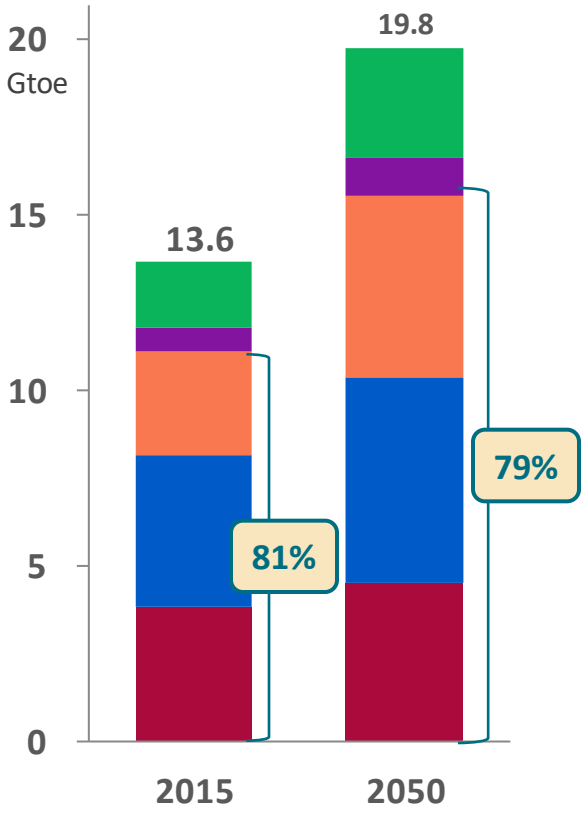
Three quarters of the growth until 2050 are for fuels for power generation and transportation. The economic development and improvements in living standards of the relatively poor and populous areas – non-OECD Asia – contribute to the global energy expansion.

High dependence on fossil fuels continues

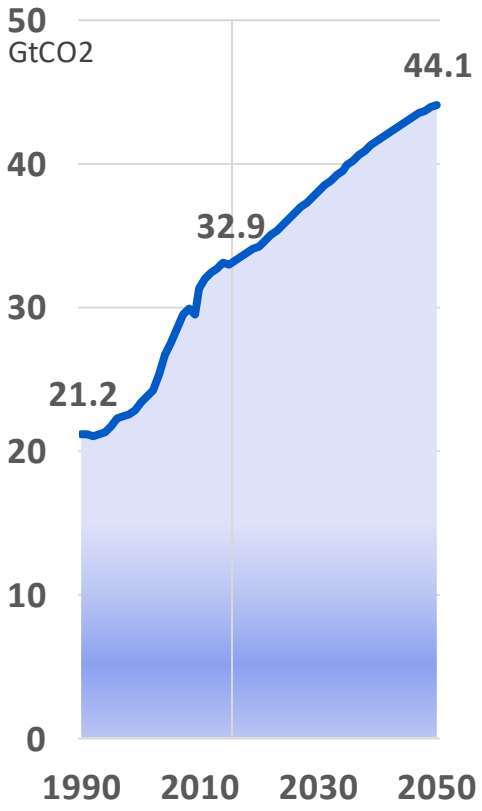
❖ Growth in Primary Energy



❖ Energy Mix



❖ Energy-related CO_2



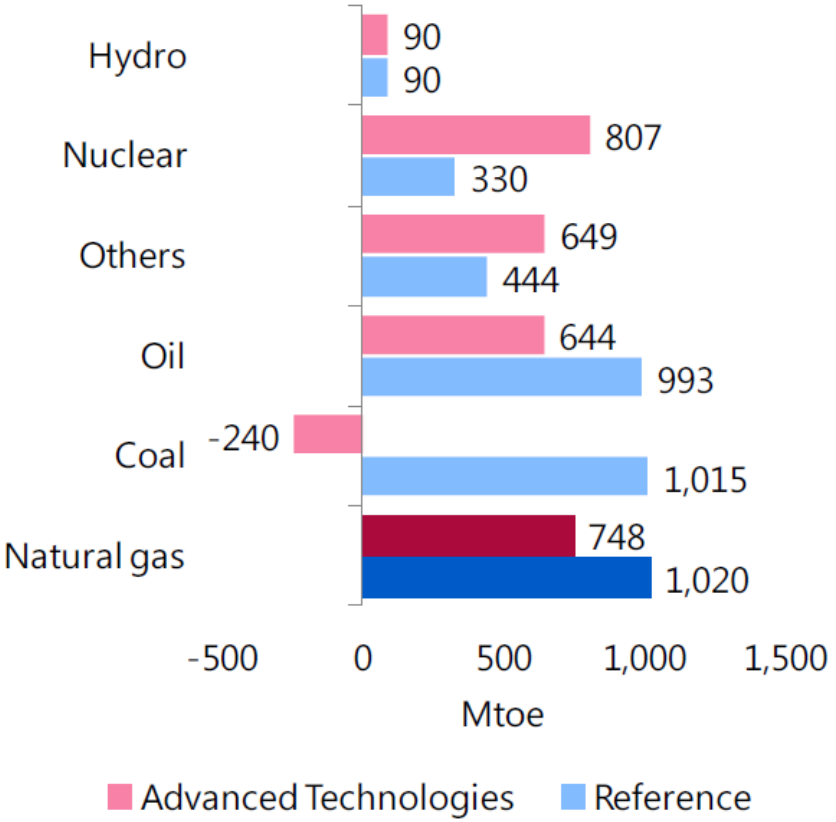
* Non-OECD Asia, **Rest of the world

Sixty percent of the growth in electricity demand will be met by thermal power generation, especially natural gas. Asia leads the large global increase in fossil fuels required for power generation as well as for transportation. The high dependence on fossil fuels remains unchanged and energy related CO_2 emissions increase by 34% by 2050.

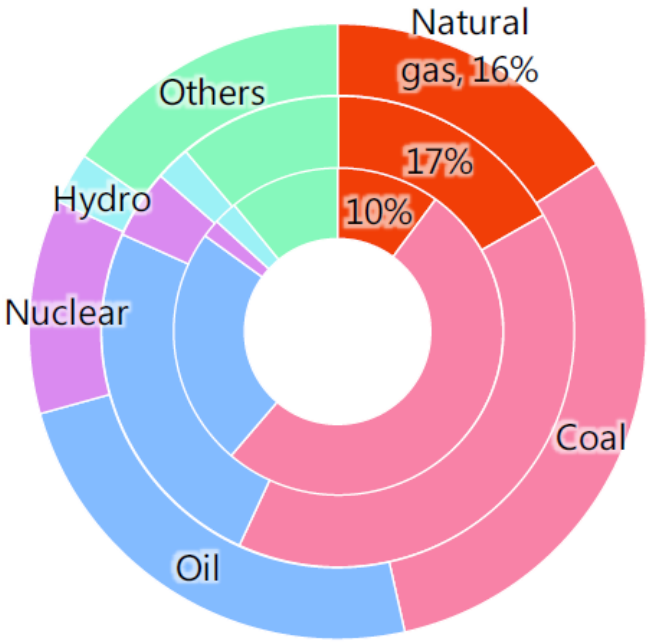
Golden Age of Natural Gas Coming to Asia

Reference and Advanced Technologies Scenario

Changes (2015-2050)



Share (2050)



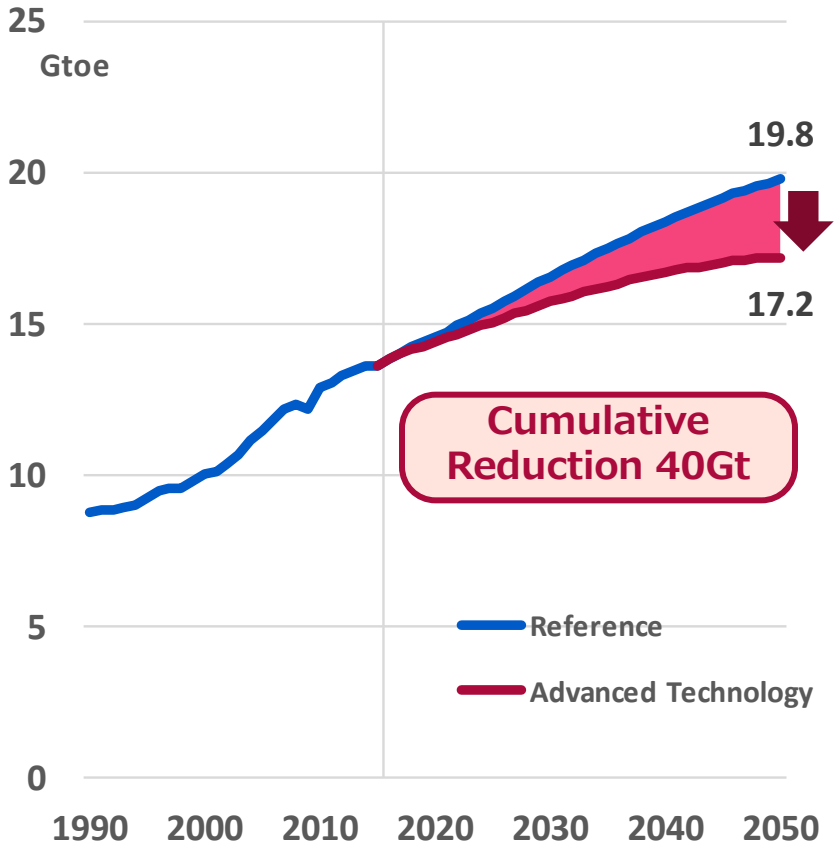
Inside: 2015
Middle: Reference, 2050
Outside: Advanced Technologies, 2050

While the current pace of natural gas demand growth is slow, it grows at the fastest pace among primary energy sources in the long term.

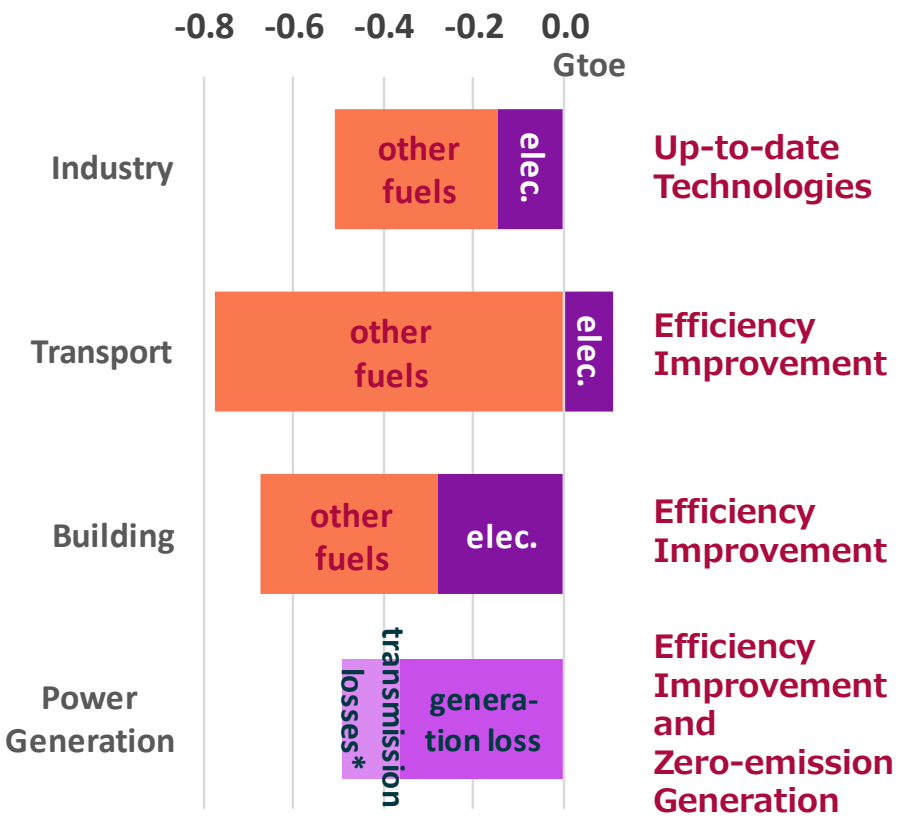
In the "Advanced Technologies Scenario, the increases are the largest among fossil fuels an from 2015.

Drawing another path – Advanced Technologies Scenario

❖ Global Primary Energy



❖ Reduction Effects by ATS in 2050

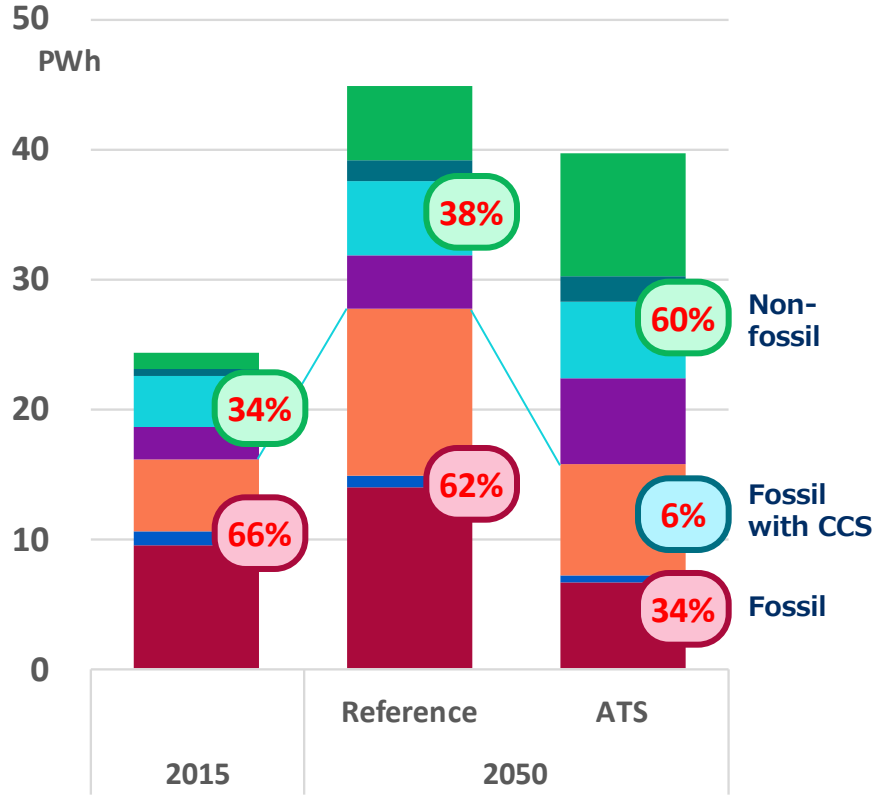


* Including station service power

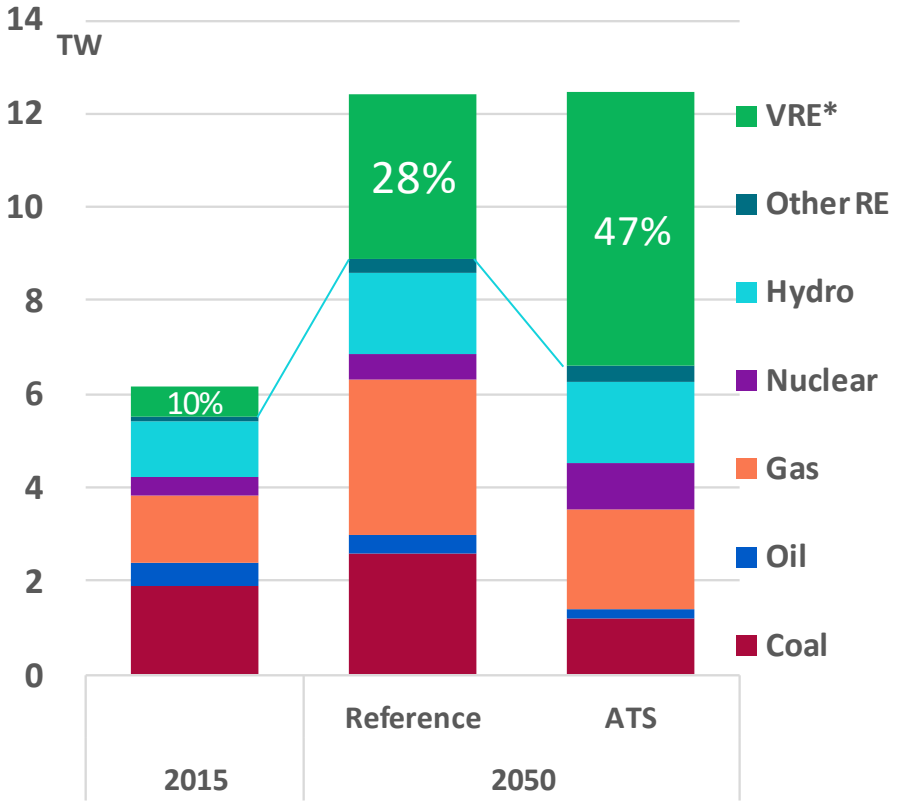
With the maximum installation of low-carbon technologies, the Advanced Technologies Scenario can reduce energy consumption by 13% in 2050. Energy efficiency in power supply/demand technologies would account for 30% of the total reduction. The energy savings in the transport sector are quite large due the introduction of HEVs, EVs, etc.

Zero-emission Generation occupies two thirds

Global Power Generation



Global Power Capacity

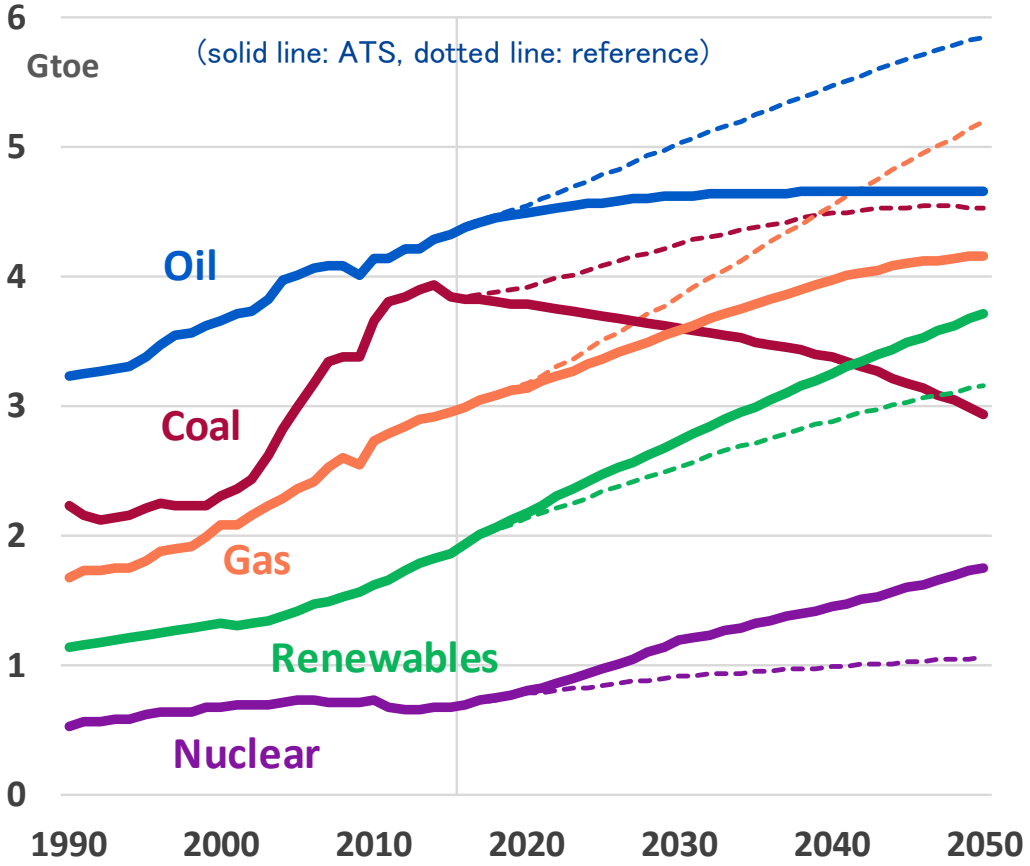


＊Variable Renewable Energy includes PV, CSP, wind and marine.

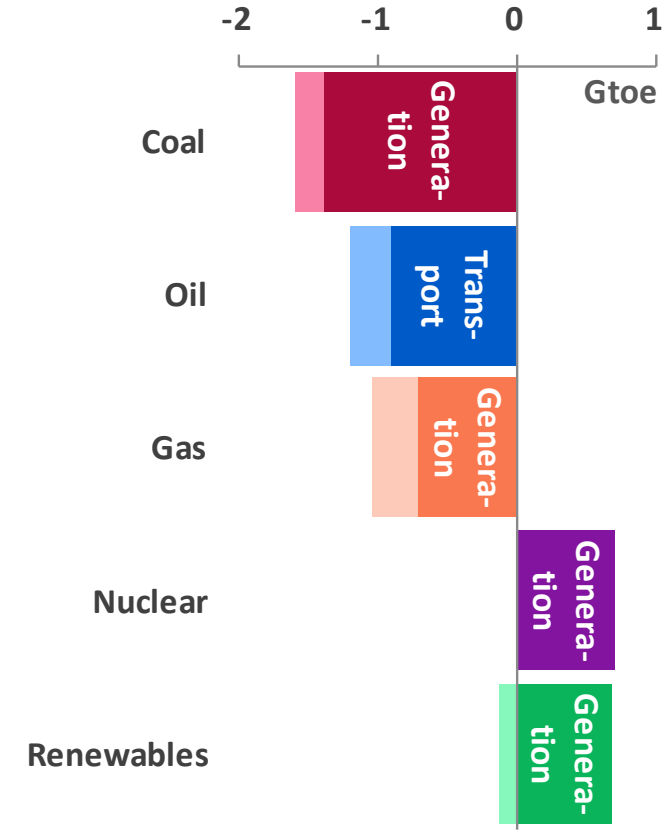
ATS slows the electricity demand growth from 1.8 times in the reference case, to 1.6 times. In ATS, non-fossil power generation accounts for 60% and zero-emission generation, including thermal generation with CCS, represents two thirds (that's half today's CO_2 emissions per unit of generation). As half of the total power capacity will be comprised of intermittent renewable energy, it will be important to enhance grid stability while further reducing costs.

Coal falls significantly and below renewables

❖ Primary Energy



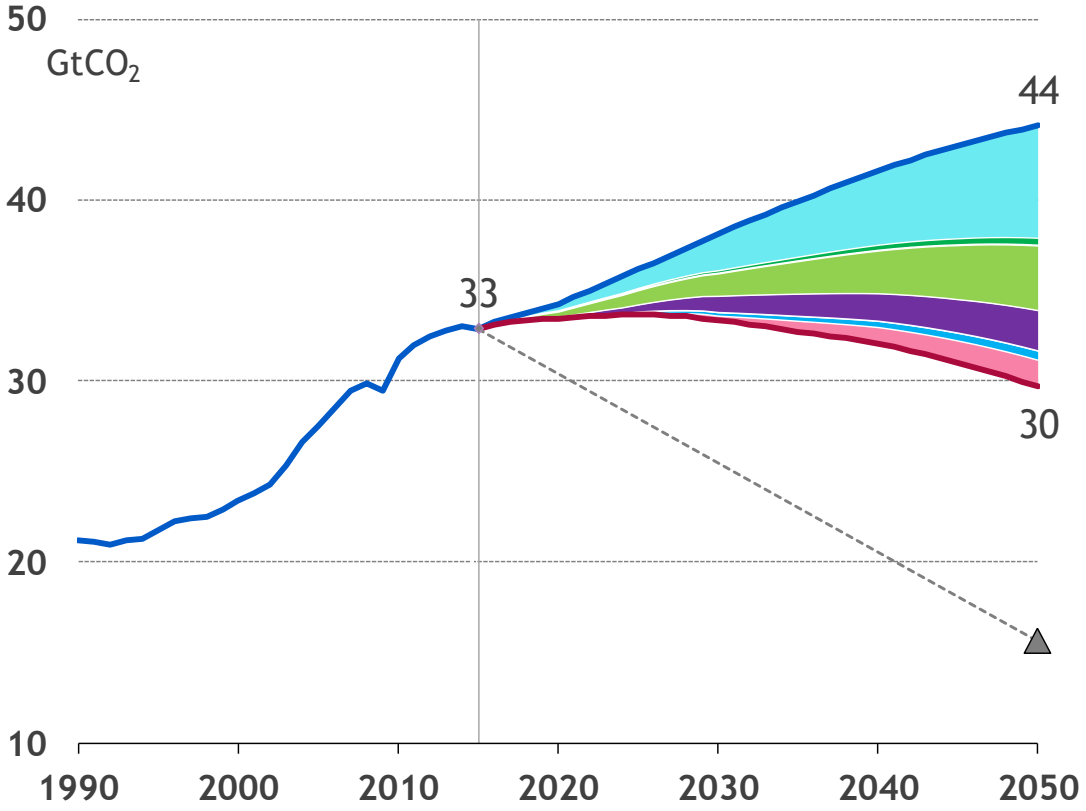
❖ Effects by ATS in 2050



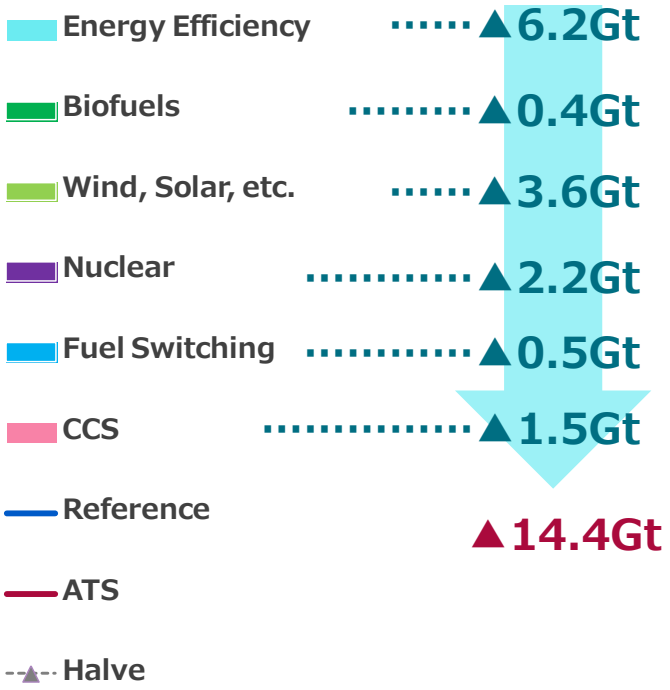
In ATS, coal starts to decline immediately and is surpassed by renewables around 2040, due mainly to energy efficiency and the elimination of emissions in the power supply/demand sectors. Despite large decline in transportation fuels, oil does not reach a peak. Fossil fuels share of the total in 2050 is reduced from 79% in the reference case to 68% in the ATS; it is still a high level of dependence.

CO_2 emissions peak in the middle of 2020s

❖ Energy-related CO_2 Emissions



❖ Reductions by technology

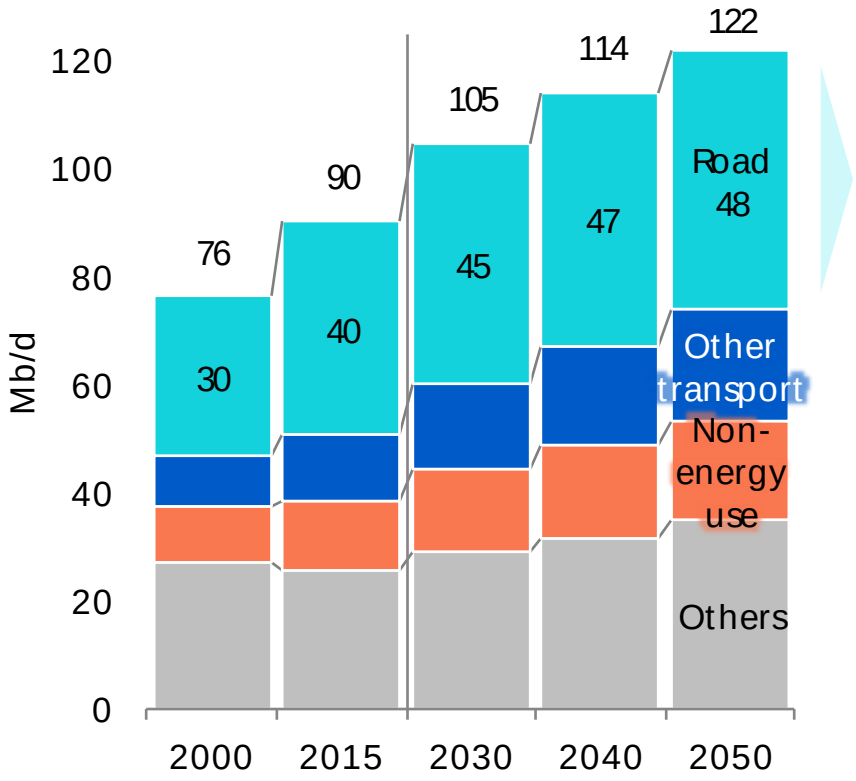


Energy-related CO_2 emissions in ATS decline after the 2020s but are still very far from reaching half of current levels by 2050. Efficiency is the most contributor for CO_2 reductions from the reference. Two-thirds of the total reductions are electricity-related technologies, including non-fossil power, thermal power with CCS and energy efficiency in power supply/demand.

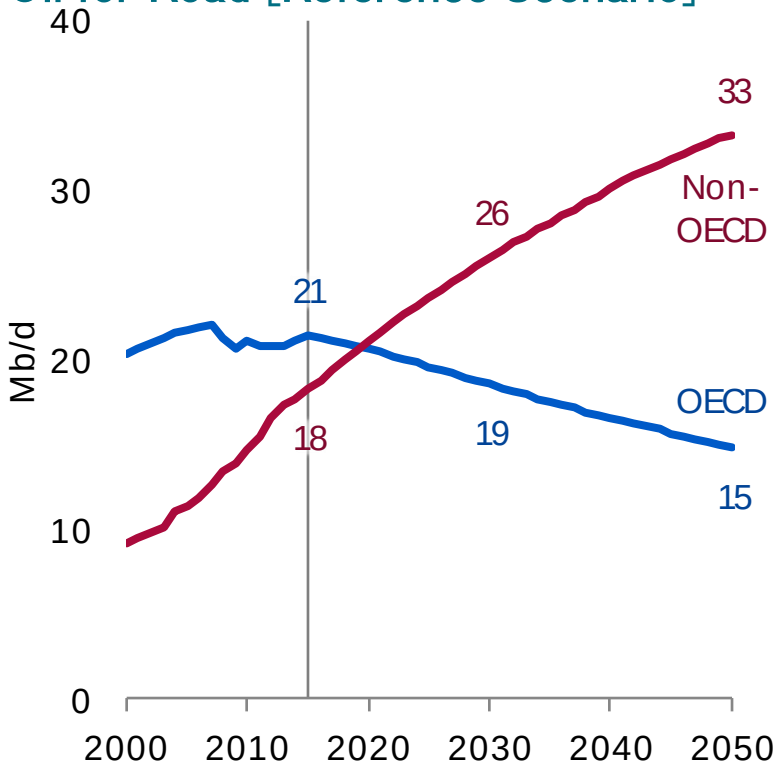
Peak Oil “Demand” Case

Transportation, especially cars, drives oil demand

Oil consumption [Reference Scenario]



Oil for Road [Reference Scenario]



About 70% of the increase in oil consumption until 2050 is by transportation and for petrochemical feedstocks. In particular, road transport may decide where demand goes.

However, oil consumption by cars in OECD is decreasing, and it will be less than in non-OECD around 2020. Non-OECD accounts for all future increases.

The time for car electrification has come?

Selected recent movements by governments/assemblies and car makers

Germany

A resolution to ban conventional car sales in the European Union by 2030 was passed by the Bundesrat of Germany (2016)

Norway

The ruling and opposition parties proposed the abolition of conventional vehicles by 2025 (2016)

France

The Government announced that it would ban conventional car sales by 2040 (2017)

United Kingdom

The Government announced that it would ban conventional car sales by 2040 (2017)

India

Minister said that all new car sales after 2030 would be electric vehicles (2017)

China

Deputy Minister mentioned that the ban on the sale of conventional vehicles was under investigation (2017)

Toyota

The target for FCV sales is more than 30,000/year in 2020 (2015). Reported of full-scale entry into EVs in 2020 (2016)

Volkswagen

Announced the strategy to increase EV share in its total sales to 25% with more than 30 models of EVs by 2025 (2017)

Renault-Nissan

Introducing 12 models of EVs by 2022. The target of 30% of its total sales as EVs (2017)

Hyundai

The plan to prepare EVs at all line up by 2020 (2015)

Ford

Announced that eco-cars combined with EVs and HEVs will be raised to 70% by 2025 (2017).

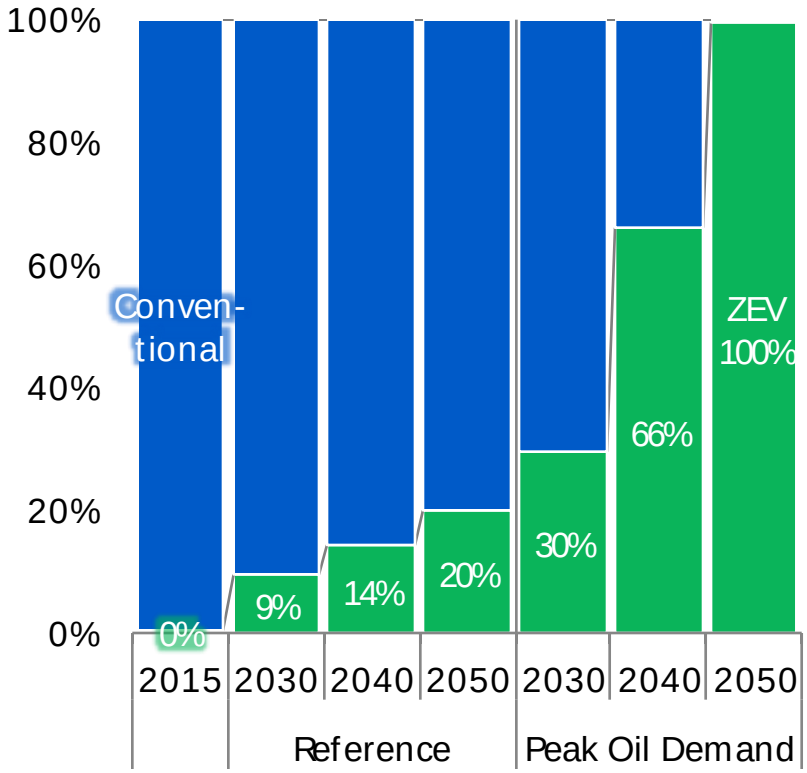
Honda

In 2030, two-thirds of automobile sales will be electrified. EVs will be released in China in 2018 (2017).

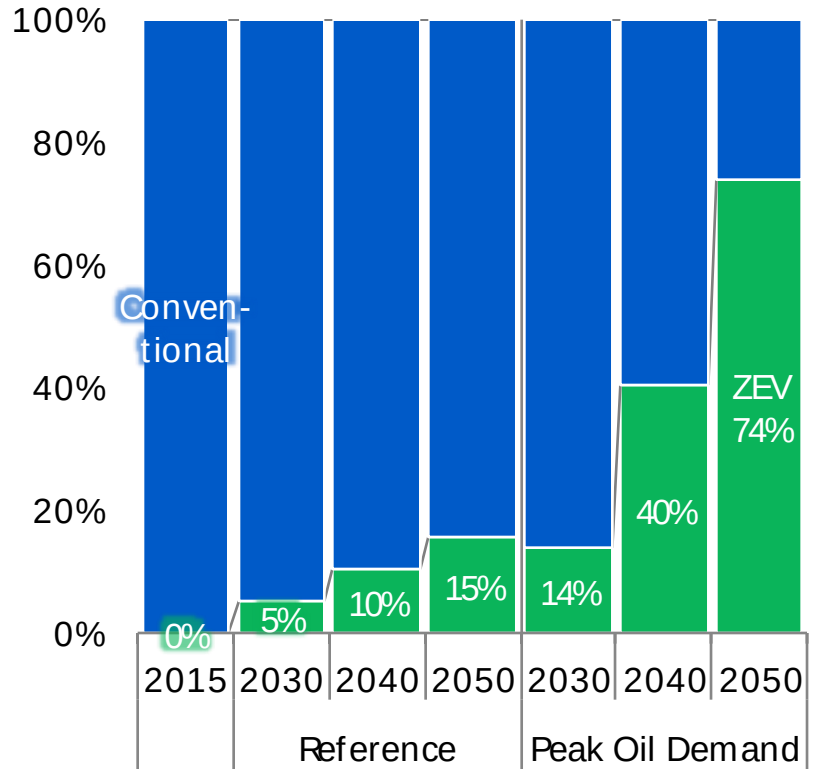
New car sales and car ownership

Peak Oil Demand Case

❖ Assumption of new car sales



❖ Car ownership

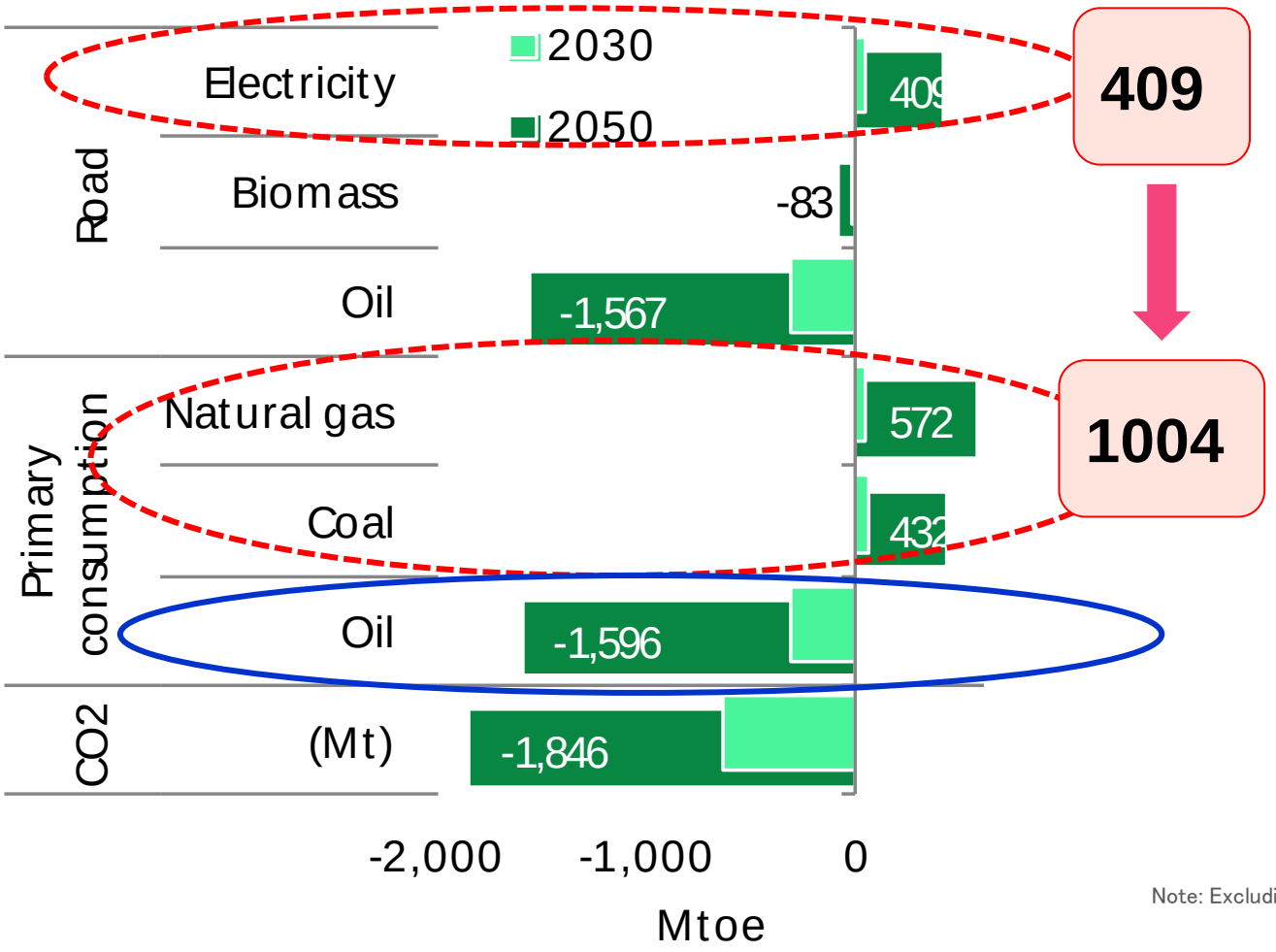


Note: ZEV consists of plug-in hybrid vehicles, electric vehicles and fuel cell vehicles

Expectation on penetration speed of ZEVs varies a lot. In the Peak Oil Demand Case, 30% and 100% of global new car (passenger and freight) sales are assumed to be ZEVs in 2030 and in 2050, respectively.

Sensitivity analysis of energy supply and demand was conducted assuming that the electricity demand increased by the ZEVs will be met by thermal power generation.

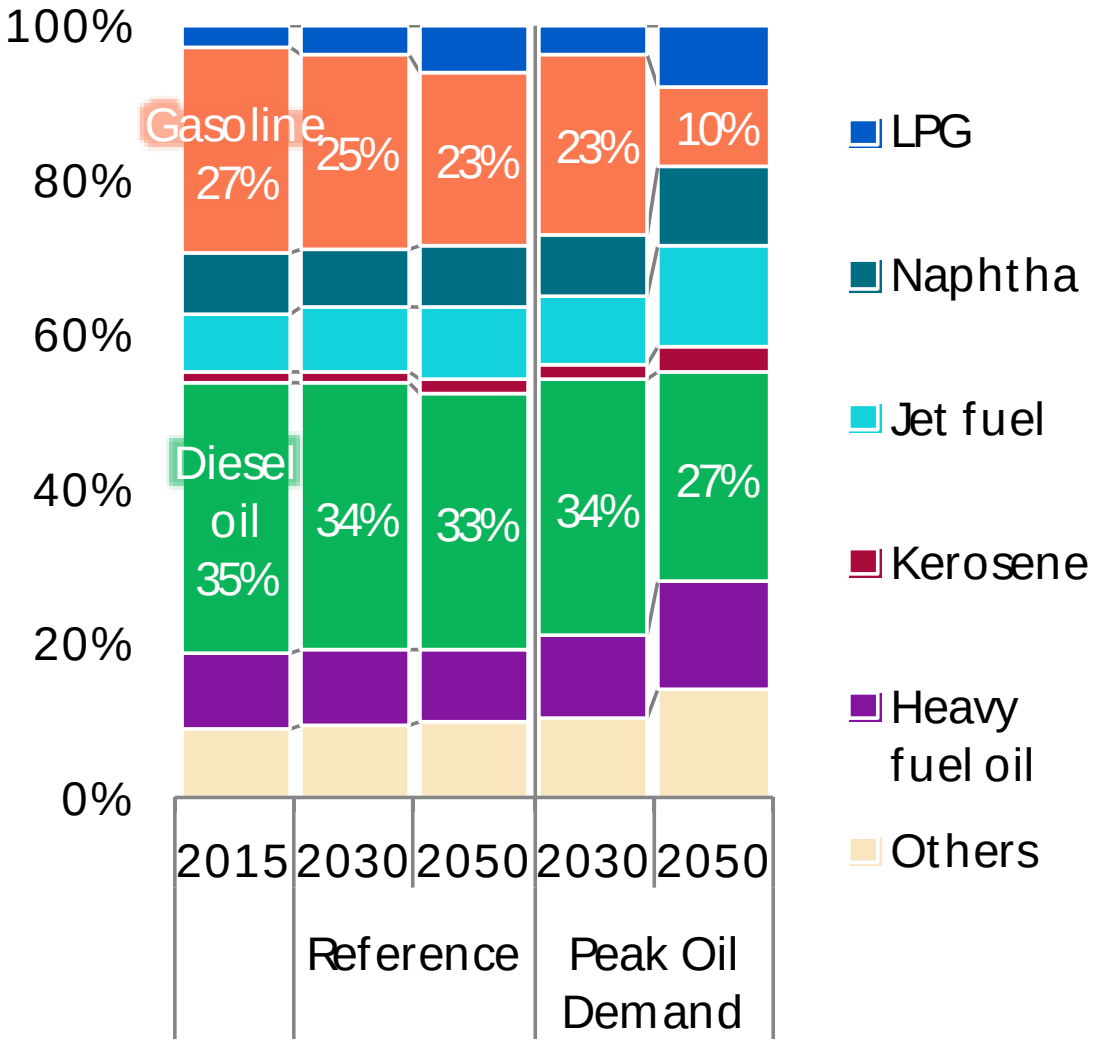
While oil decreases, natural gas and coal increase



Note: Excluding own use

Whilst oil consumption declines, electricity demand by ZEVs increases fuel consumption for power generation. Both natural gas and coal exceed oil by the late 2030s. Since then, natural gas is the largest energy source.

The composition of petroleum product changes

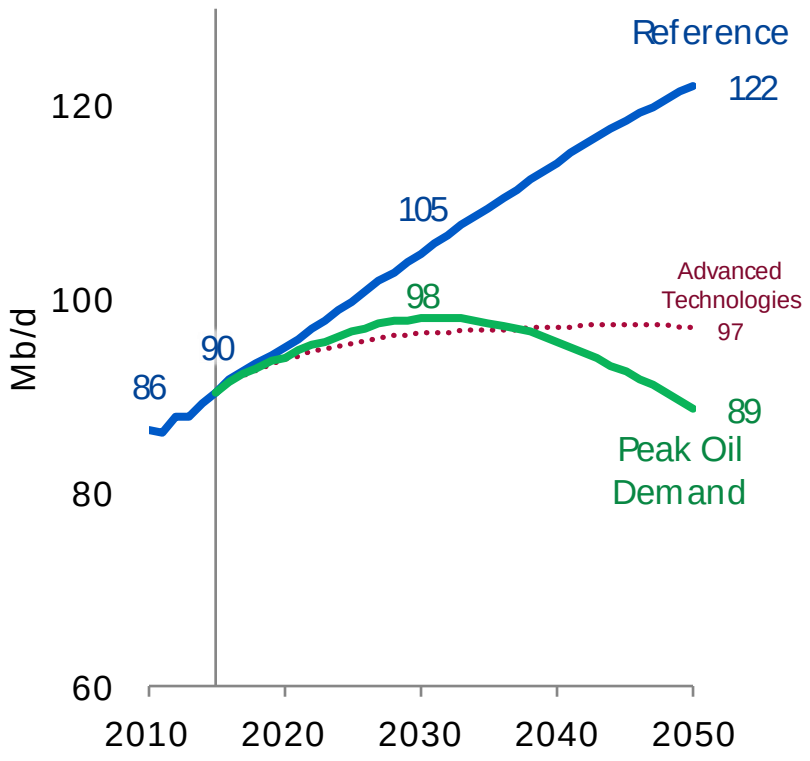


Note: Excluding own use

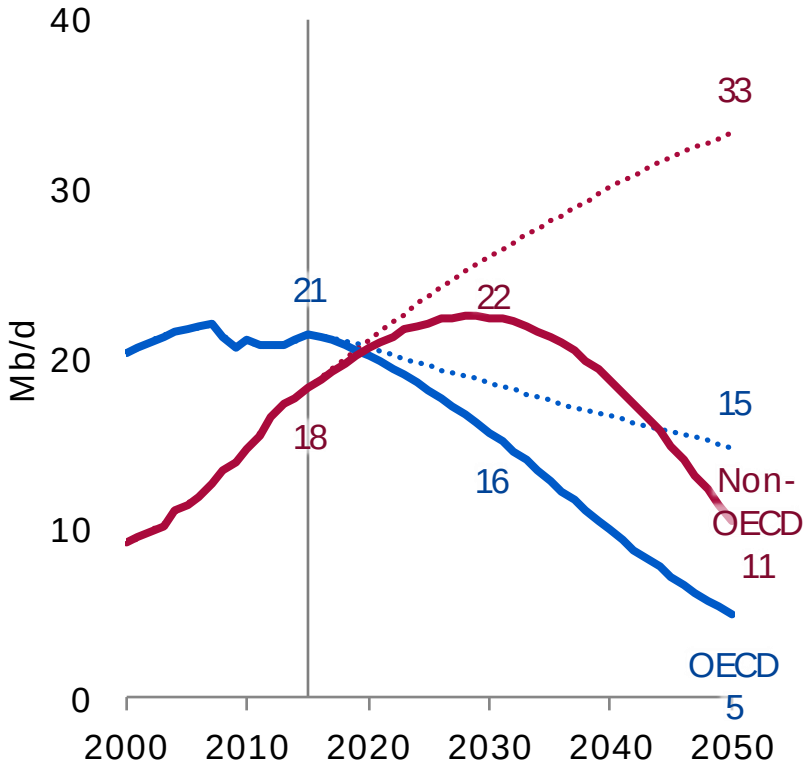
Gasoline reduces its share to 10% in 2050. The share of diesel oil is not smaller than gasoline because diesel oil has other uses; it is nonetheless 8 points lower than today.

Oil peaks around 2030 by rapid penetration of ZEVs

Oil consumption



Oil for Road [Peak Oil Demand Case]



Note: Dotted lines are the Reference Scenario

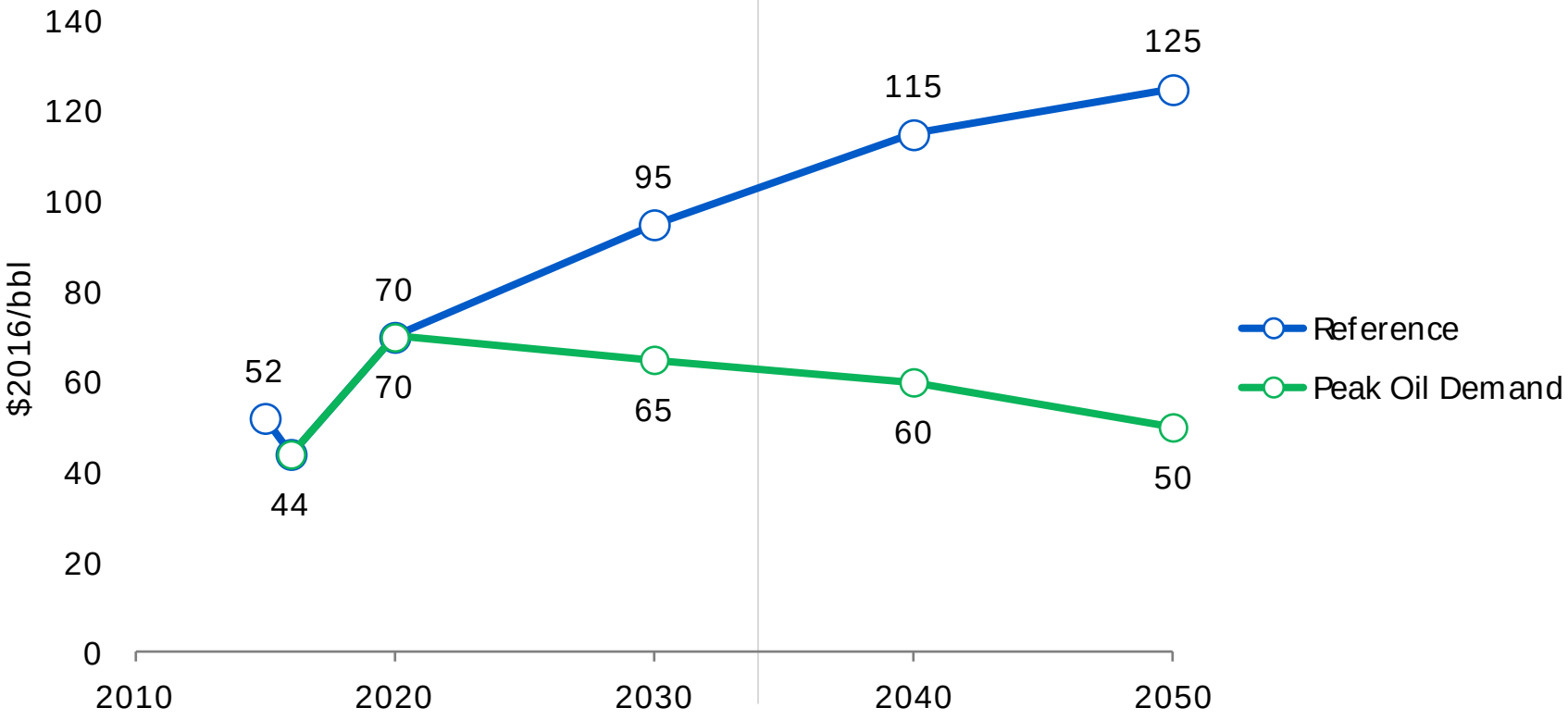
In the Peak Oil Demand Case, oil consumption hits a peak of 98 Mb/d around 2030 then declines. The reduction from the Reference Scenario is 7 Mb/d and 33 Mb/d in 2030 and in 2050, respectively.

Oil consumption by cars in Non-OECD, which continues to increase rapidly in the Reference Scenario, also declines from around 2030. It is as much as one third of the Reference Scenario in 2050.

Oil price goes down as oil demand peaks

Peak Oil Demand Case

❖ Assumption of real crude oil prices

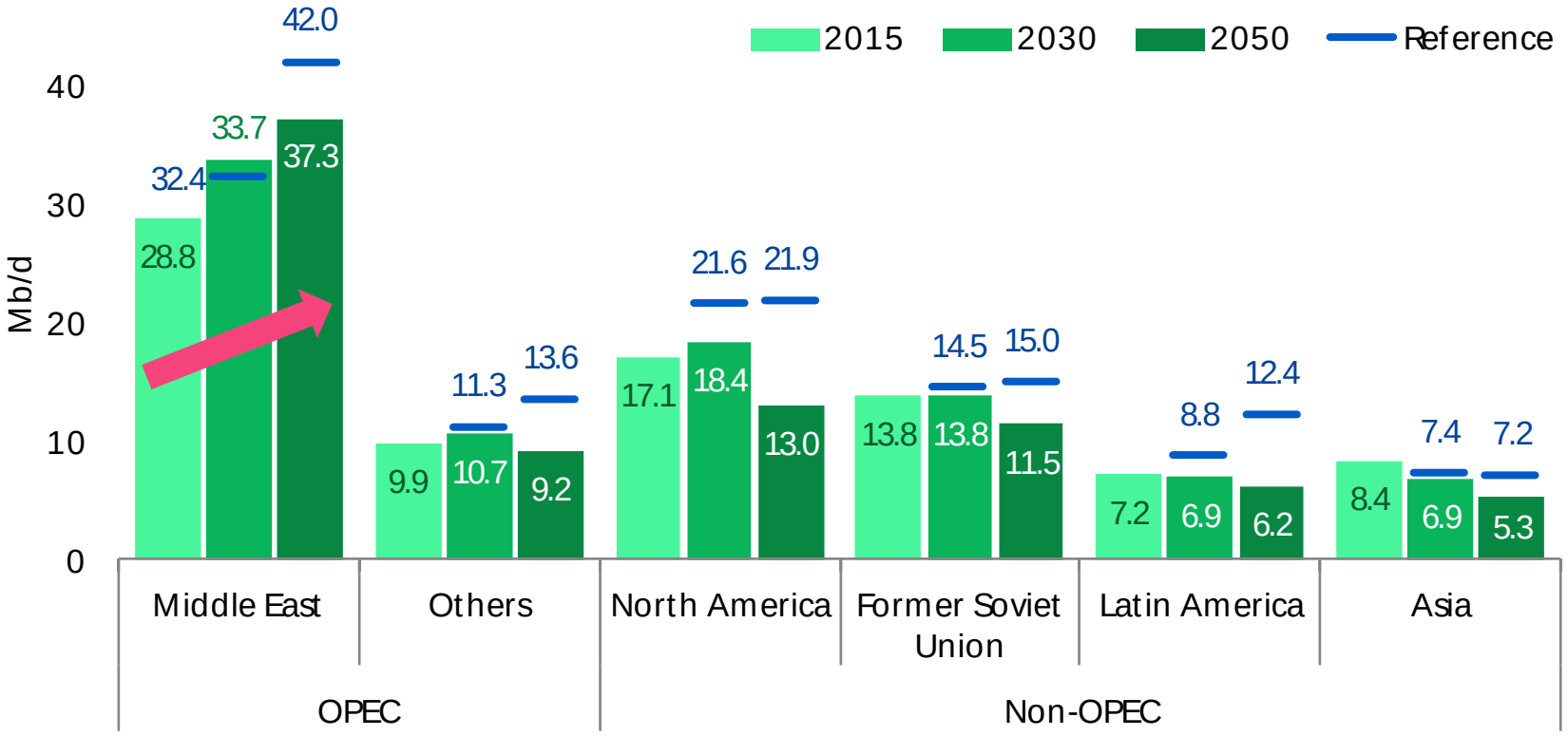


Assuming that the supply and demand relaxation will result in a decline in international oil prices.

In the Peak Oil Demand Case, the prices begin to decline after the 2020s and fall to $50/bbl in 2050.

Crude oil production shifts to low-cost regions...

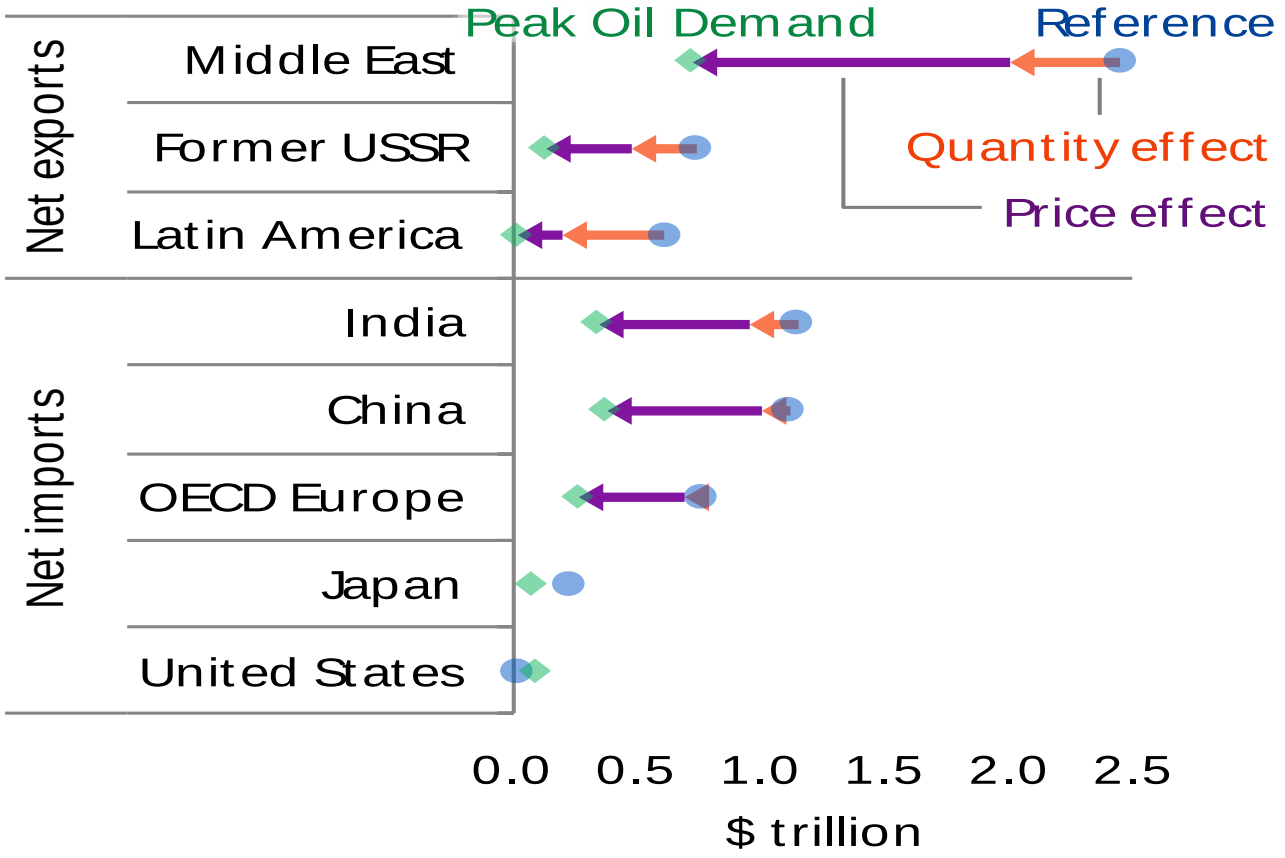
Crude oil production [Peak Oil Demand Case]



Oil price falls due to the change in supply and demand pressure and market sentiment – $65/bbl and $50/bbl in 2030 and in 2050, respectively, compared to $95/bbl and $125/bbl in 2030 and in 2050, respectively, in the Reference Scenario (in $2016). Given this drastic price decrease, superiority of lower production costs-regions increases, and only the Middle East produces more in 2050 than today. North America decreases by 40% from the Reference Scenario to 13 Mb/d.

...but the economic downturn also works in the Middle East

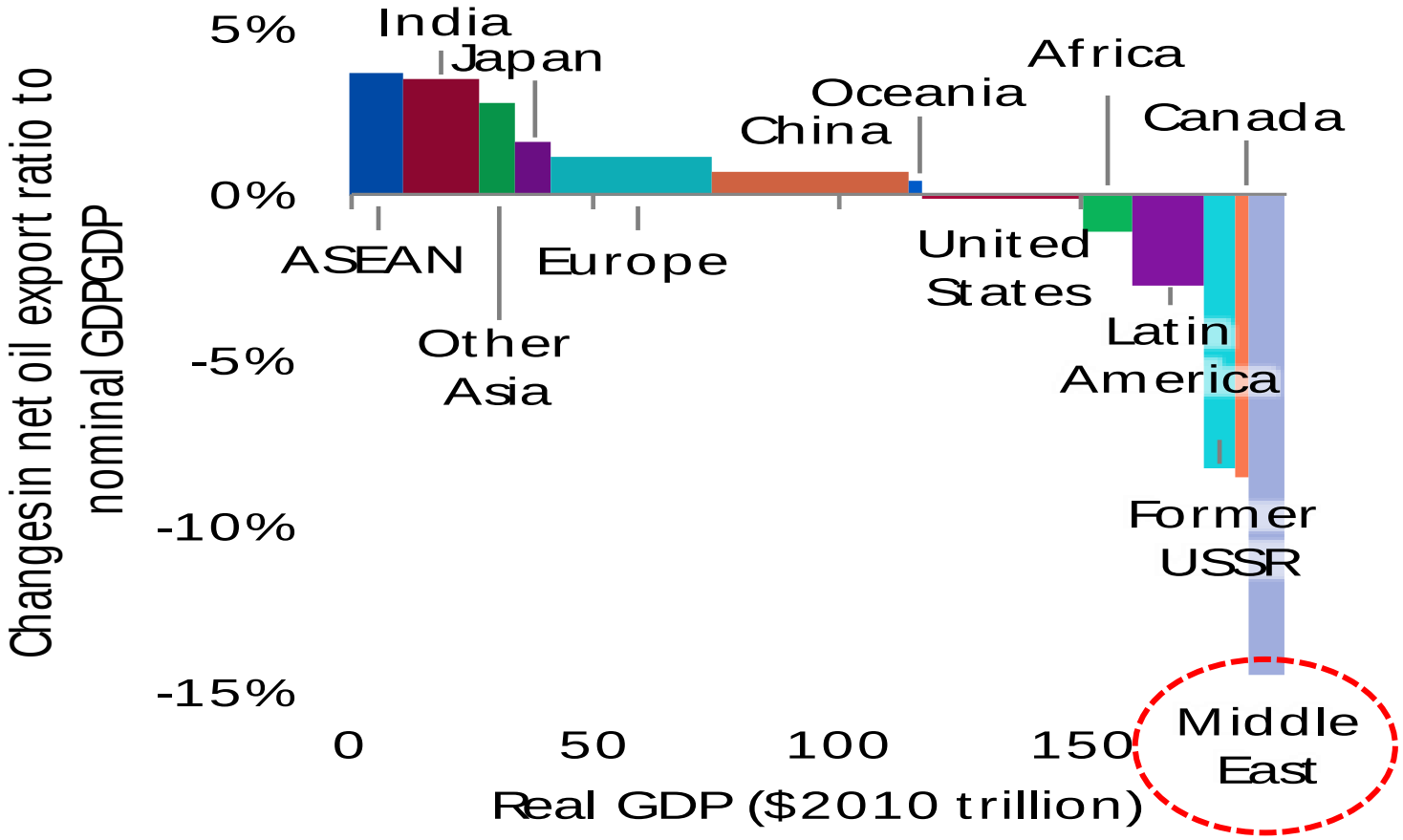
Changes in net oil exports/imports [2050]



Although the Middle East obtains a relative gain, its net oil export decreases of $1.6 trillion or 13% of nominal GDP is significant. The price effect is bigger than the quantity effect in reducing trade income.

Due to lower prices, Middle East will suffer the largest economic downturn

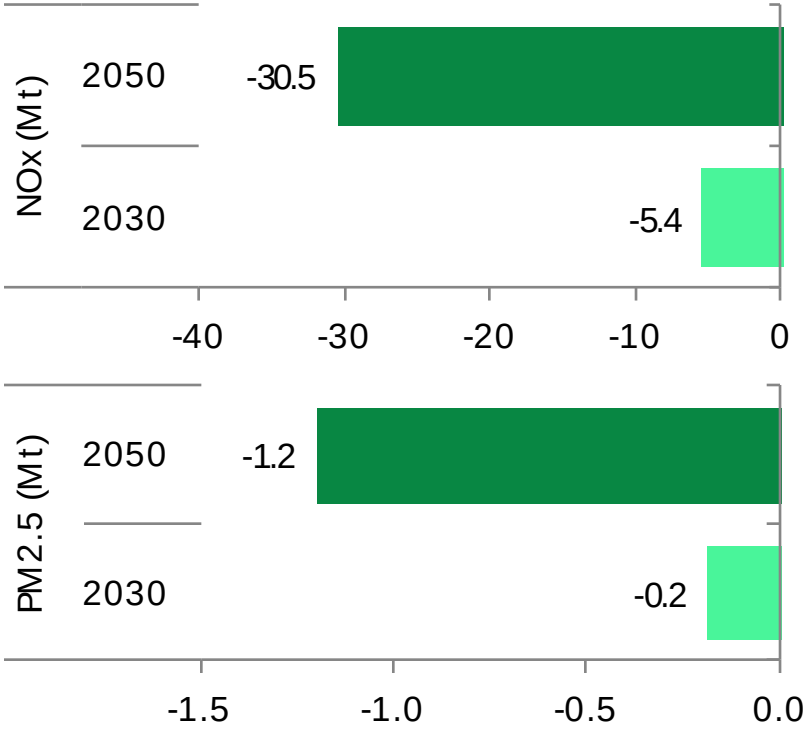
The ratio of net oil exports/imports to nominal GDP [2050]



On the other hand, India, the second largest oil consumer, benefits the most from decreases in net oil imports. It is followed by China, which has a larger car fleet than any other countries. The United States has little impact despite of its consumption scale since it is almost oil self-sufficient.

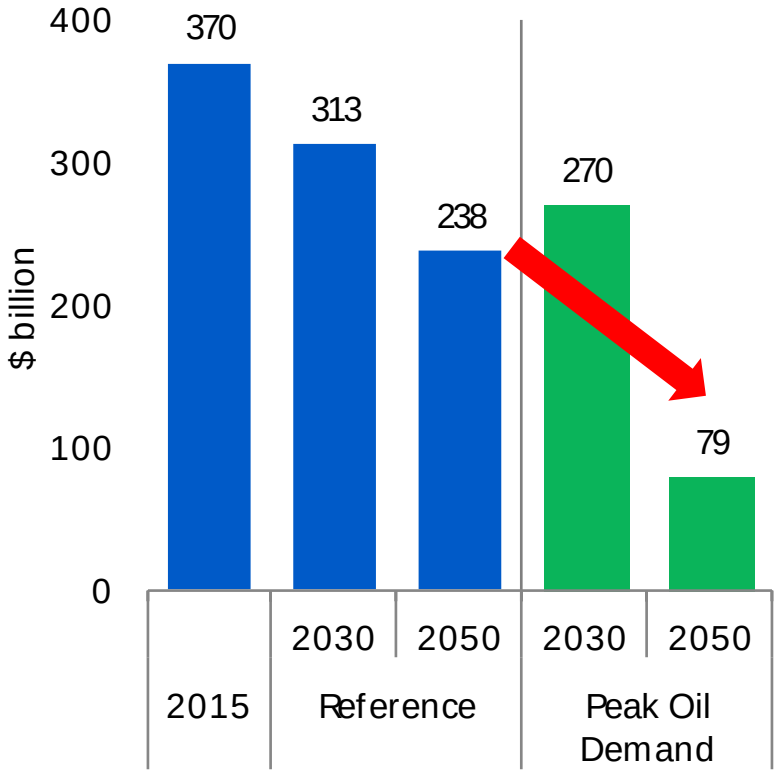
Impact of less oil consumption diverges

Changes in emissions (from the Reference Scenario)



Note: Automobile origin. Excluding effect on improvement of conventional automobile emission control performance

Excise taxes on gasoline and diesel oil for automobiles in OECD



Emission reductions in NO_x and $PM_{2.5}$, the major drivers of the car electrification, are 27% and 3%, respectively, compared to total emissions in 2010. Contributions are expected to improve air quality in urban areas.

Unless the tax regime changes, revenues from Excise Taxes on automotive gasoline and diesel oil decline significantly. They may cause financial/fiscal problems similar to the subsidies for ZEVs during their promotion period.

What are the implications of declining oil use?

- Under certain circumstances, oil consumption can turn into a decline in the not too distant future.
- The extreme assumption on the penetration of ZEVs is challenging. Oil consumption may not easily peak out.

Oil is required even at the same scale of today in 2050 .

- The lack of supply investment because of pessimism could threaten **energy security** and that would further decrease oil demand. The rising dependence on the Middle East will **increase geopolitical risk**.
- **Collaboration between consuming and producing countries** will become even more important. Supporting efforts such as Saudi Arabia's "Vision 2030" is essential.

Thank you for your attention

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