McKinsey&Company

The future energy landscape

Global trends and a closer look at the Netherlands

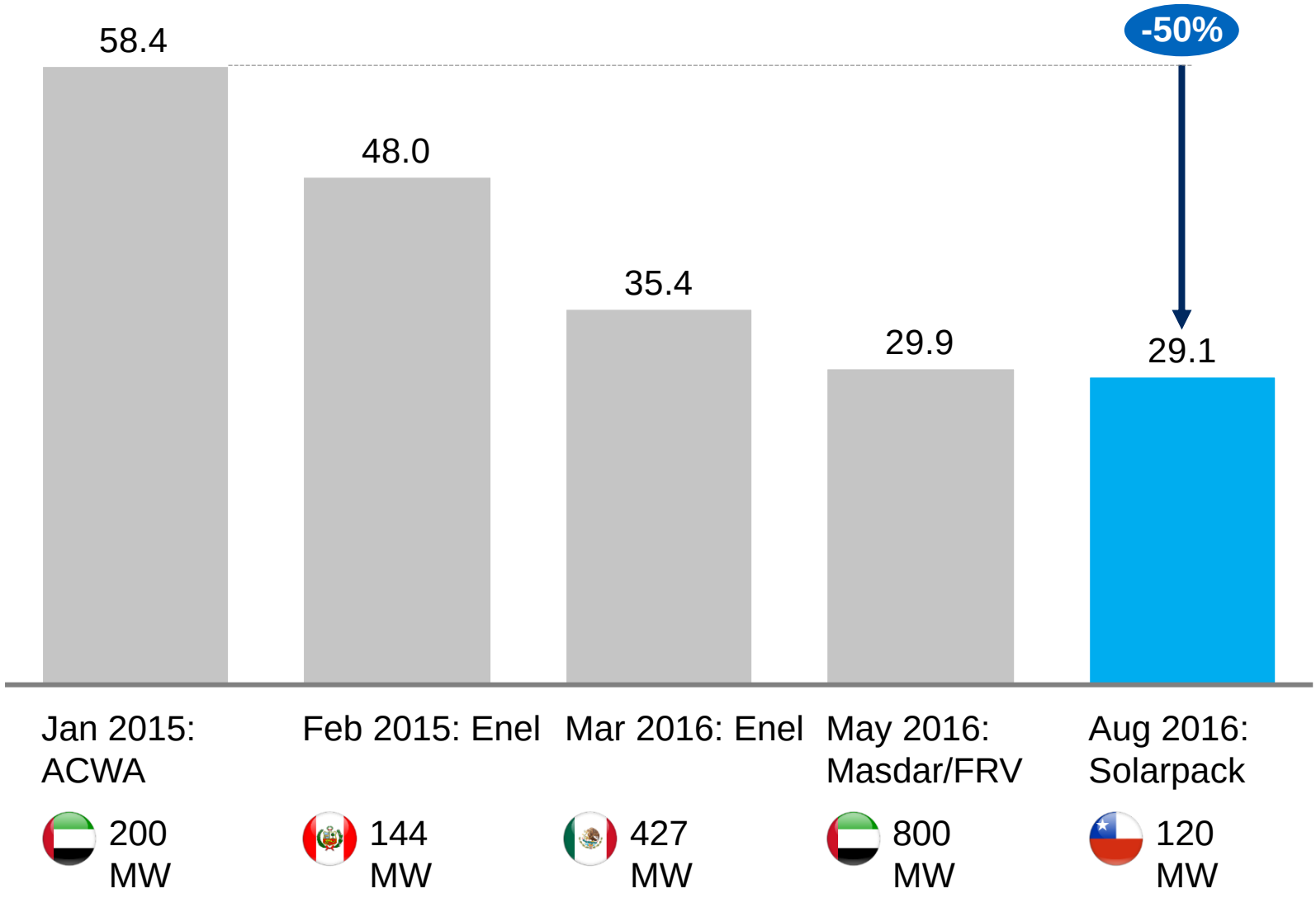
June 2017
Presentation to Dutch Financial sector, Rotterdam

Occo Roelofsen

PV auctions ~50% price drop

LCOE, USD/MWh

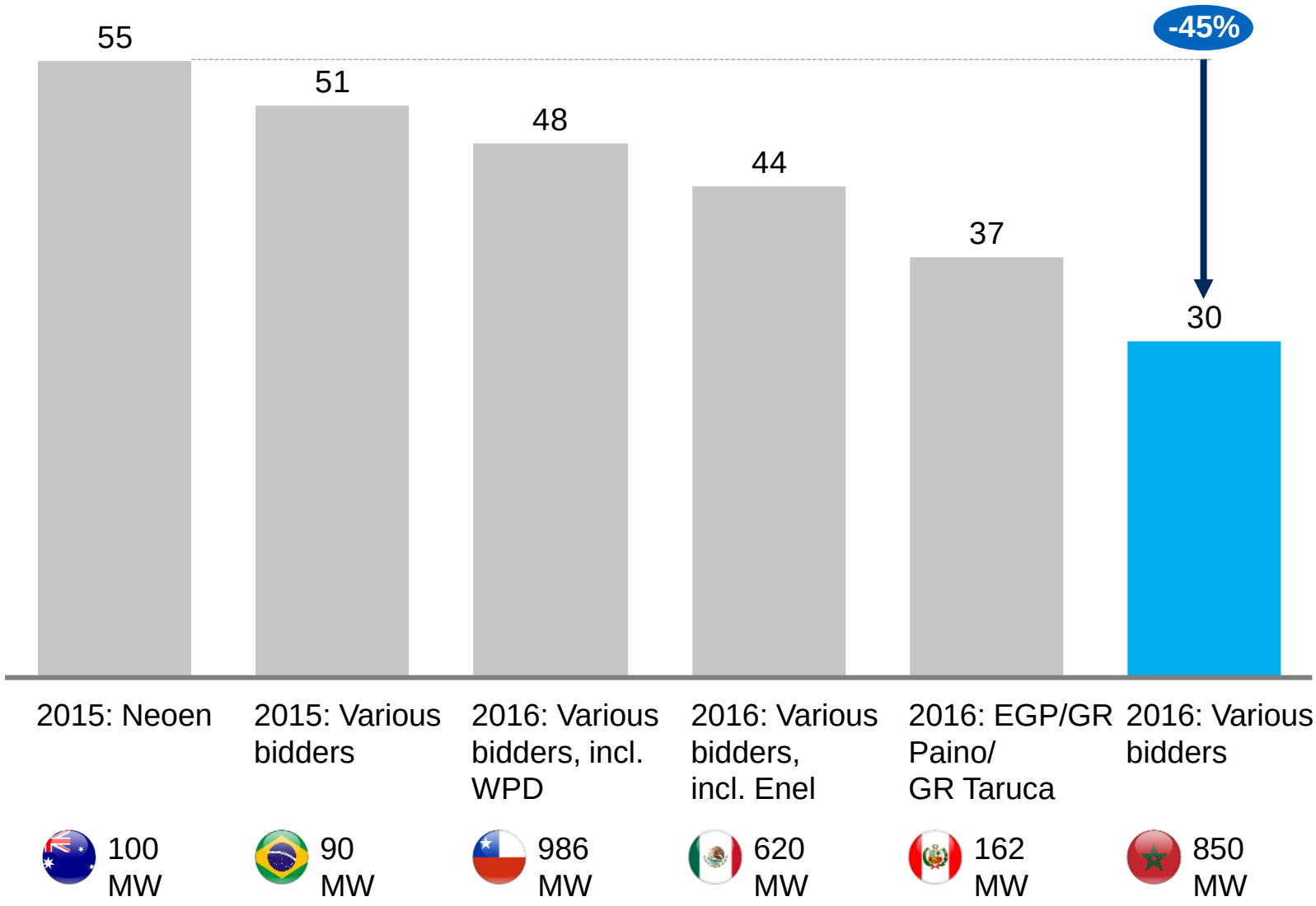
Lowest winning solar PV bids



Onshore wind -45%

LCOE, USD/MWh

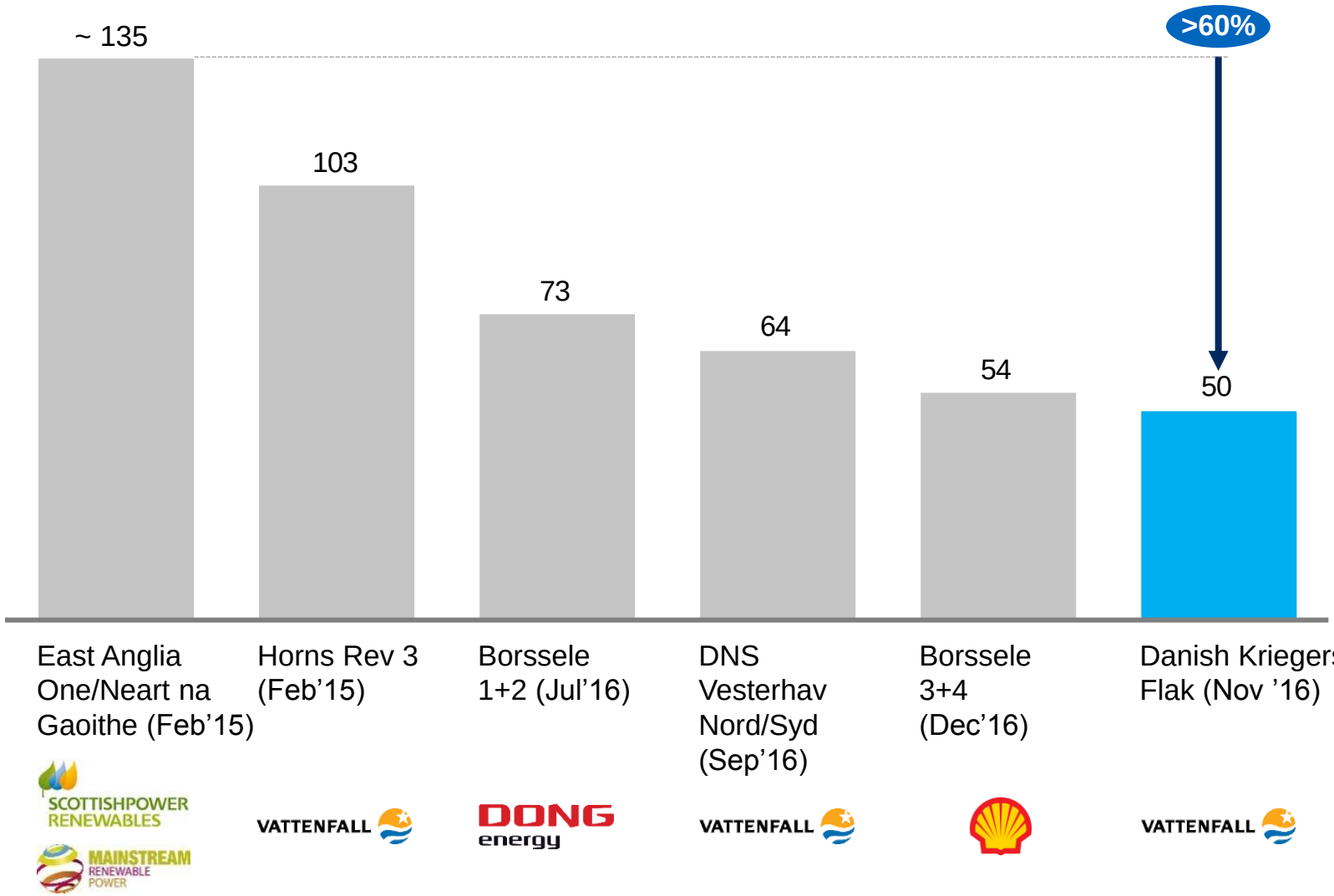
Winning onshore wind bids



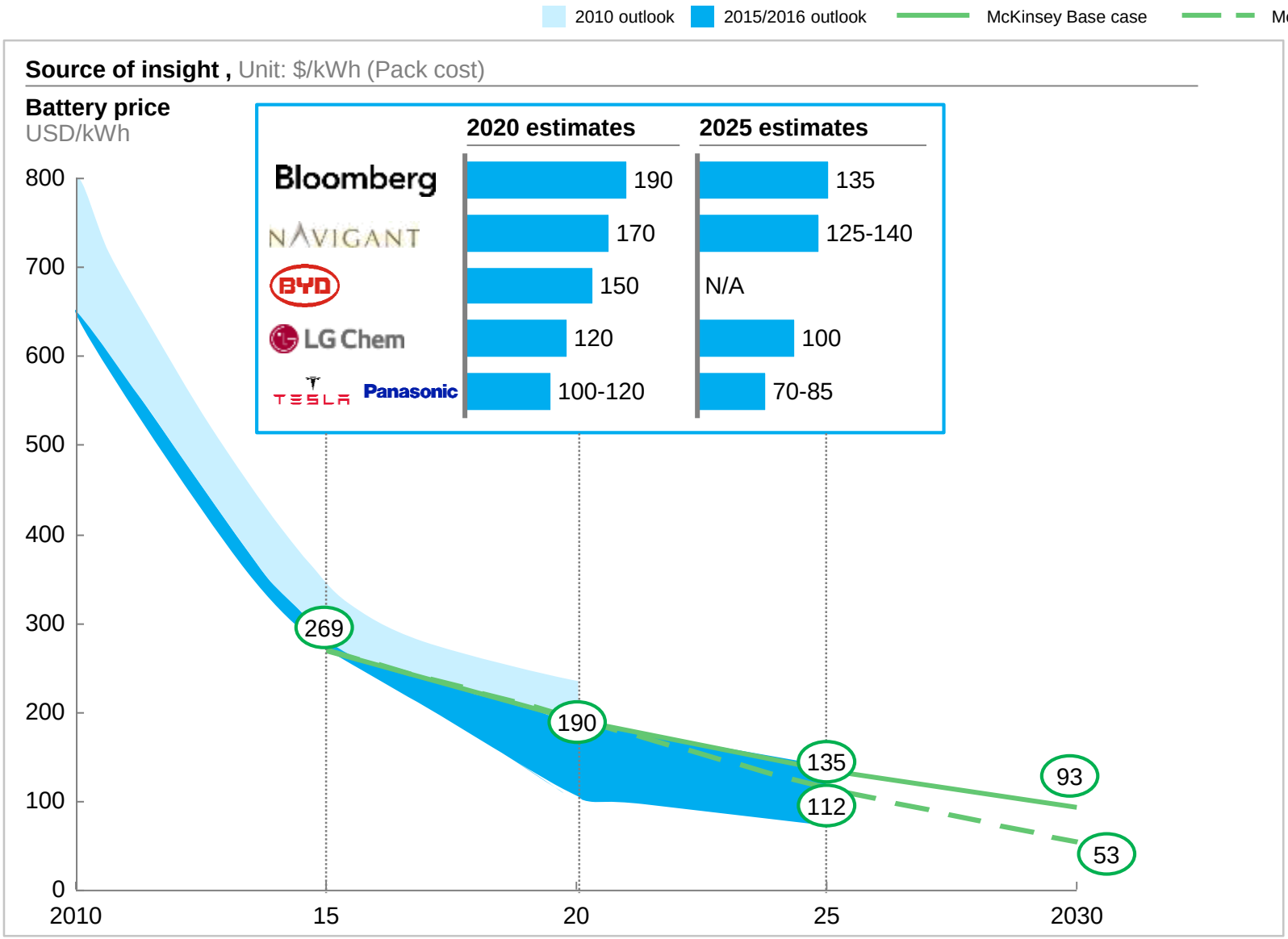
… and offshore wind tenders have dropped by over 60%

LCOE, EUR/MWh

Offshore wind tenders have dropped ~60%

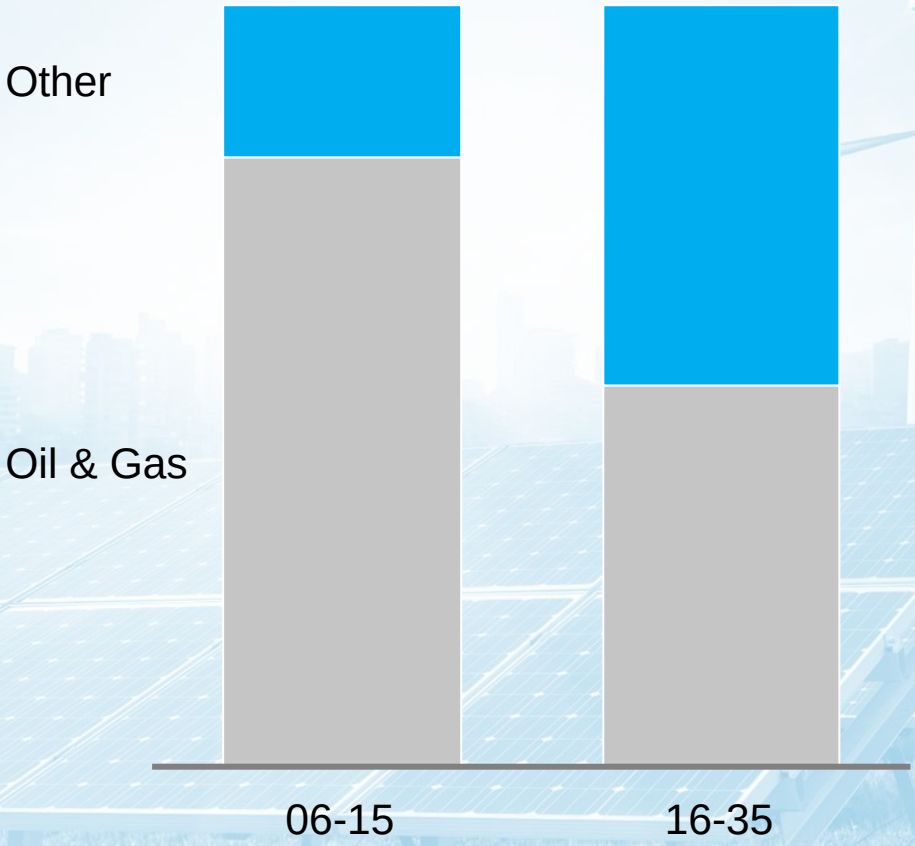


And Battery costs continue to fall, faster than expected



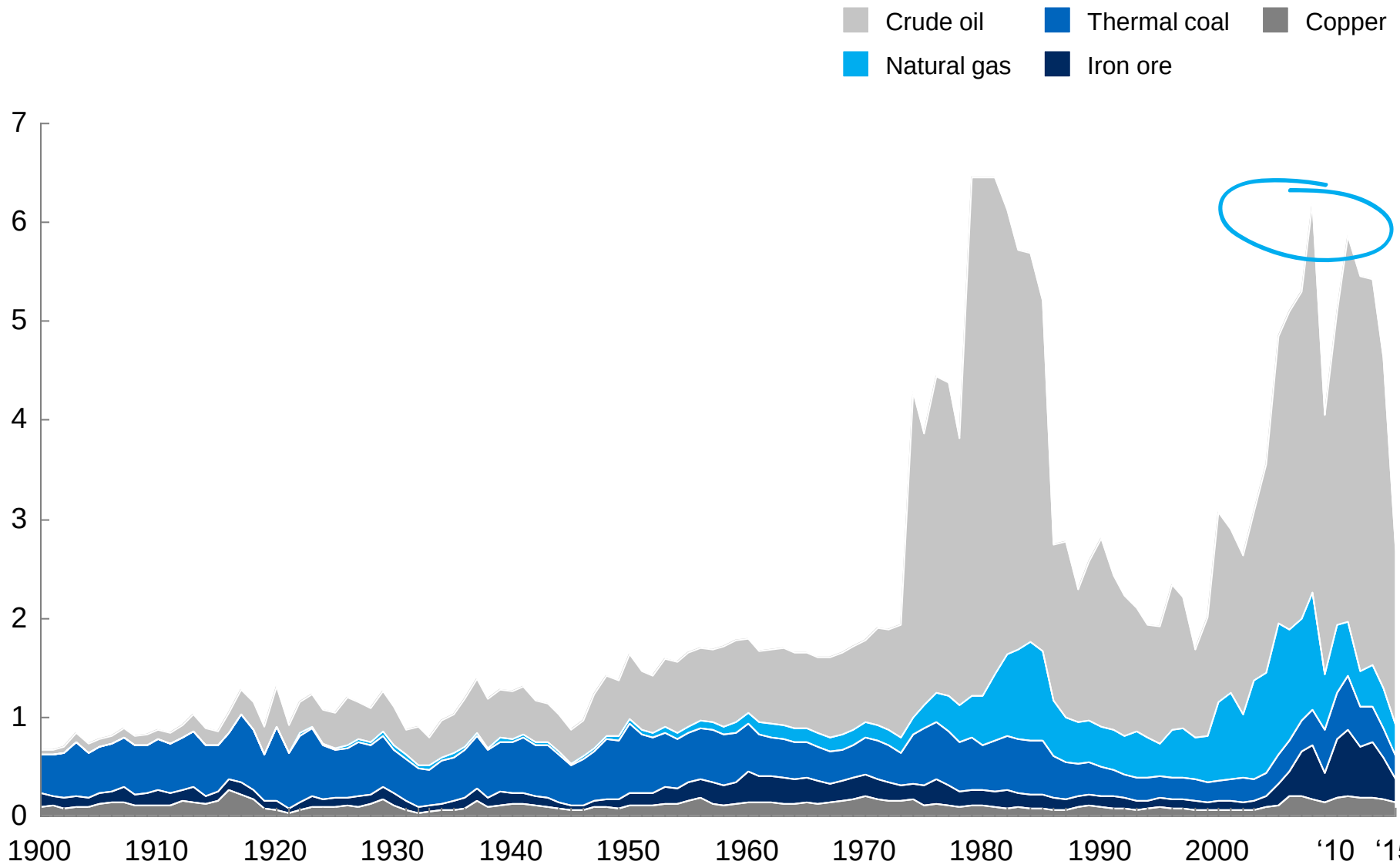
SOURCE: Expert interview, SNE research, Navigant, Avicenne Energy, Berstein

Investments in the energy system are shifting



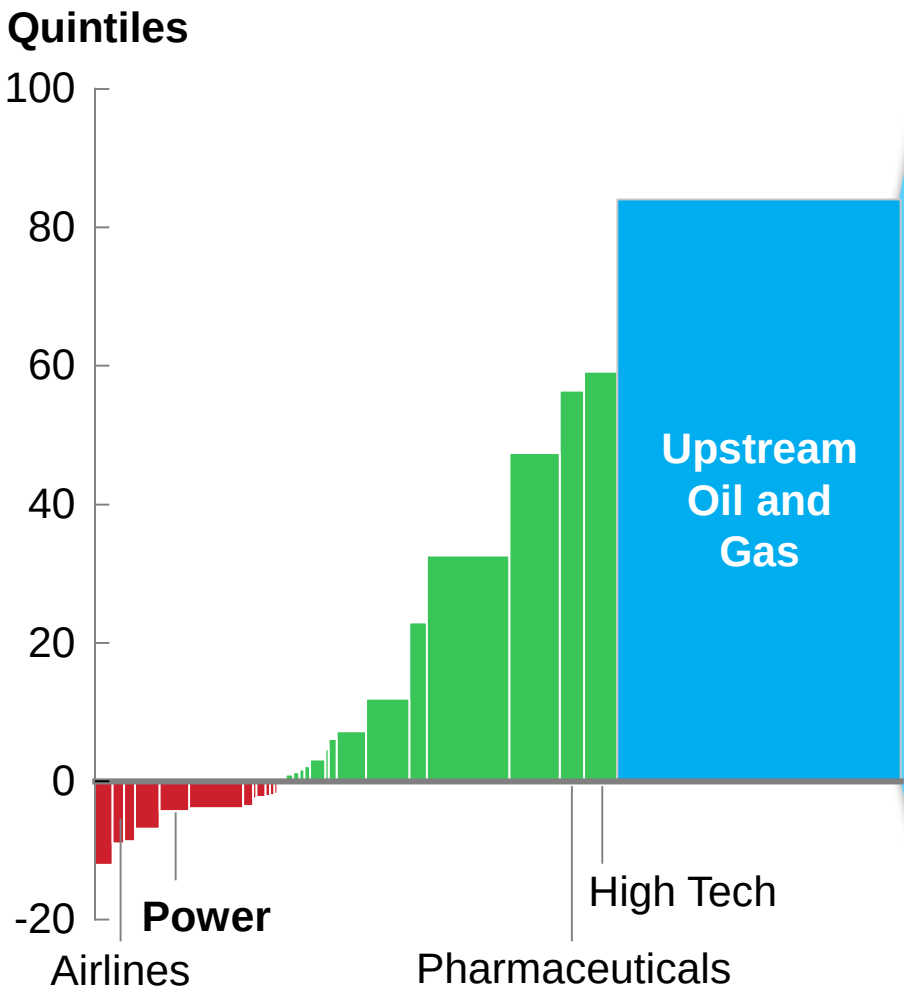
Are we going back to the ‘normal’ levels for resource cost?

Resource expenditures as share of global GDP, Percent

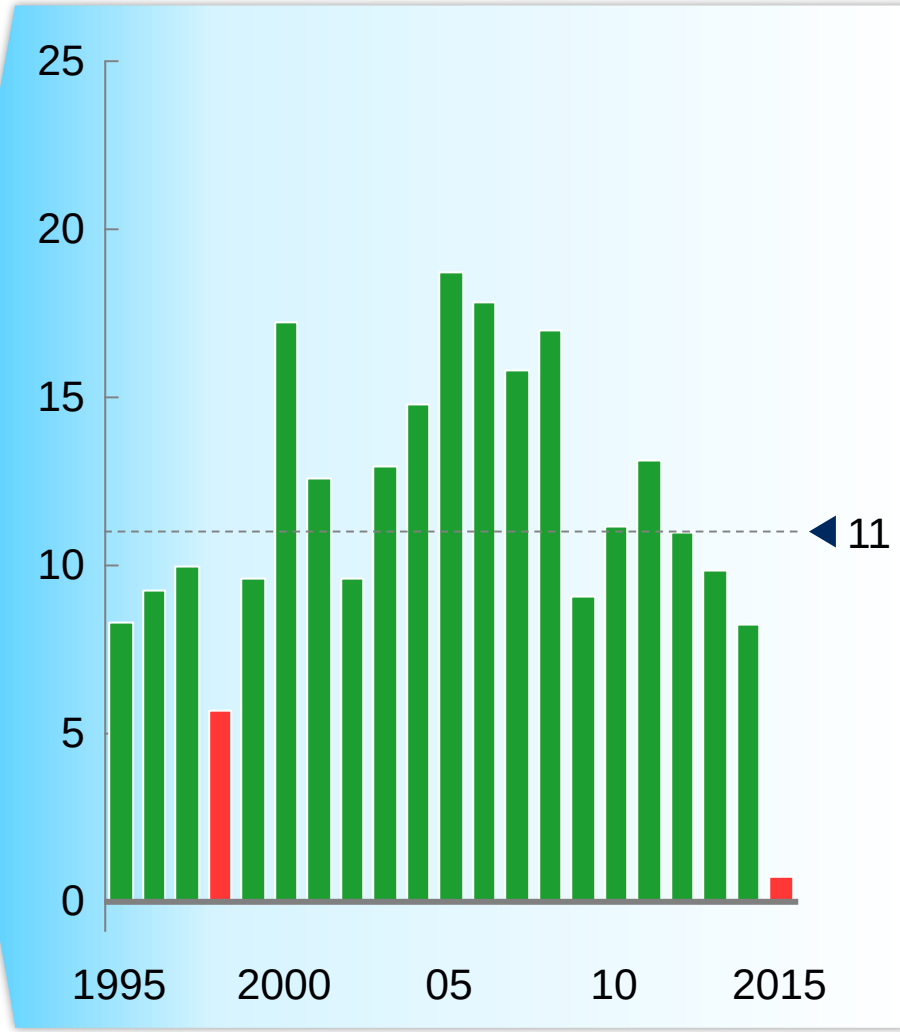


Economic profits in Upstream oil and gas

Economic profit per year, 1995-2015
$Bn, per annum

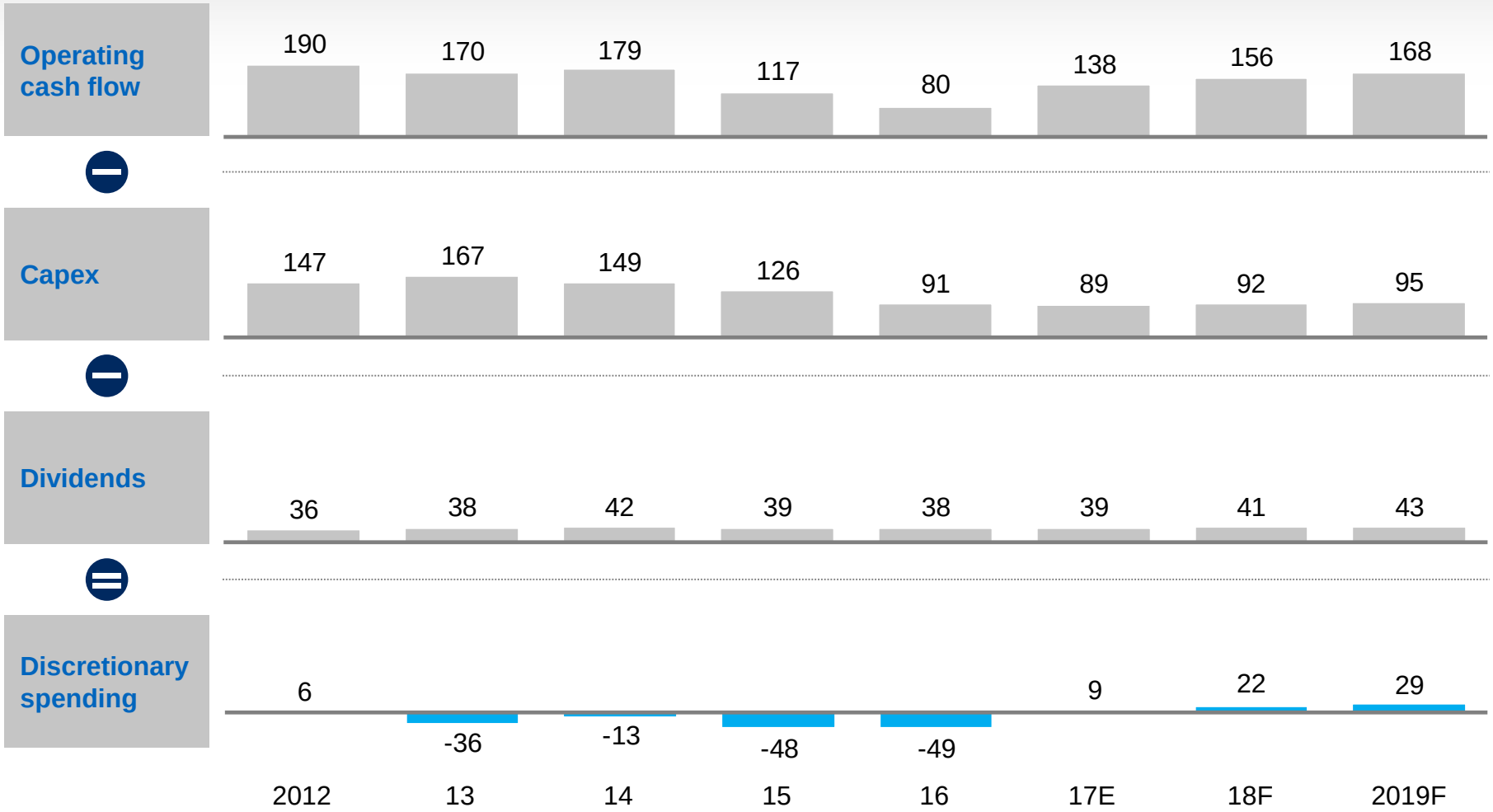


Economic profit evolution of upstream O&G, 1995-2015, % per annum



After 4 years of bleeding cash, consensus is that the Majors will have cash available for discretionary spending in 2017

"Committed" cash flow for Majors[1,2], USD billion



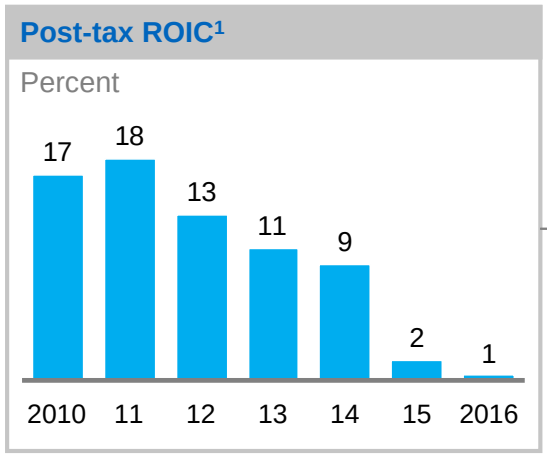
1 Including Exxon, Shell, Chevron, Total and BP; 2 Cash flow from operations split in uses - capex and dividend payments which are defined as committed usages; cash flow source/ usage excludes Acquisition/ sale, change in debt balance, equity issuance, share repurchases, other investing/ financing and forex activities; 3 Cash flow from operations, capex based on analyst consensus, dividends are grown at 5% each year from 2016 levels

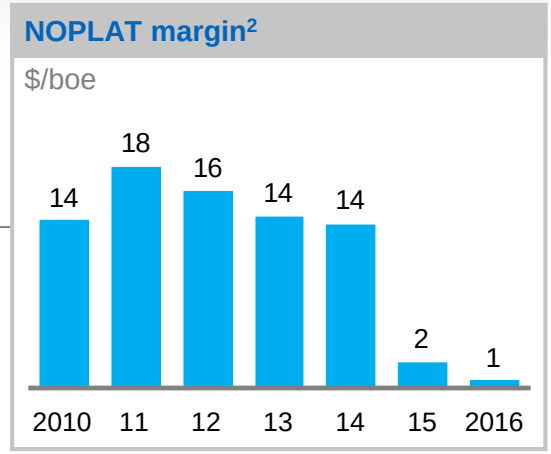
SOURCE: CapitalIQ, team analysis

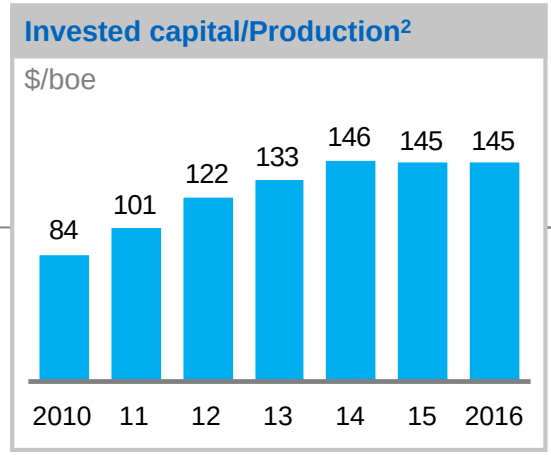
However, fundamental upstream performance remains weak

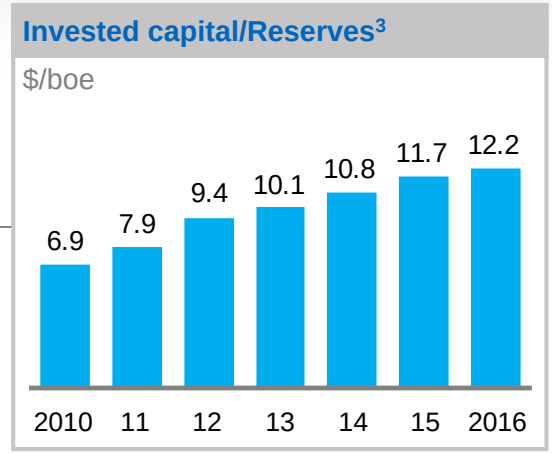
UPSTREAM

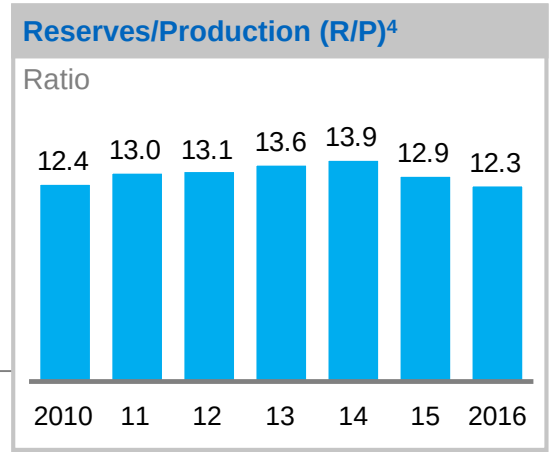
Breakdown of upstream returns on invested capital 2010-2016











1 ROIC based on year end IC; based on SEC O&G reporting; Invested capital based on reported capitalised costs 2 Based on net production
3 Based on reported proved reserves 4 Based on year end reserve by production ratio

Source: Company filings; Team analysis

The 3 trends shaping the energy company of the future

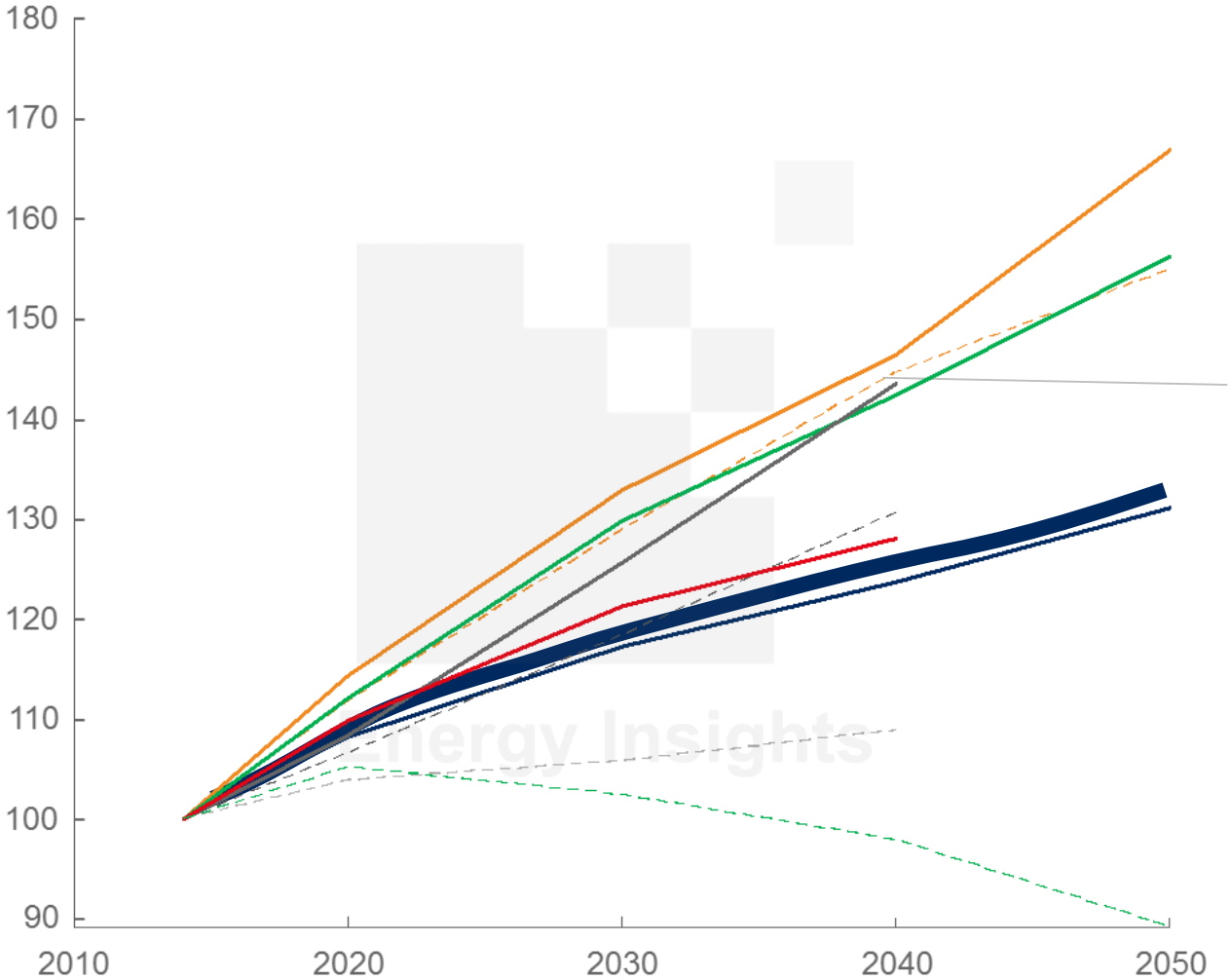
1 **‘The shifting energy landscape’**

2 **Lower for longer for oil, gas, power prices as a base case?**

3 **A closer look at the Netherlands**

Our latest outlook is lower than “base case”-like views

Primary energy demand
Index, 2014 = 100

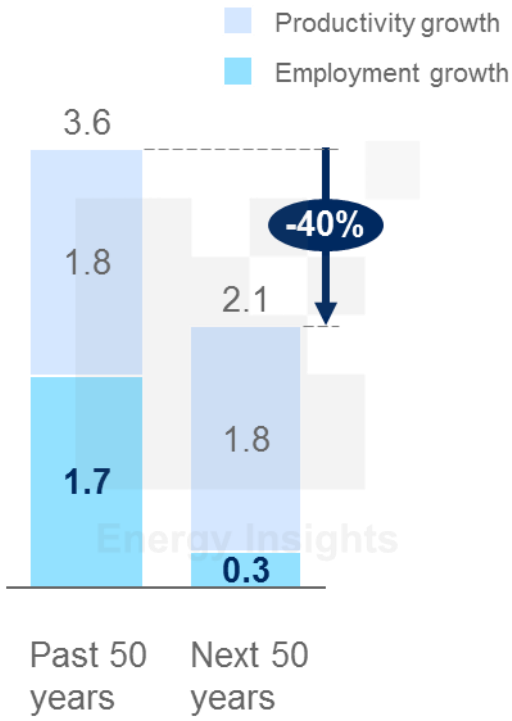


CAGR 2014-2040	Scenario
1.5	Shell Oceans
1.5	Greenpeace Reference
1.4	Shell Mountains
1.4	IEA Current Policies
1.0	IEA New Policies
1.0	ExxonMobil
0.8	**McK BaU (Q4 ’16)**
0.3	IEA 450
-0.1	Greenpeace Revolution

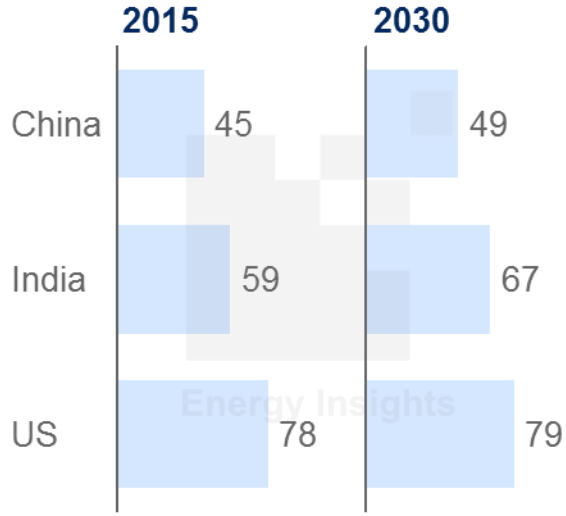
SOURCE: IEA World Energy Outlook 2015; Shell New Lens Scenarios 2013; Greenpeace Energy Outlook 2015, ExxonMobil Energy Outlook 2015

We see structural shifts in fundamental energy demand drivers

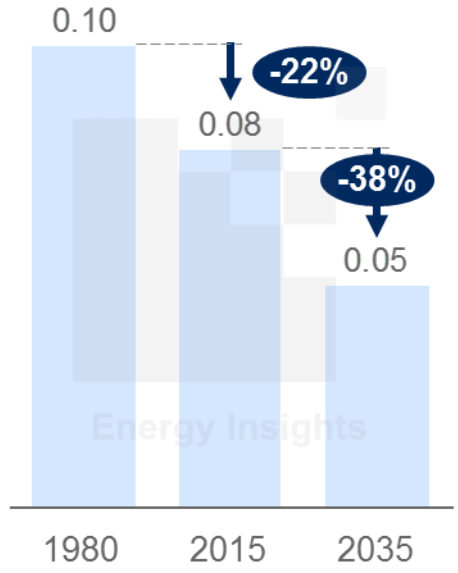
Overall GDP growth is depressed
G19 and Nigeria GDP CAGR; %



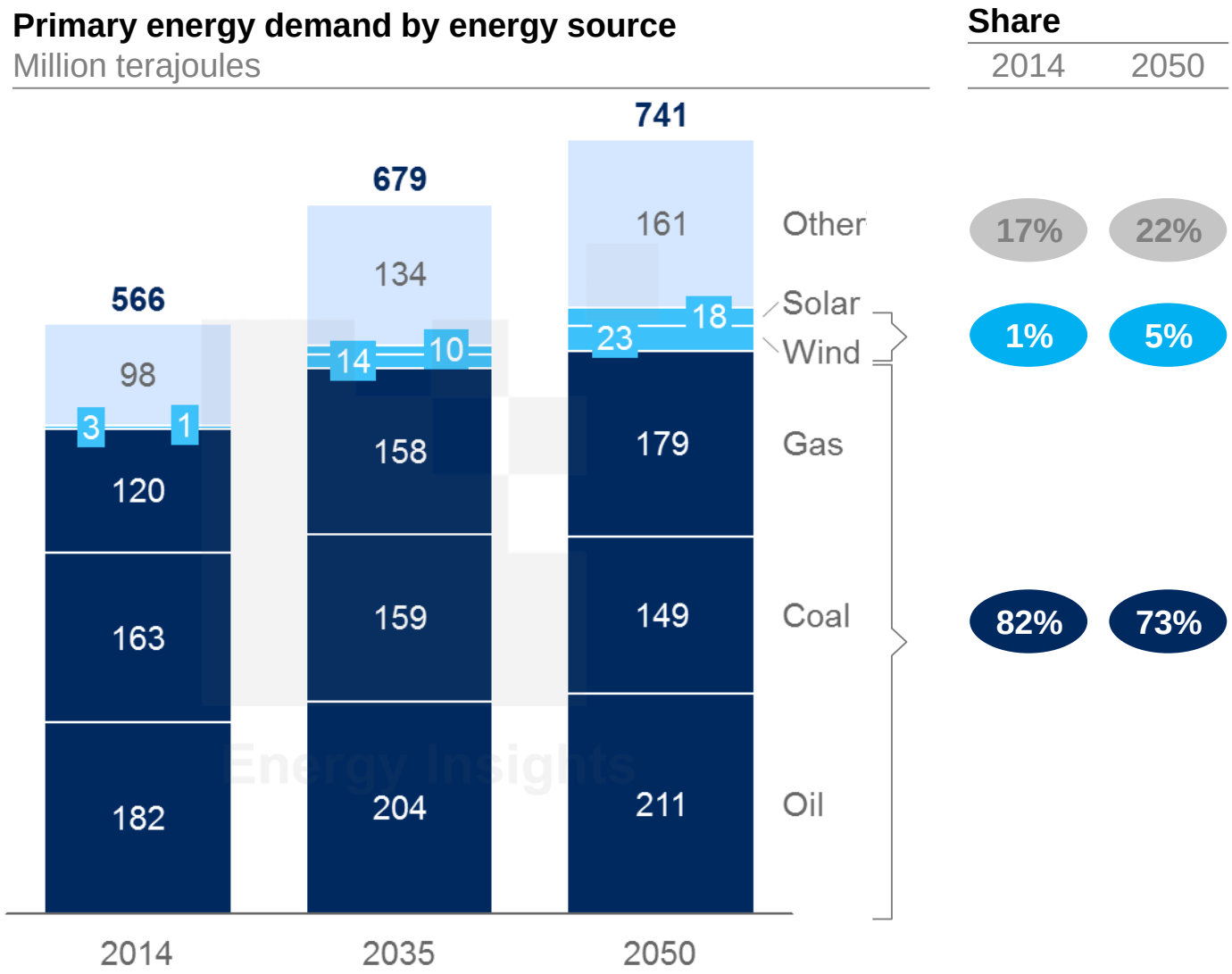
Structure of GDP shifts towards services
Services as % of GDP



The growth is becoming increasingly energy-efficient
Liters/kilometer for passenger cars

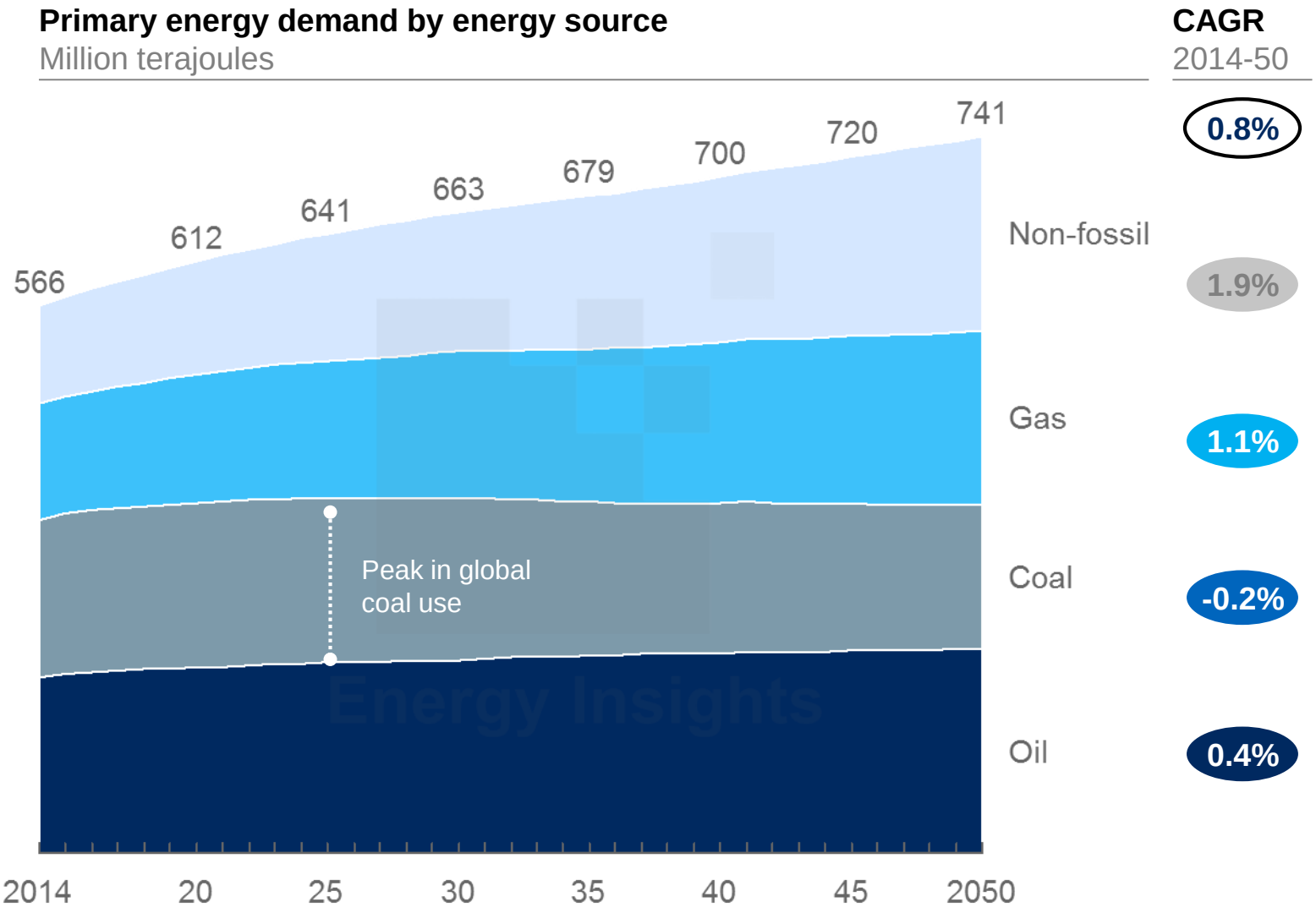


The energy mix remains reliant on fossil fuels despite the rapid growth of non-fossil sources



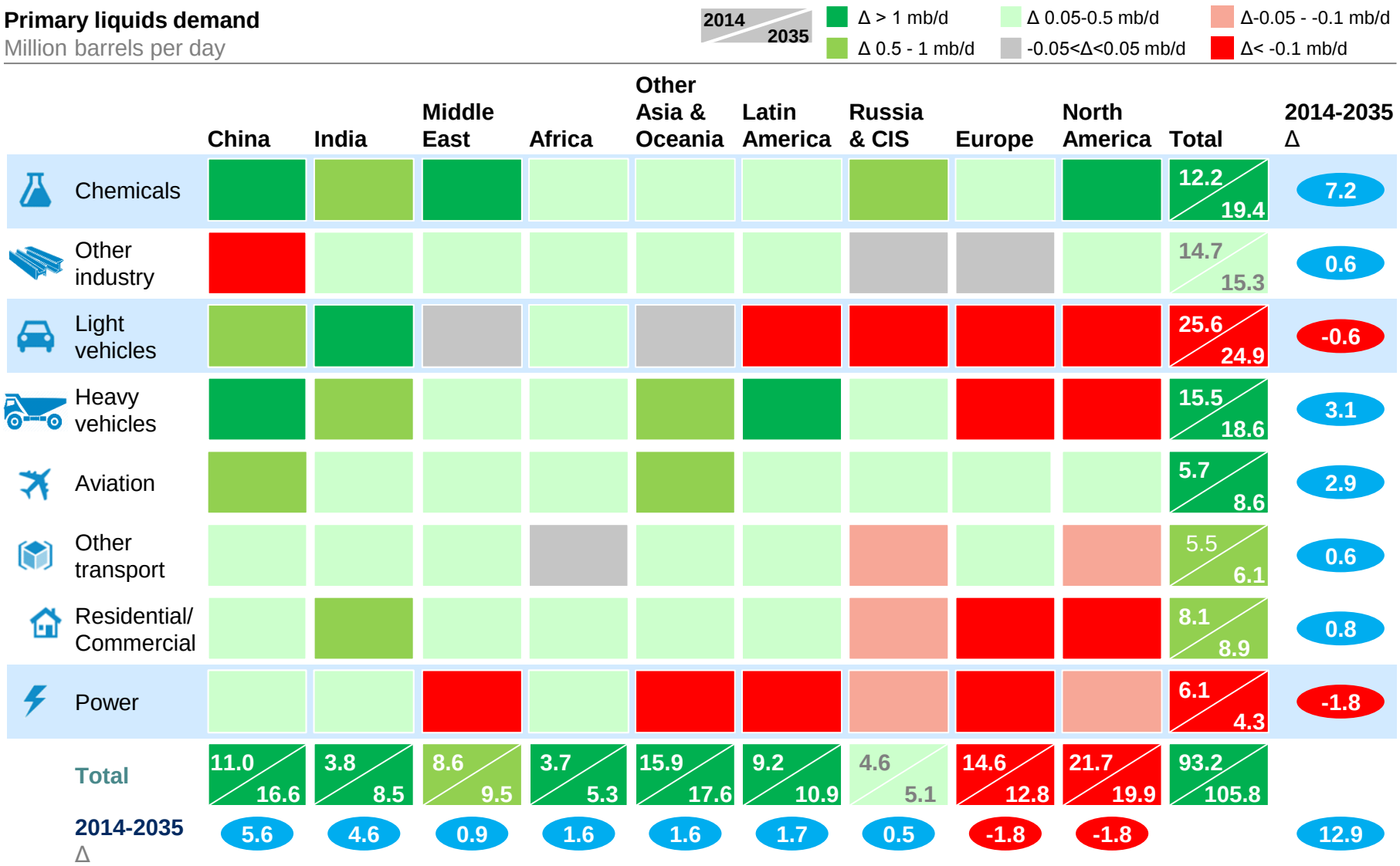
SOURCE: McKinsey Energy Insights' Energy Demand Intelligence, Business As Usual Scenario, 1Q2017

Among fossil fuels, gas is a relative winner and oil demand remains resilient, however coal use peaks around 2025



SOURCE: McKinsey Energy Insights' Energy Demand Intelligence, Business As Usual Scenario, 1Q2017

Chemicals drive almost 60% of liquids demand growth through 2035, while light vehicles and power demand declines

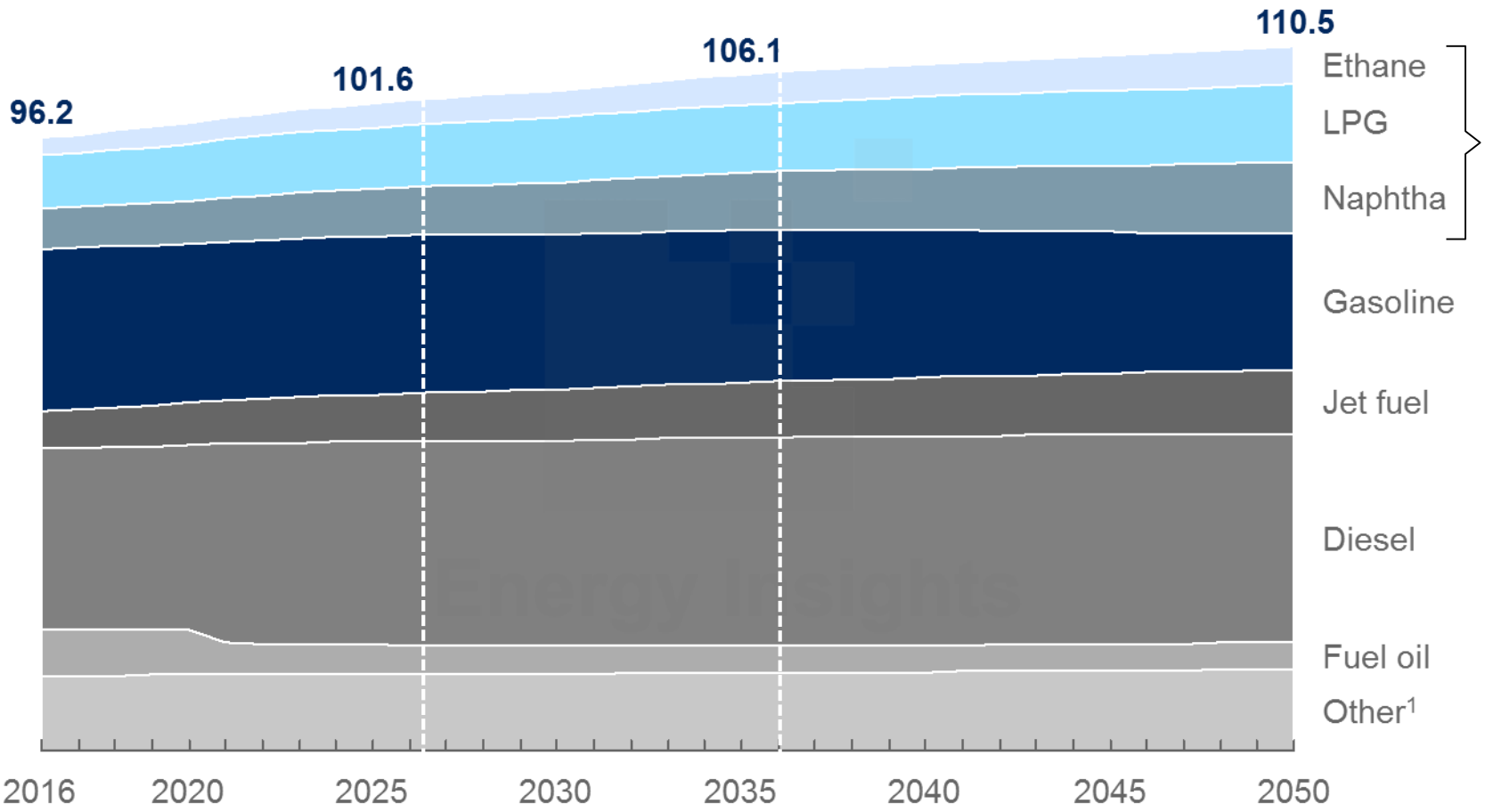


SOURCE: McKinsey Energy Insights' Energy Demand Intelligence, Business As Usual Scenario, 1Q2017

Could peak crude demand be in sight?

Liquids demand by product

Million barrels per day



SOURCE: McKinsey Energy Insights' Energy Demand Intelligence, Business As Usual Scenario, 1Q2017

The Thought experiment: technology disruption

Mobility electrifies and becomes more efficient

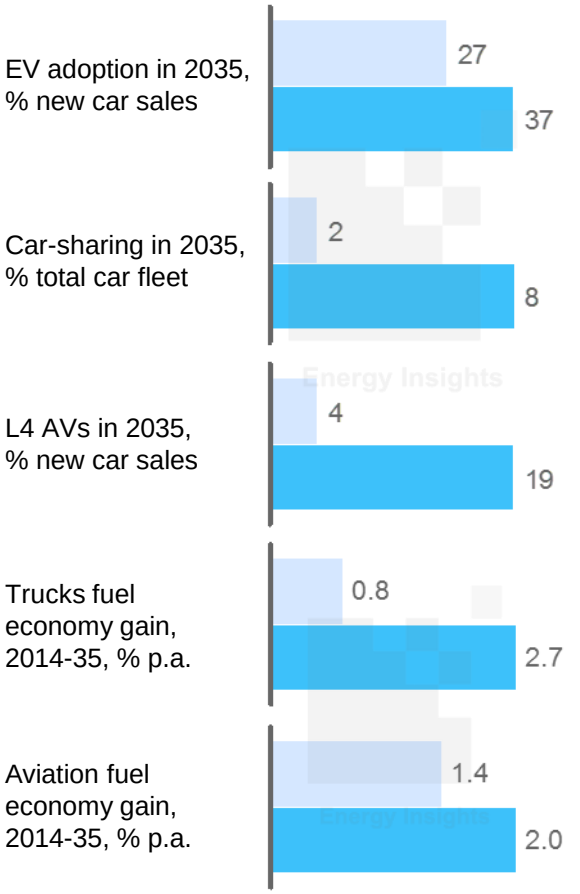
Energy use is optimized by IOT and smart devices

The power sector is transformed by renewables

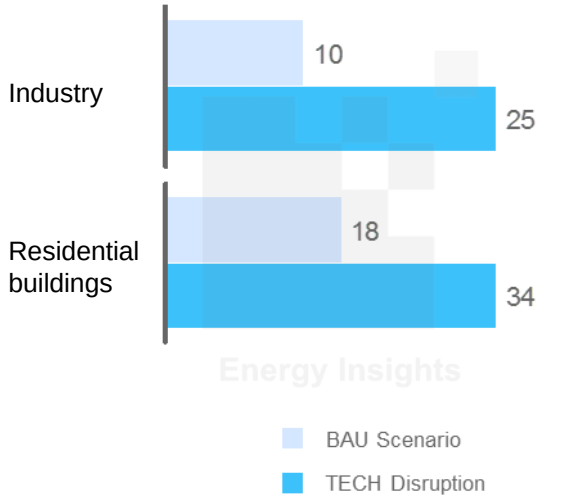
The assumptions in the Tech Scenario

Thought experiment assumptions

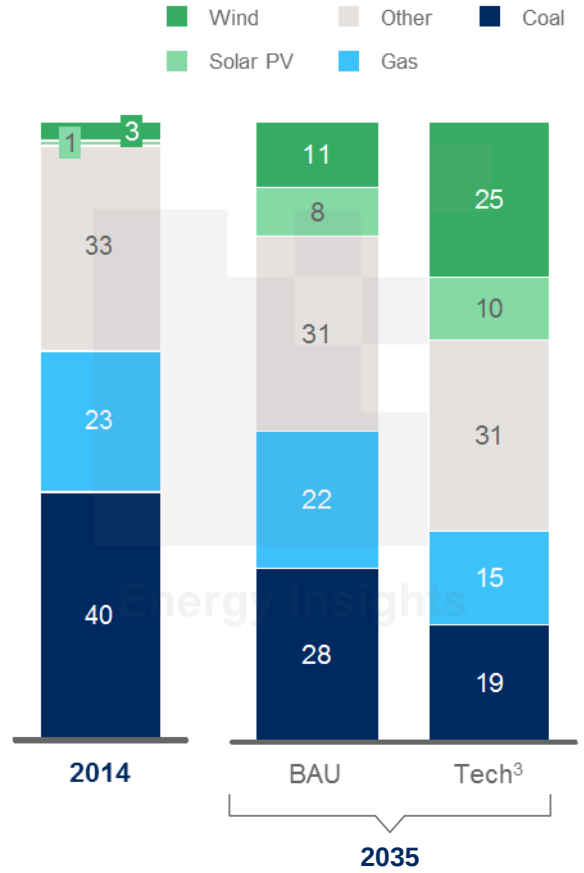
Global mobility



Global average efficiency improvement by sector in 2035 % savings relative to 2014

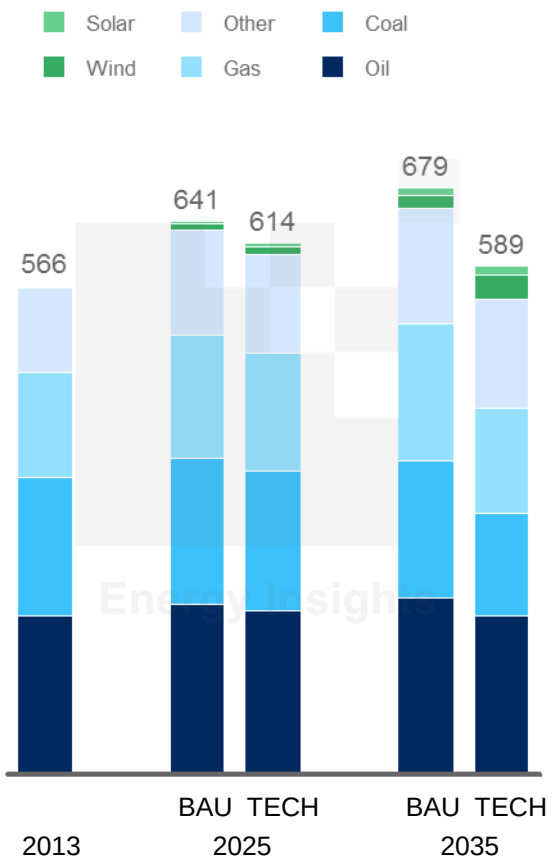


Global power generation by source
% of total

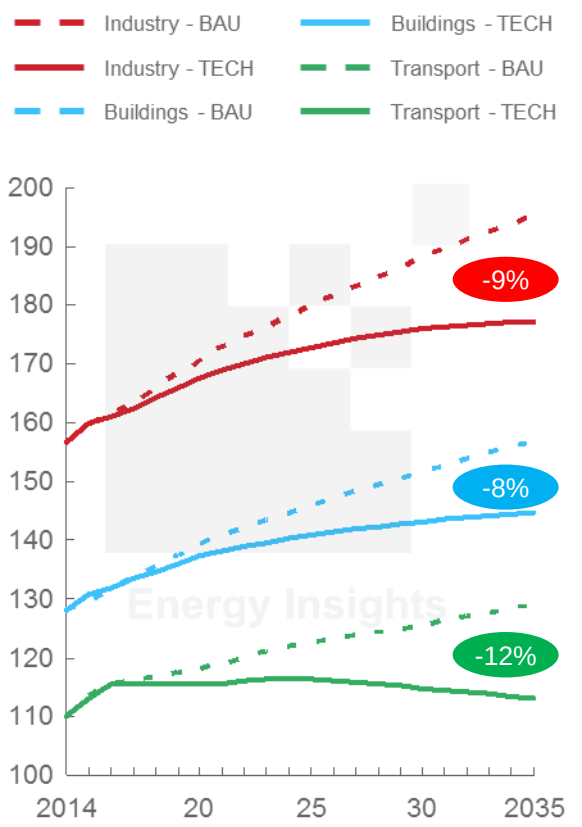


The technology disruptions significantly reduce energy demand

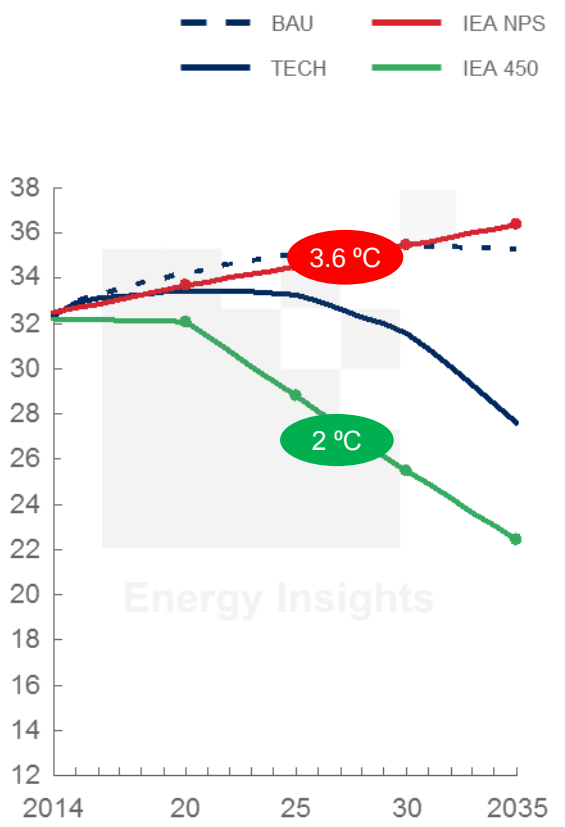
Global primary energy demand by energy source, Million TJ



Global final energy consumption by end-use sector, Million TJ



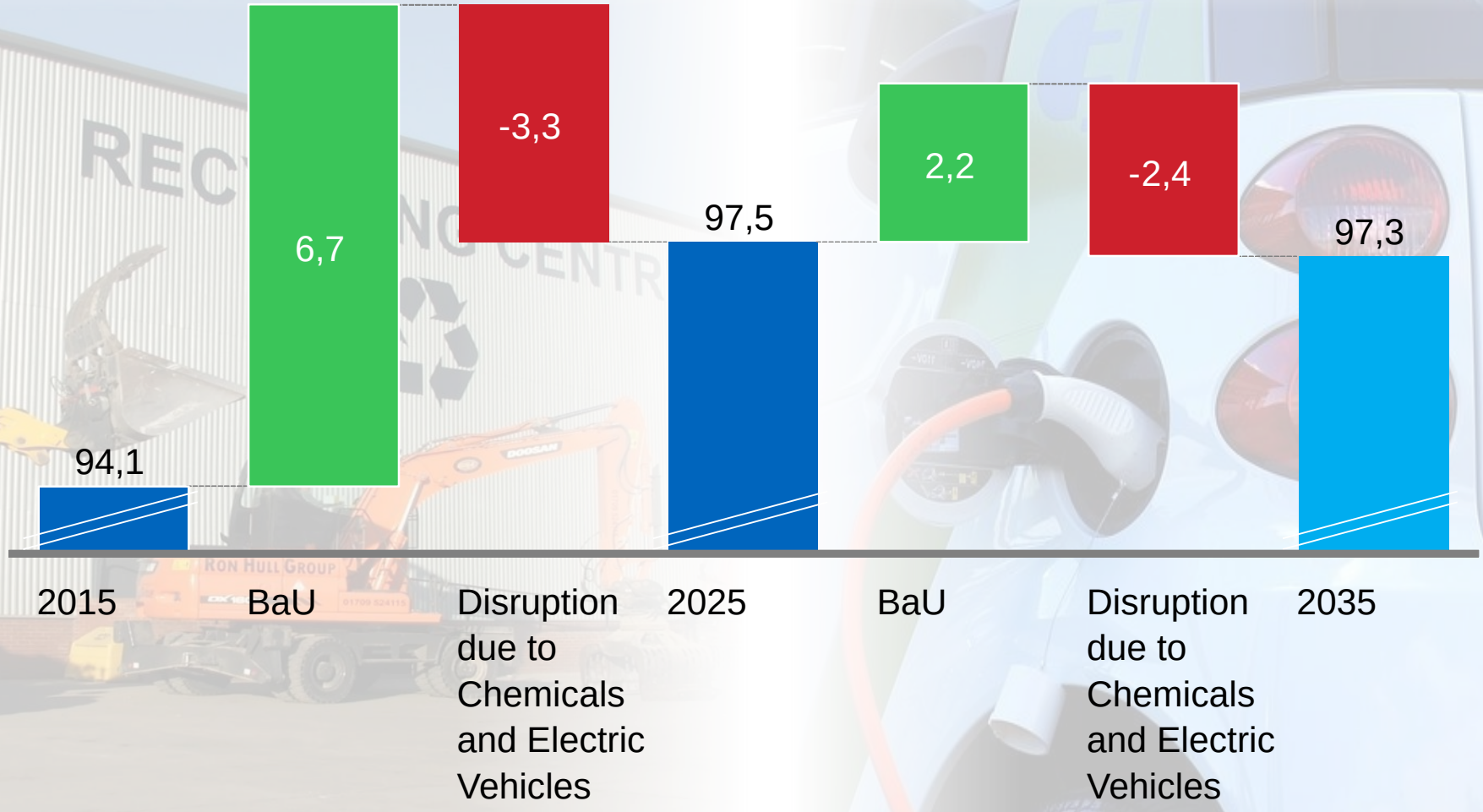
Global energy-related emissions
Gt CO_2-equivalent



SOURCE: McKinsey Energy Insights' Energy Demand Intelligence; IEA World Energy Outlook 2015

Such a scenario would accelerate peak oil (not just crude) demand

Million barrels/day

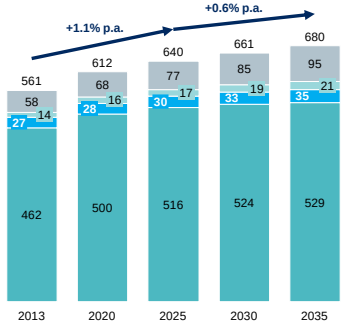


Technology acceleration leads to tipping point around 2025 for oil and gas

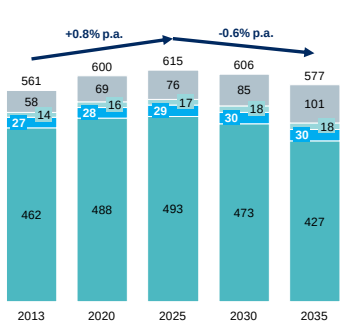
Primary energy demand to peak by 2025

Million terajoules

Moderate case scenario[2]



Tech acceleration scenario[2]



1 Includes biomass and geothermal as well as solar and wind.
2 Both scenarios assume annual average global GDP growth of 2.7%.
NOTE: Numbers may not sum due to rounding.

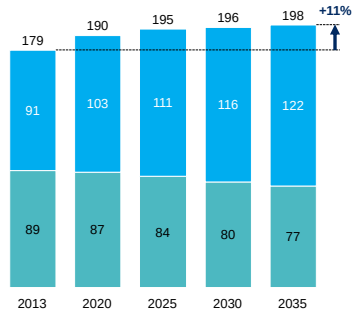
SOURCE: *Global energy perspective*, McKinsey Energy Insights; McKinsey Global Institute analysis

…peak oil by 2025…

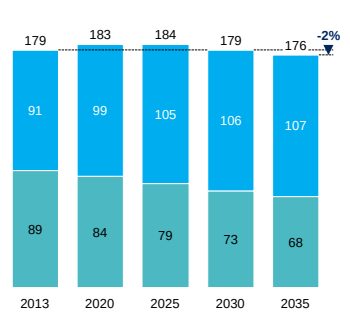
Oil demand
Million terajoules

Non-OECD OECD

Moderate tech scenario



Tech acceleration scenario



NOTE: Numbers may not sum due to rounding.

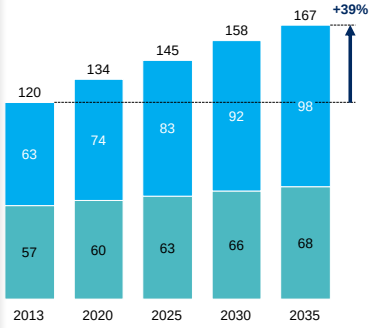
SOURCE: *Global energy perspective*, McKinsey Energy Insights; McKinsey Global Institute analysis

…and even gas demand decline by 2025…

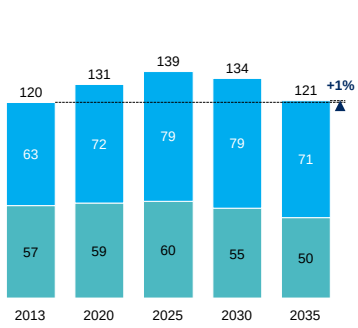
Global primary natural gas demand
Million terajoules

Non-OECD OECD

Moderate tech scenario



Tech acceleration scenario



NOTE: Numbers may not sum due to rounding.

SOURCE: *Global energy perspective*, McKinsey Energy Insights; McKinsey Global Institute analysis

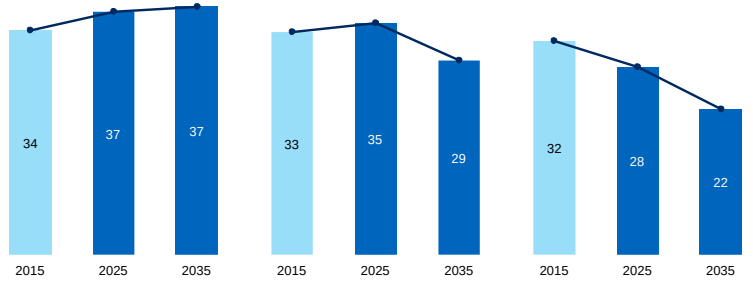
…even whilst CO2 targets are not being met.

Greenhouse gas emissions by scenario
Gigatonnes CO2 equivalent

Moderate case
Emissions continue to grow until 2035

Tech acceleration case
Emissions peak in 2025

450 ppm scenario[1]
Emissions drop resulting in 450 ppm atmospheric CO2 by 2035



1 This chart has been adapted from IEA data about the levels of CO2 from greenhouse gases required to limit global temperature in 2100 to two degrees Celsius above pre-industrial levels. We took IEA data for 2020, 2030, and 2040 and interpolated midpoints assuming a linear trajectory.

SOURCE: McKinsey Energy Insights; *World energy outlook 2016*, IEA; McKinsey Global Institute analysis

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3 **A closer look at the Netherlands**

Recent years have been focused on survive

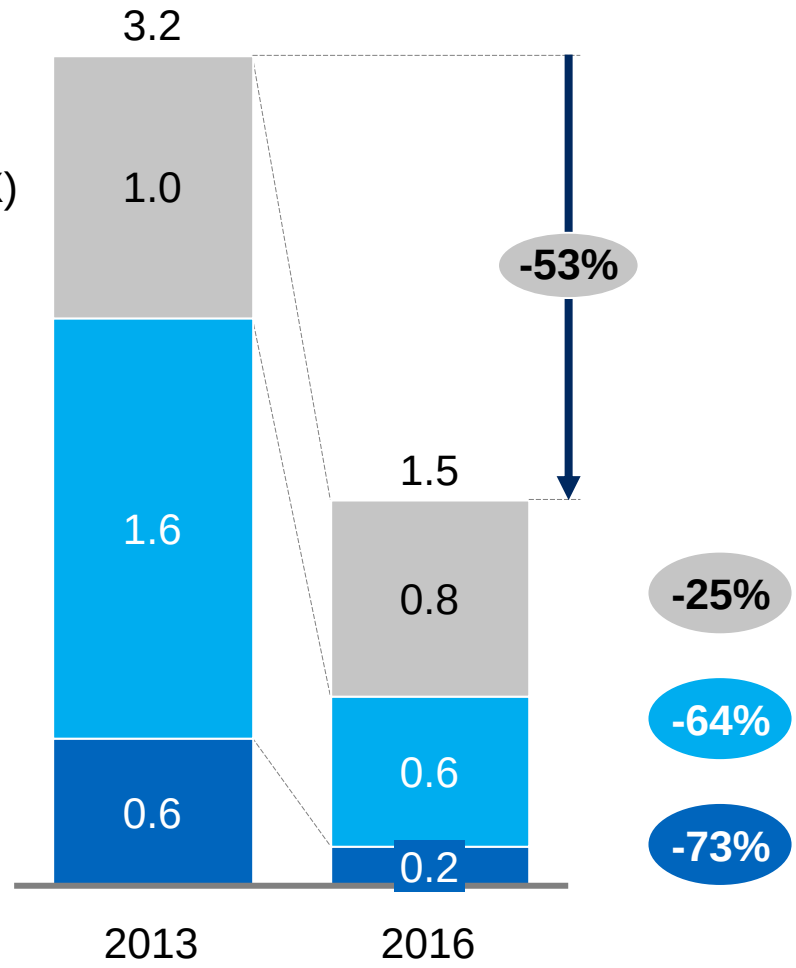
Decline in oil industry revenue

USD Trillion

Cost (CAPEX + OPEX)

Government take

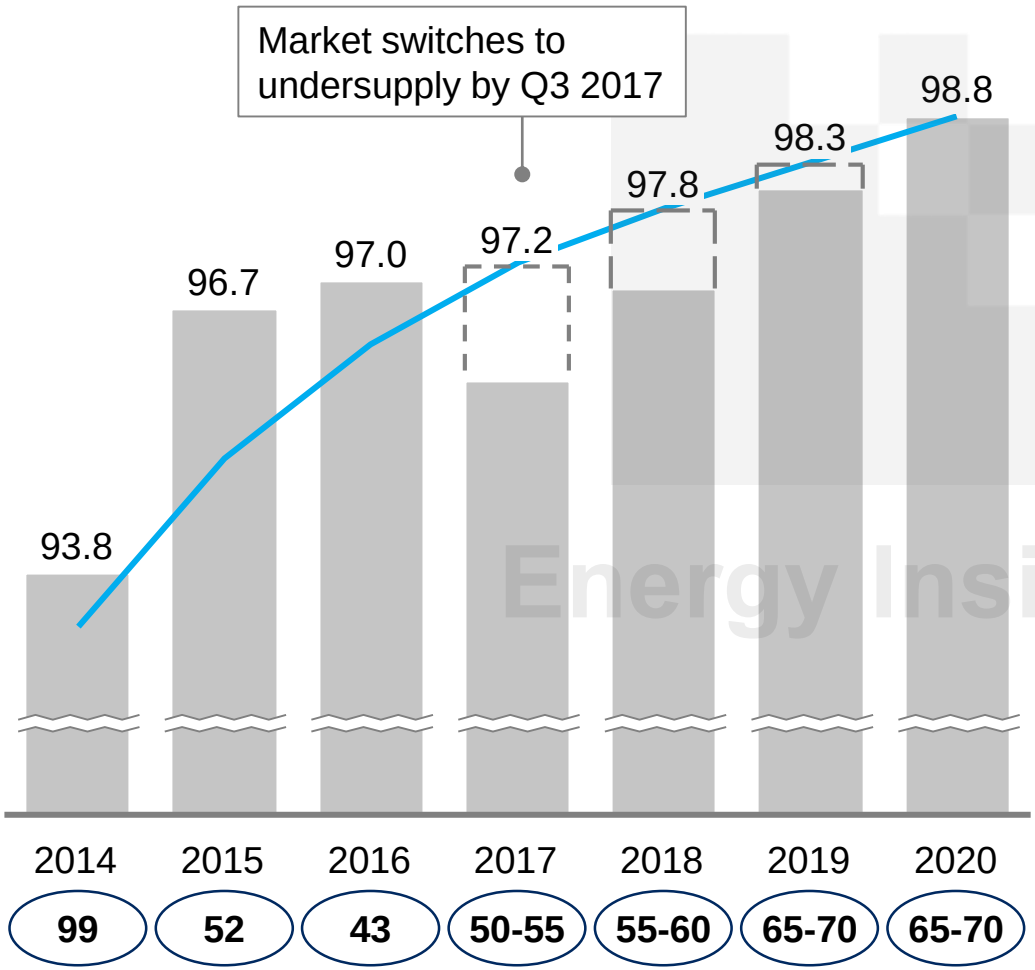
Cash profit



Several oil price scenarios – Price recovery case example

Global oil market balance – price recovery scenario

MMb/d



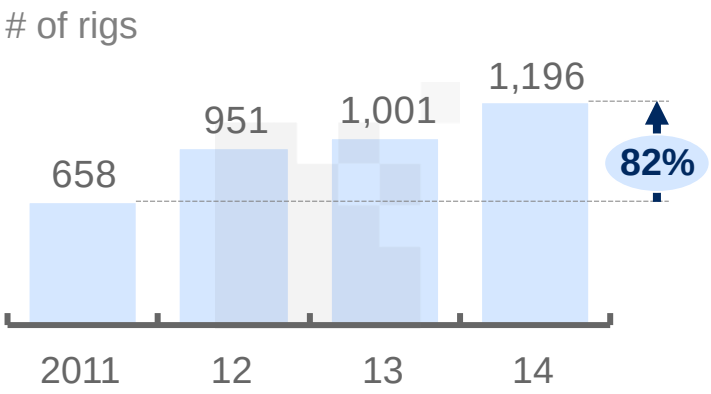
What you need to believe

- Flattened global economic growth leads to slow down in oil demand
- Lack of upstream investment accelerates legacy declines affecting supply stack to 2020
- Cost compression of 30-40% is partially maintained in short term
- LTO production returns to strong growth by 2020
- OPEC plays a role as the balancing actor
- Existing inventories keep the market well-supplied and put downward pressure on prices

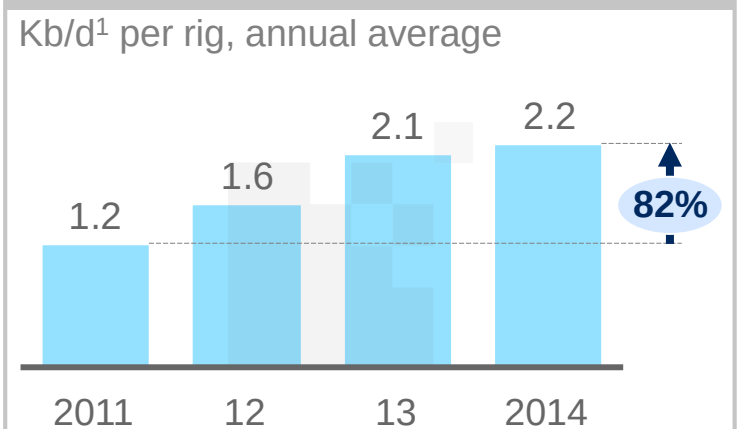
SOURCE: Energy Insights by McKinsey

High drilling activity growth in LTO plays was complemented by increased drilling and completion efficiency

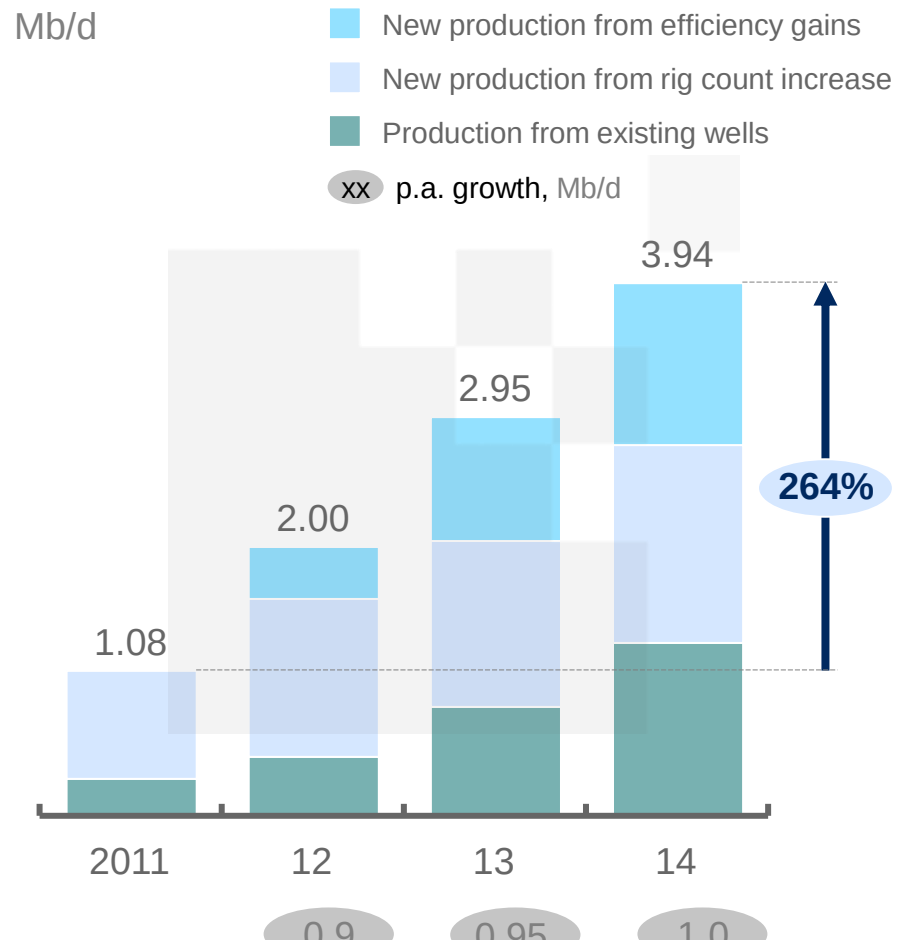
North America Horizontal Rigs



New Production per Rig



North America LTO Production

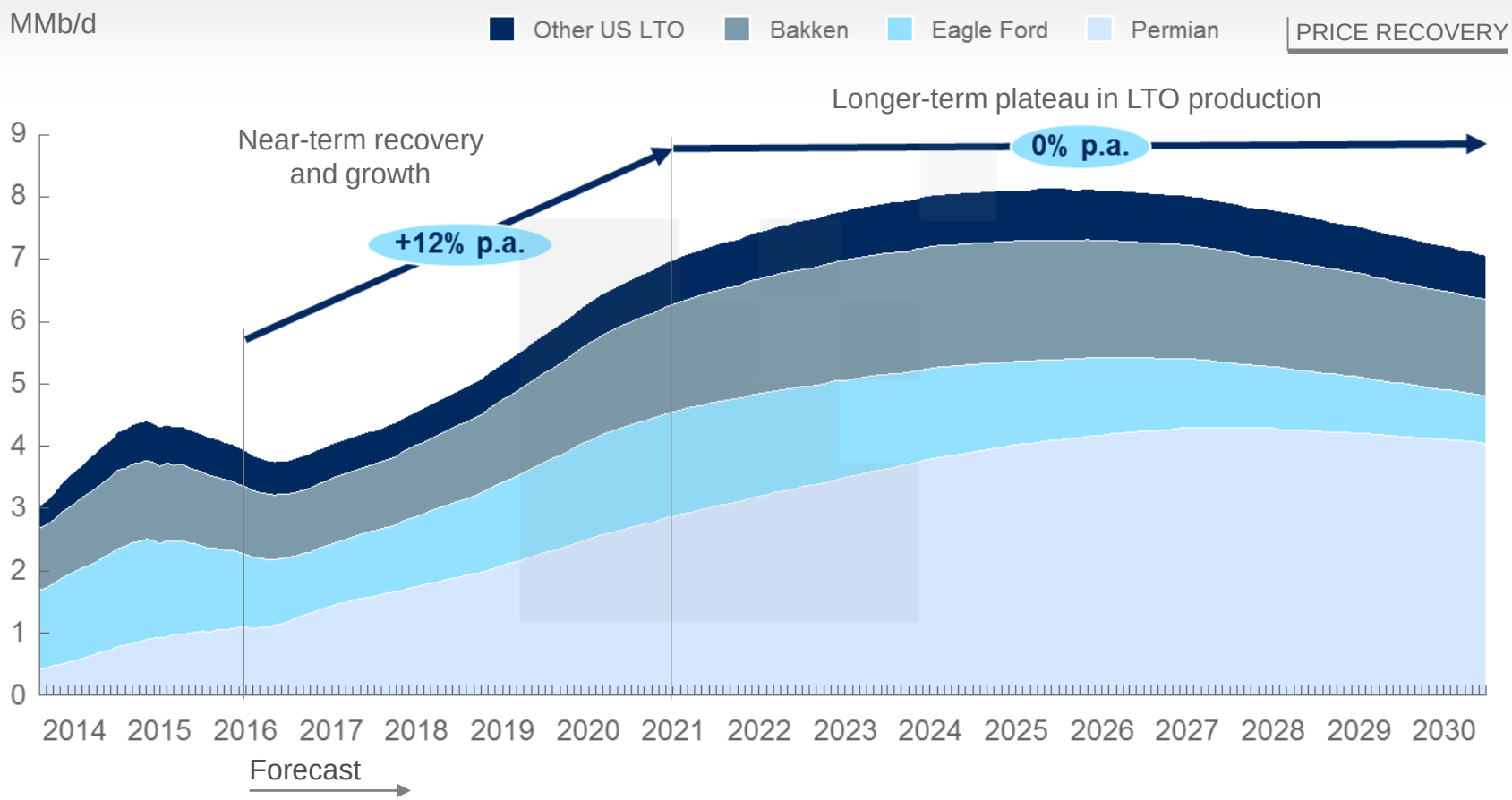


1 Rig productivity includes two factors: rig efficiency as number of wells per year per rig, and well productivity as production per well

SOURCE: Baker Hughes, Energy Insights

Following near term growth, we expect US LTO production to remain economically competitive, but plateau due to resource constraints

US light tight oil production outlook



1. LTO is projected to remain competitive in the global supply curve through 2030…
2. …However, production is likely to plateau post 2021 as Eagle Ford and Bakken resource becomes constrained

SOURCE: Energy Insights, NavPort

The 3 trends shaping the energy company of the future

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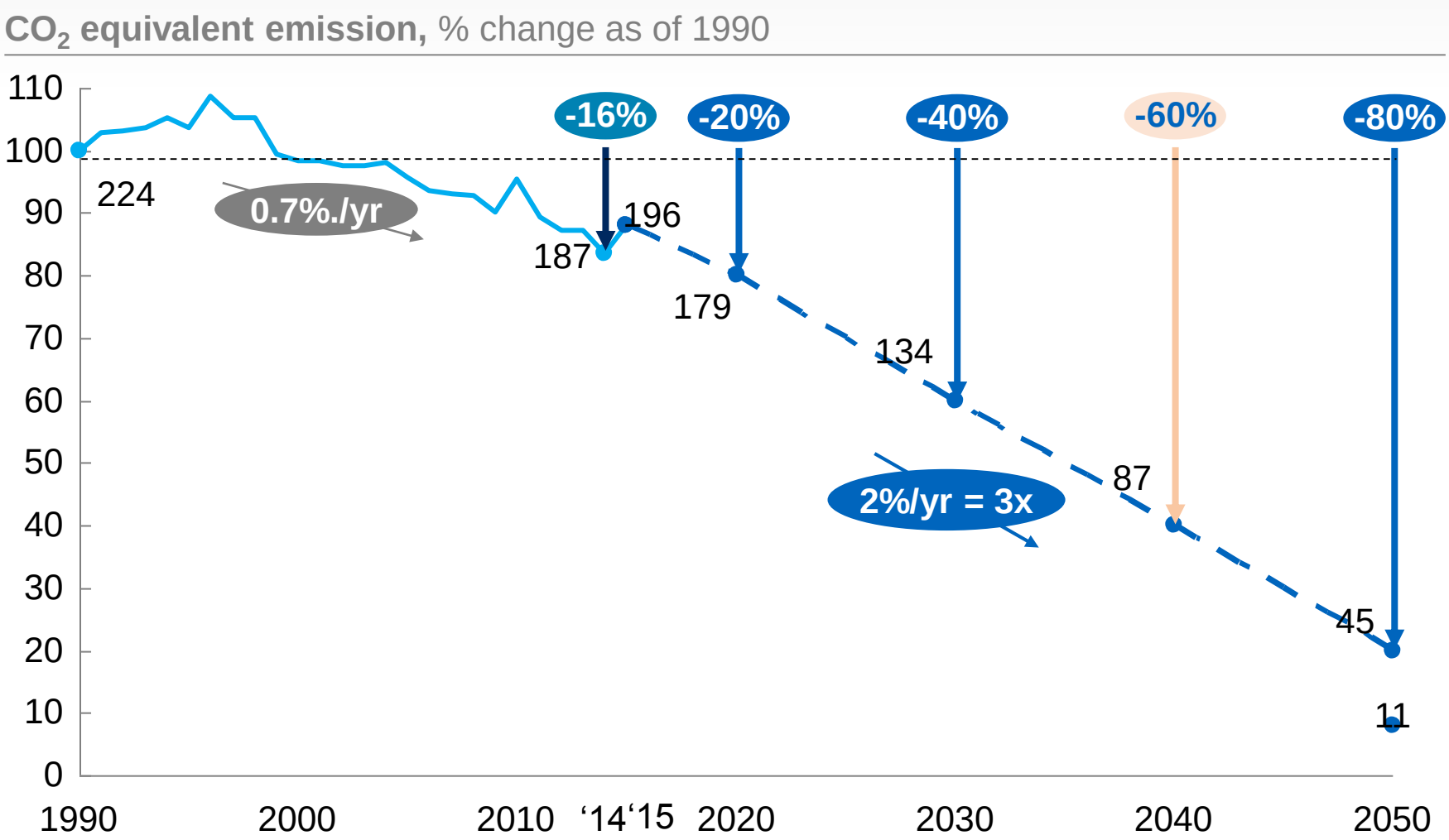
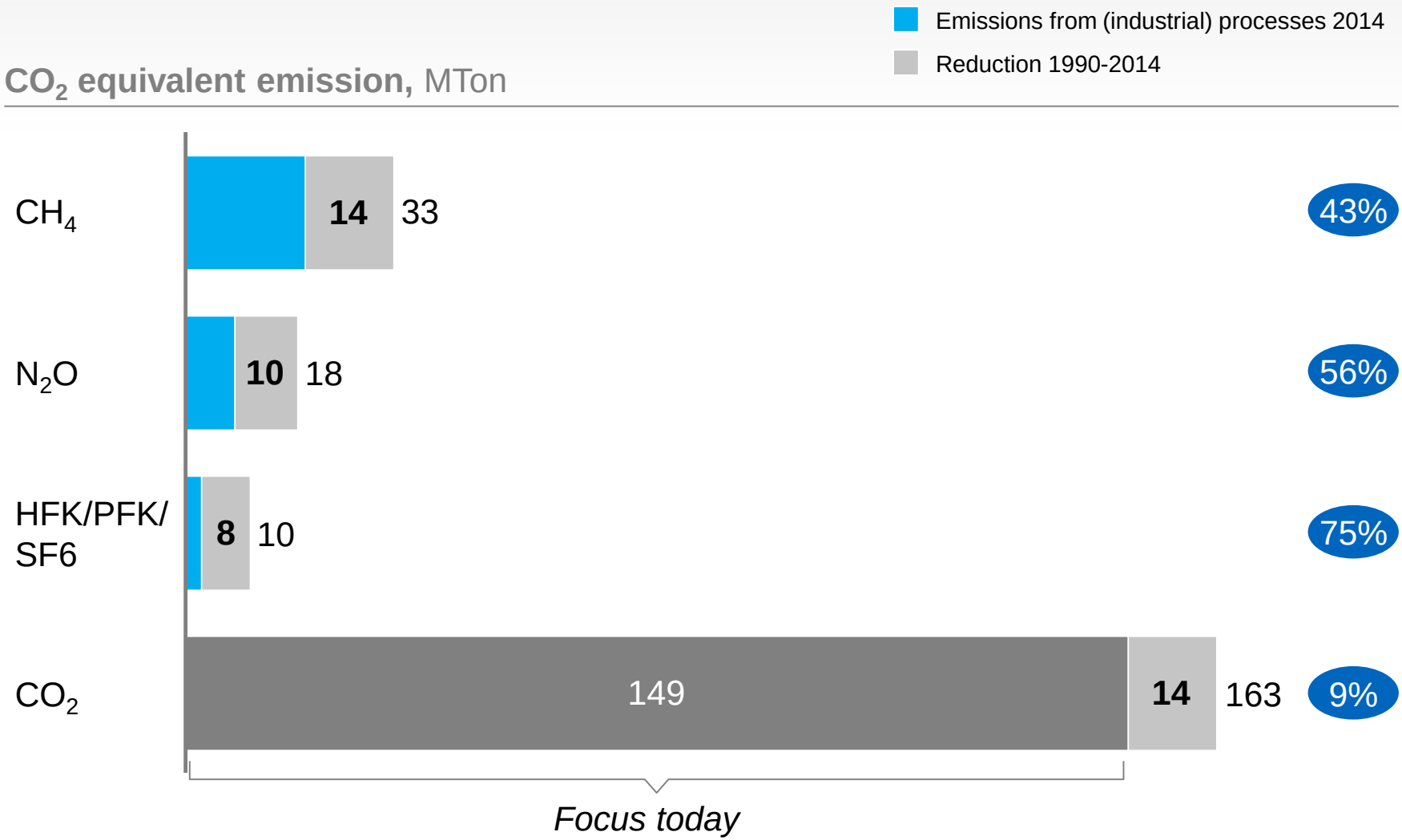
To achieve EU 2050 ambition of GHG emission reduction of 80 percent, the Netherlands would need to accelerate with factor 3



SOURCE: CBS

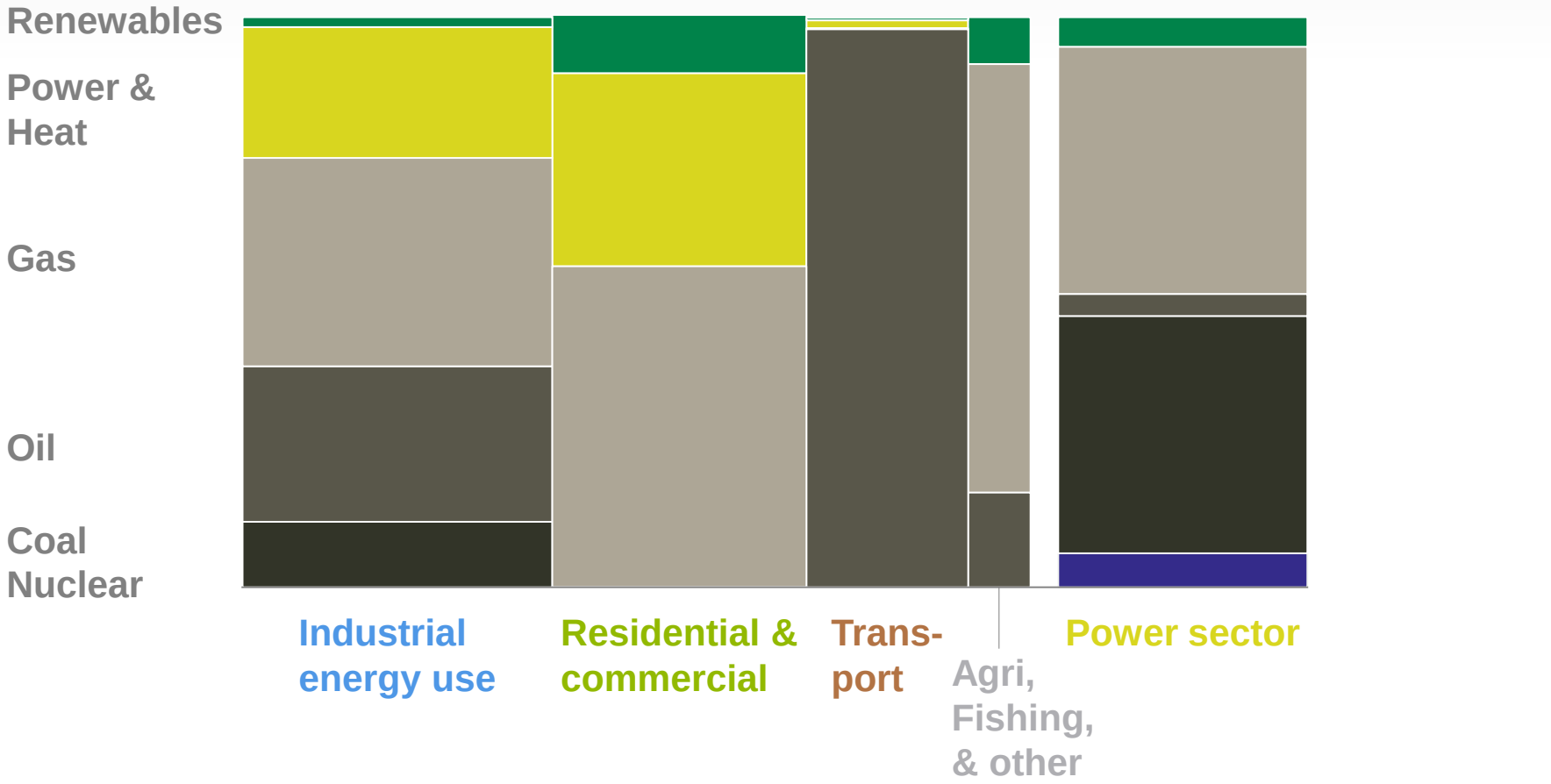
Until now, most of the GHG emission reduction was realized through reductions in non-CO_2 emissions



SOURCE: CBS – Emissieregistratie (1990 – 2014)

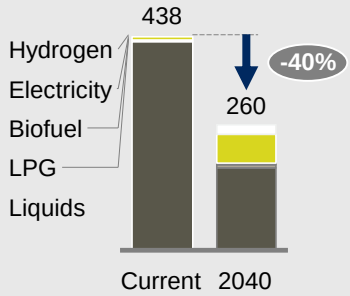
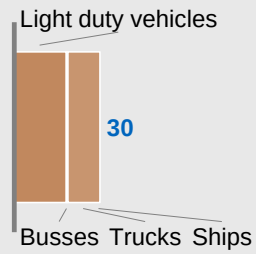
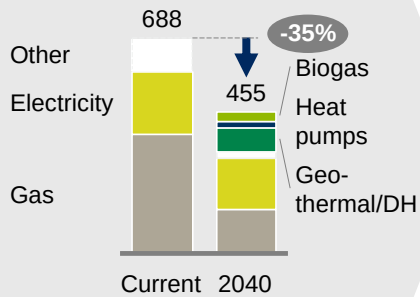
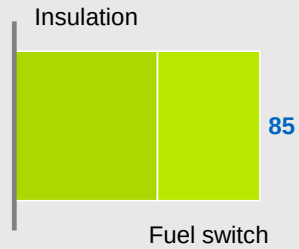
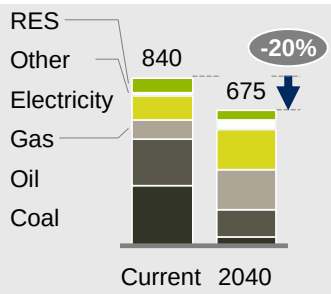
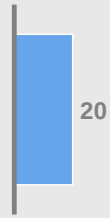
Our current energy system

CO_2 emissions, 2014, CO_2e, MTon



SOURCE: Centraal Bureau voor de Statistiek (2014), “Energiebalans” and “Energieverbruik” databases

An investment of ~ EUR 135 billion is required to decrease and decarbonize the energy demand of the Dutch economy towards 2040

	Energy demand by energy carrier, PJ	**Scale of measure - assumptions**	**Magnitude of investment,** EUR billions
Transport		▪ By 2040, 50% of the vehicle fleet reaches zero CO_2 emissions ▪ Conventional ICE vehicles are replaced at end of life ▪ All vehicles will be BEV except trucks, which will switch to hydrogen ▪ Efficiency improvements of ~1% p.a.[1]	
Residential & Commercial		▪ All houses and services buildings are insulated to at least Label B ▪ Half of the current building stock and all of new built switches to a low carbon energy source ▪ Electricity becomes the principle heating source (54%), followed by (geothermal) district heating (28%), and biogas (18%) ▪ Cooking becomes electric for 82% of the houses that switch heating source ▪ Efficiency improvements of ~1% p.a.[1]	
Industry		▪ 50% of gas furnaces and boilers replaced by electric furnaces and boilers ▪ 50% of steel production capacity (one Blast Furnace) decarbonized ▪ Efficiency improvements of ~1% p.a.[1]	

1 Efficiency improvements only affect share of energy use (and thus CO_2 emissions) that are not impacted by other measures

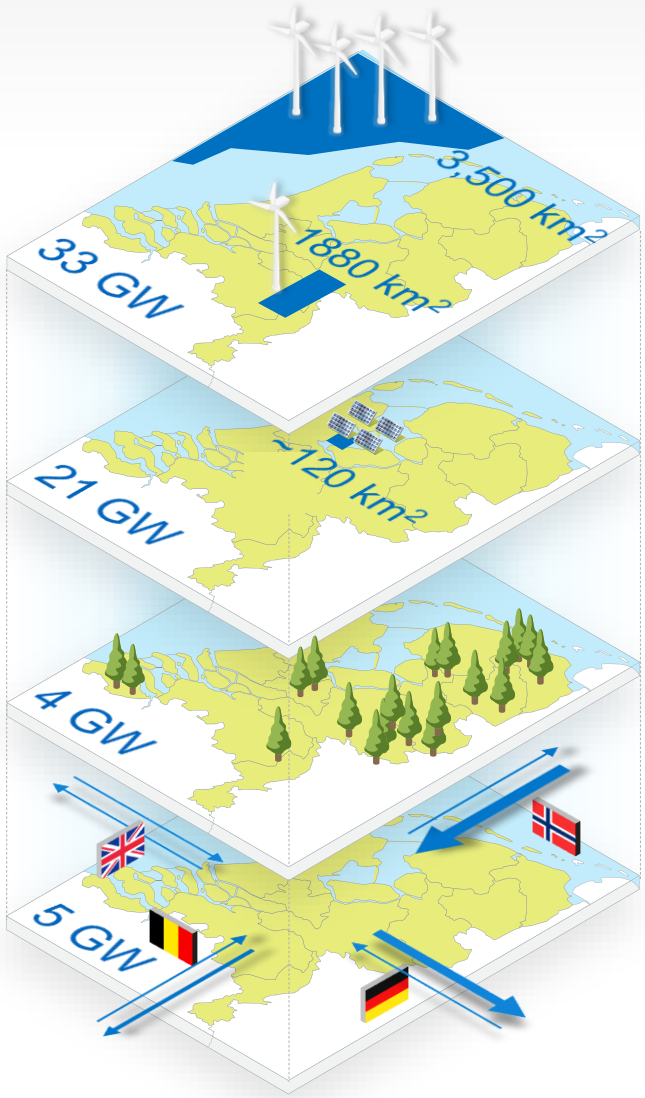
Power sector: “80% renewable power supply” by 2040 would be needed illustrative scenario, other choices also possible

Wind
62% of production

Solar
12% of production

Biomass
8%

Flexibility measures



~11 thousand turbines[1]

- 6% of Dutch North Sea

~63 million solar panels[2]

- Third of current roof area

8,500 kton dry biomass[3]

- Conversion of existing coal plants to biomass

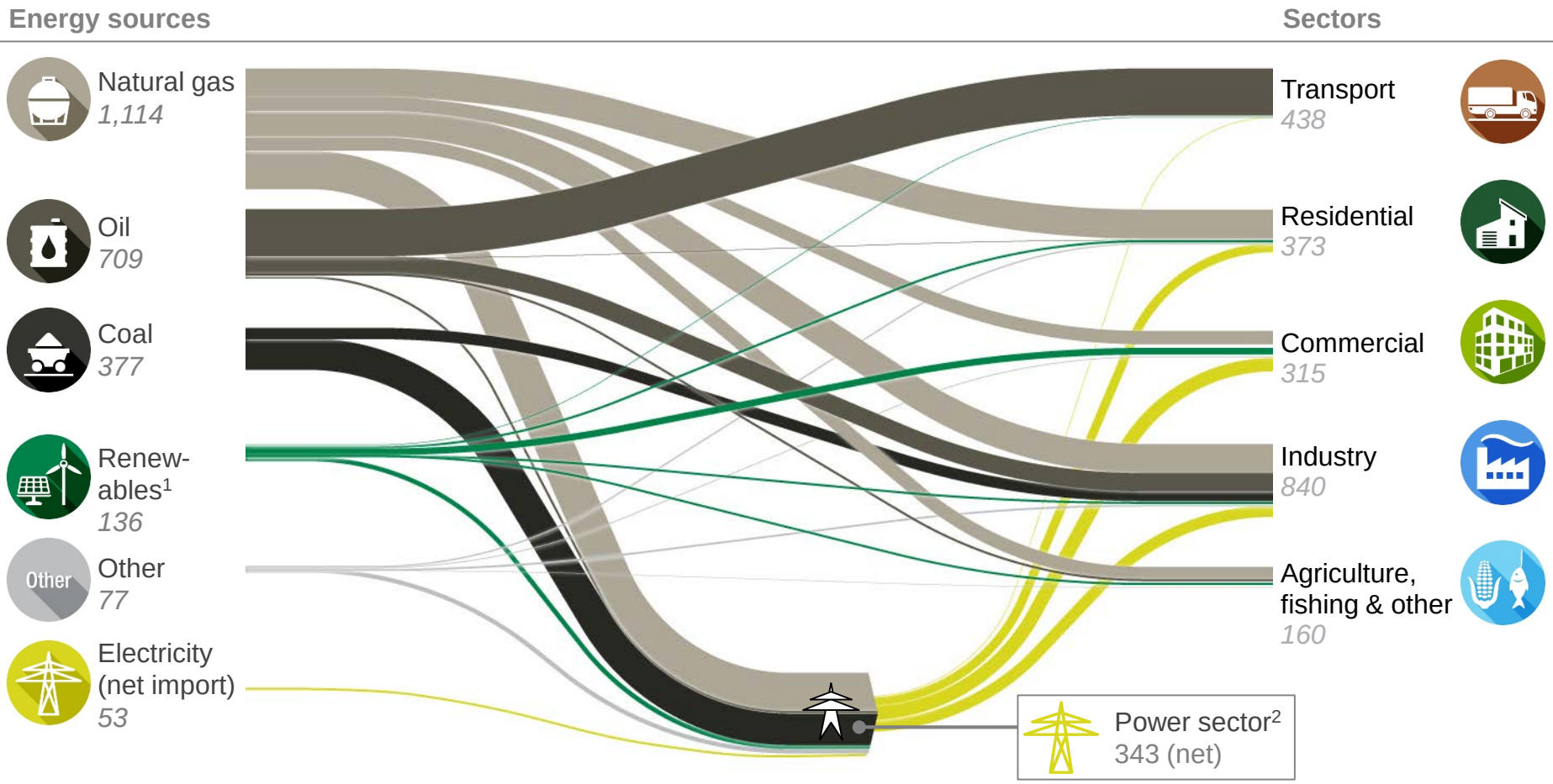
- As illustration, 5 GW of (seasonal) storage

Other choices would also be possible, e.g. with larger role for (coal/gas) CCS, imports

1 45% capacity factor, turbines of 3 GW 2 1.65 m2 per solar panel, 235 kW 3 17 MJ/kg biomass, 2 ktons/km2

In 2014 the energy system is largely dependent on fossil fuels

Netherlands energy demand in 2014; flow between energy sources and sectors, PJ

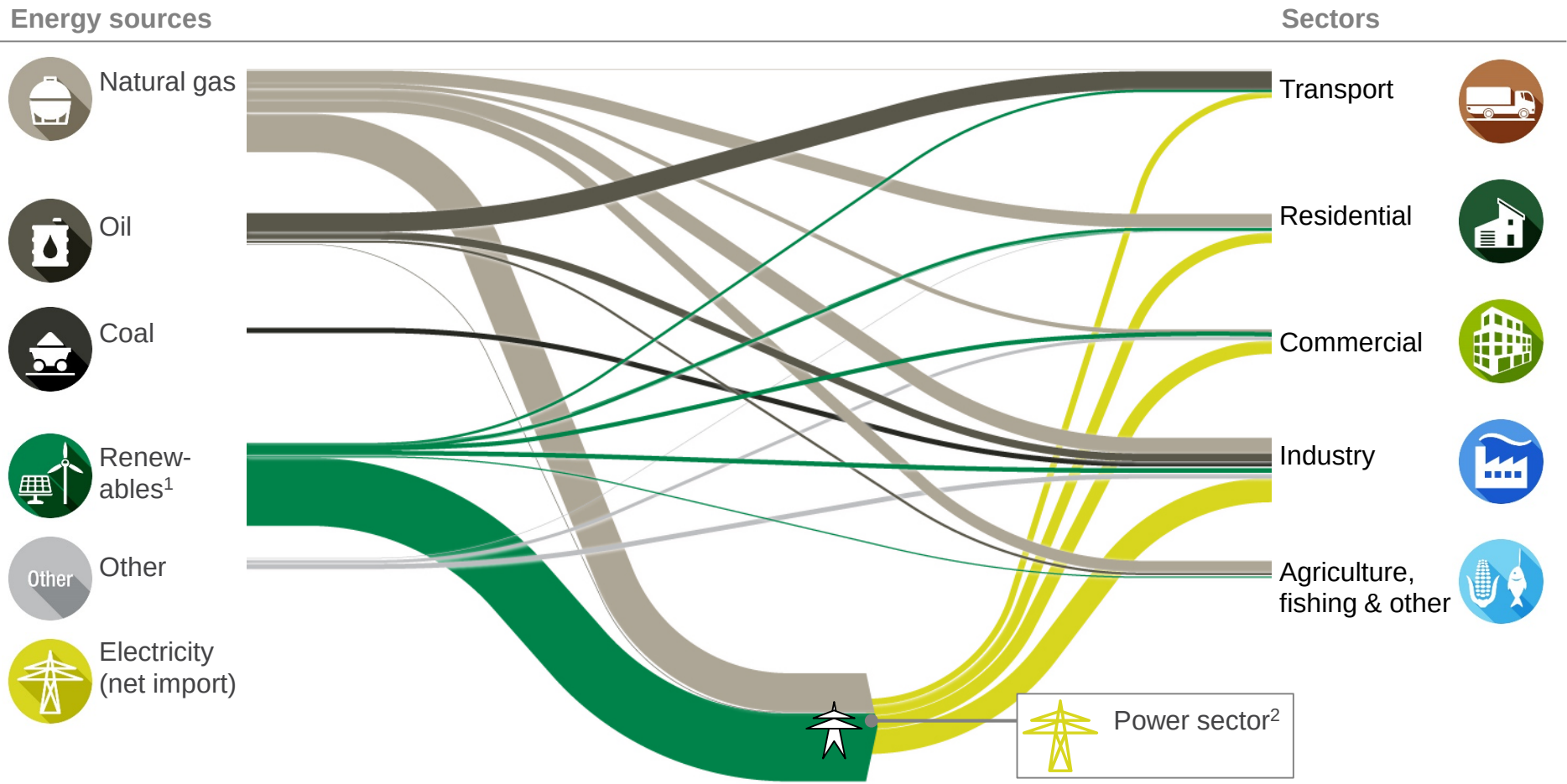


1 Includes: hydro, geothermal, solar, wind, and biomass
2 Only includes net use for central power production (320 PJ) and transmission and distribution losses (23 PJ); energy sector own use (e.g., oil consumption in refining is included in industry)

Source: Centraal Bureau voor de Statistiek (2014), “Energiebalans” and “Energieverbruik” databases

In 2040,the energy system would look and function very differently

Netherlands energy demand in 2040; flow between energy sources and sectors, PJ

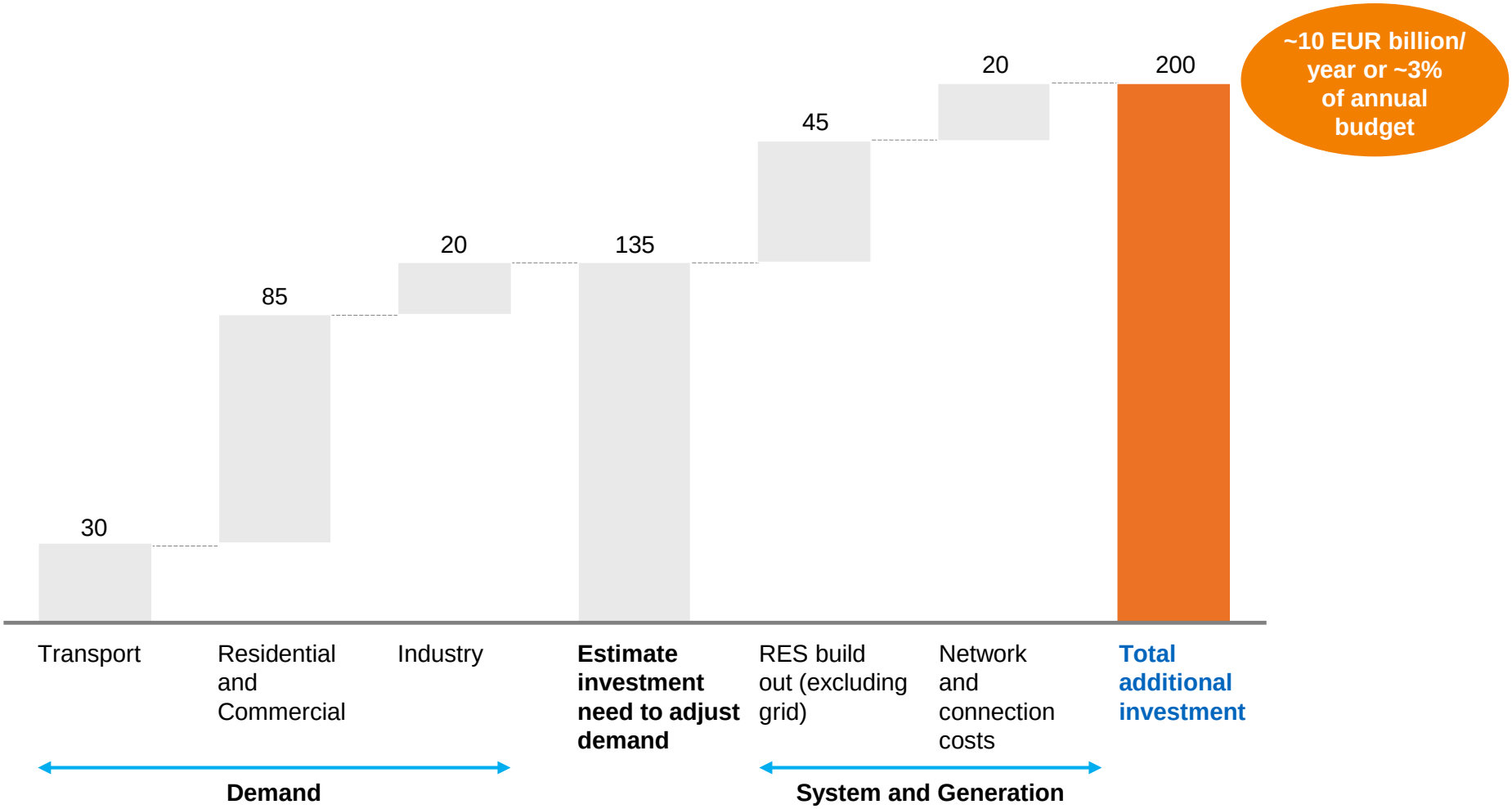


1 Includes: hydro, geothermal, solar, wind, biomass, and hydrogen
2 Includes net biomass use (94 PJ), gas use (111 PJ) and own use and transmission and distribution losses

Source: Centraal Bureau voor de Statistiek (2014), “Energiebalans” and “Energieverbruik” databases

An annual investment of ~EUR 10 billion would be needed to move towards a 60% CO_2 reduction by 2040

Indicative net investment need, EUR billions, 2020 to 2040



What could be new economic ‘sectors’ for the Netherlands?

‘New’ transport – Novel solutions to improve urban transport

Sustainable building heating – Climate control systems and residential energy management

Heavy industry transformation and CCS/U – Alternative feedstock configurations with innovative processes and technologies

Offshore wind – programmatic wind build out capturing benefits of scale

Integrating renewables with the energy system- Integrating renewables (conversion – storage – transport)

Potential job creation: the long-term impact comes from new sectors