Energy Insights
By McKinsey

Business in the Energy Transition

Presentation to 2017 Alberta Climate Summit |
28 September 2017

Key take-aways for today

1 

Structural deceleration in energy demand growth as population ages; Non-OECD countries drive all the growth

2 

Electrification continues to expand as renewables start to outcompete fossil fuels

3 

Peak oil demand may be in sight. What will happen to gas demand?

4 

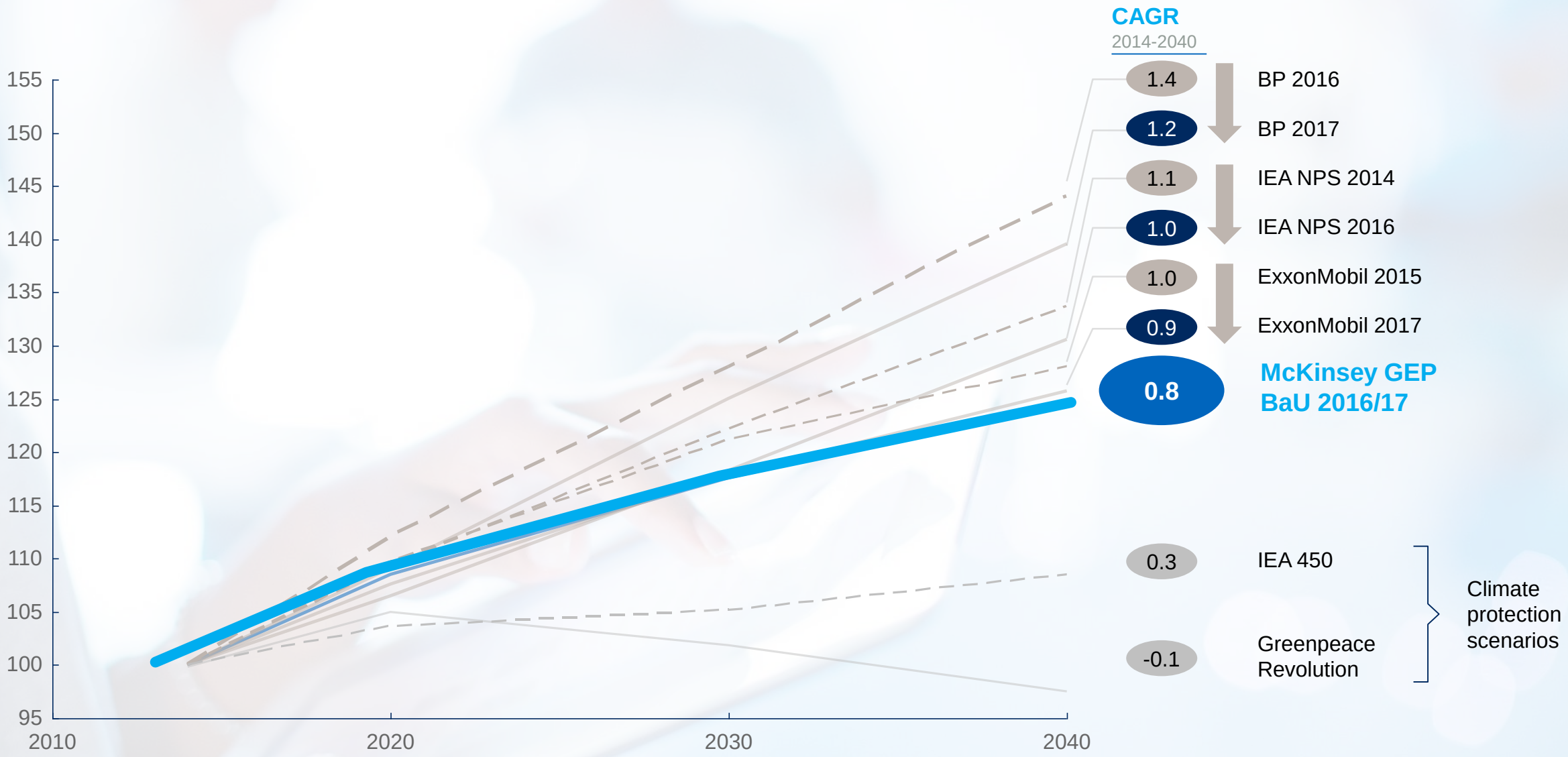
Despite high renewables growth, the world (and Canada) are not on pace to achieve emission reduction targets

5 

Significant opportunities for innovation driven productivity gains ahead—defining the new basis for competition

Primary energy demand

Index, 2014 = 100



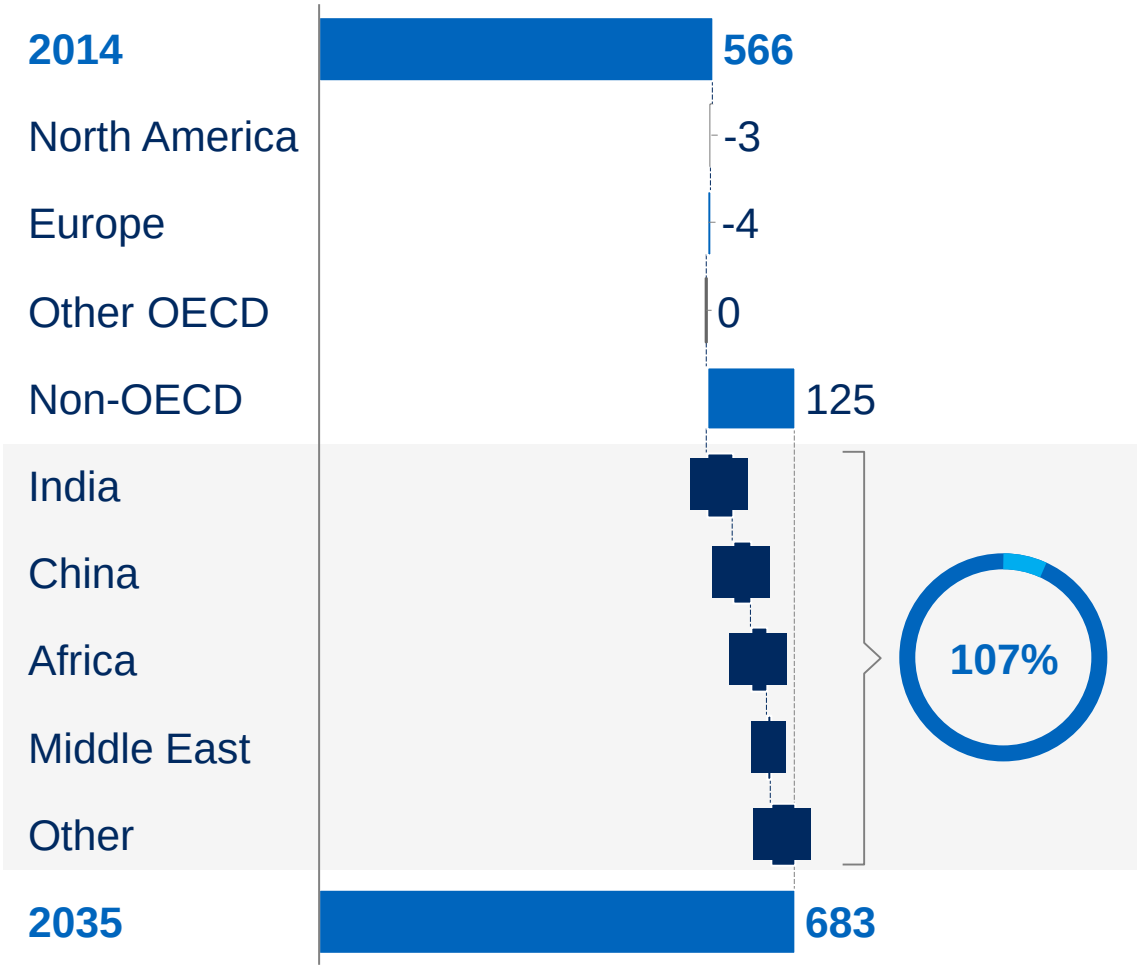
SOURCE: McKinsey Energy Insights' Global Energy Perspective, July 2017

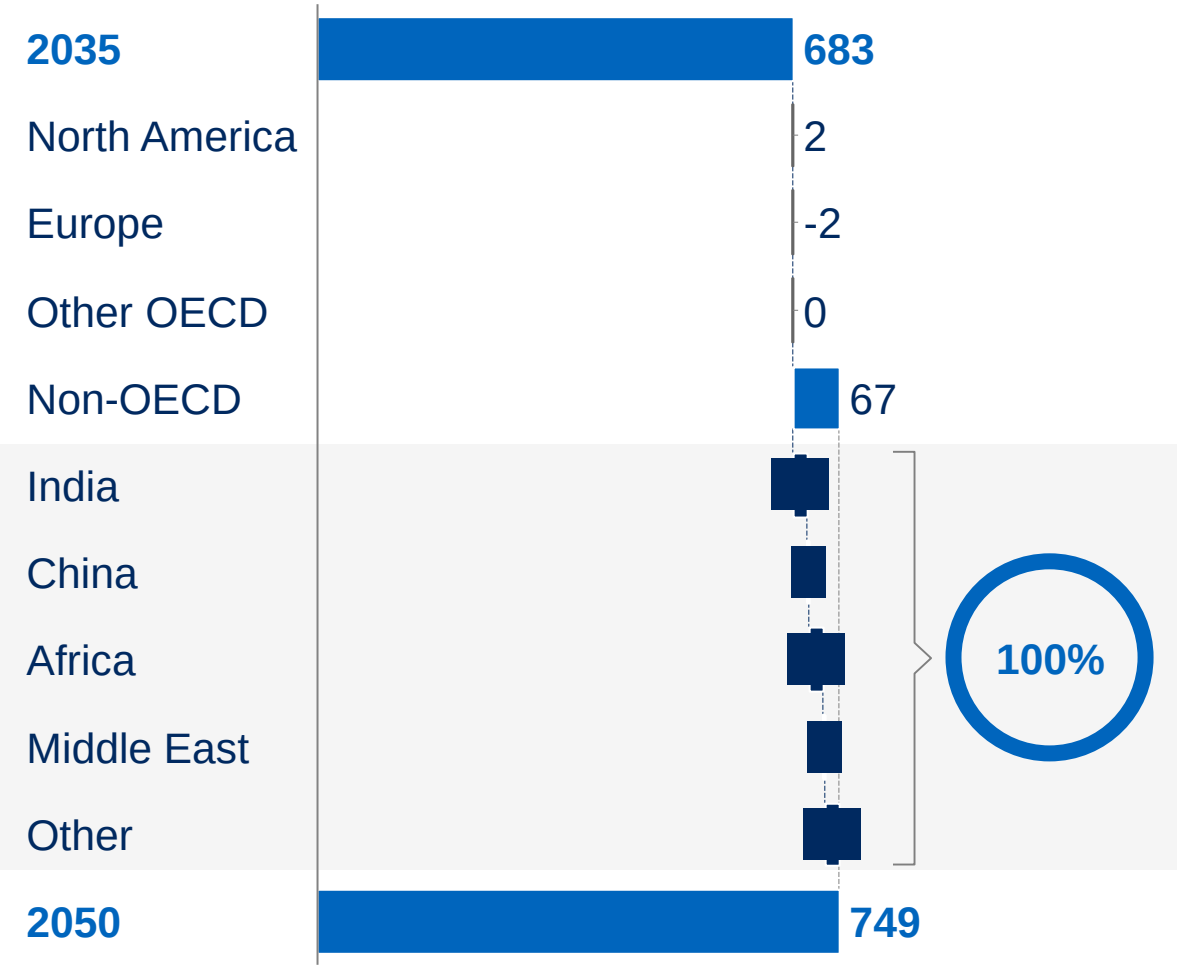
All energy demand growth comes from non-OECD markets, OECD demand declines

x% Share of total energy demand growth

Primary energy demand

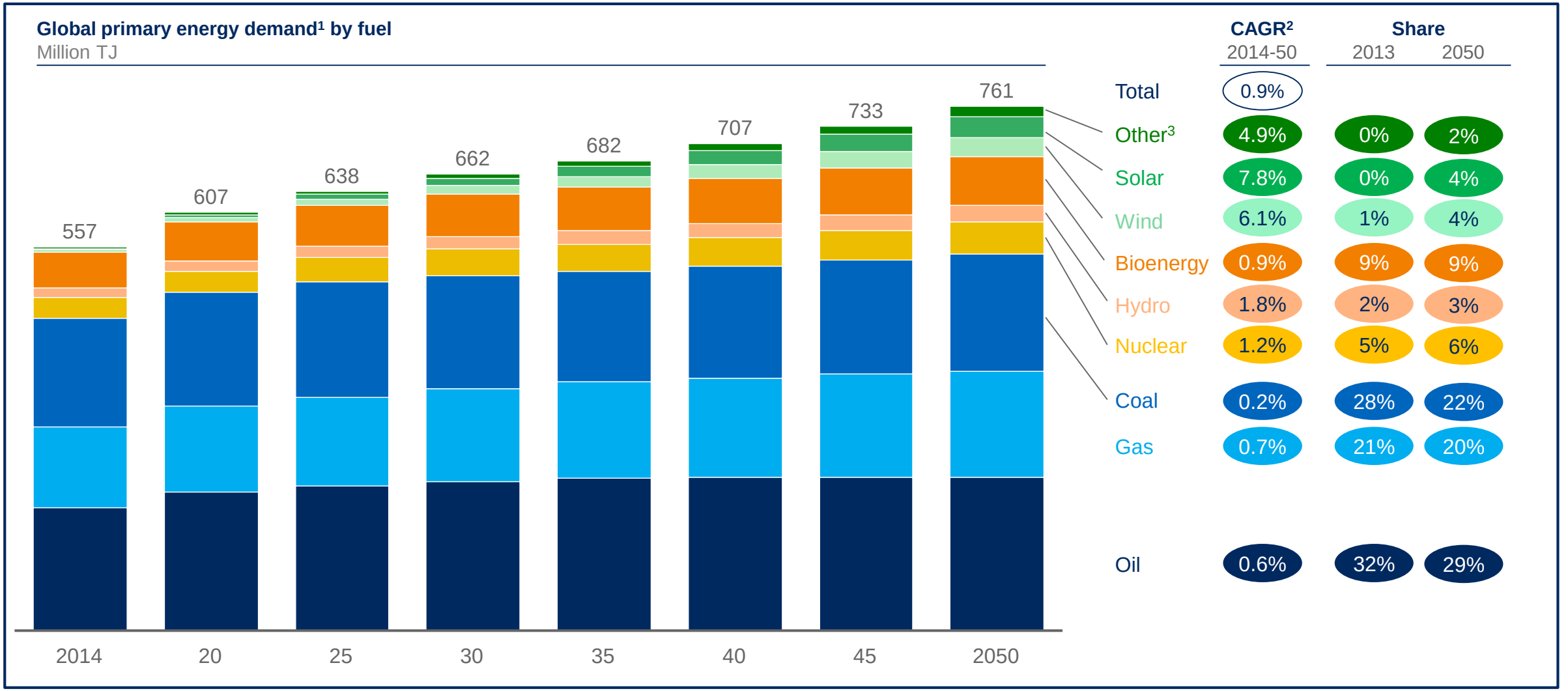
Million terajoules





SOURCE: McKinsey Energy Insights' Global Energy Perspective, July 2017

Despite strong growth in renewables through the period to 2050, the global energy system remains reliant on oil, coal, and natural gas

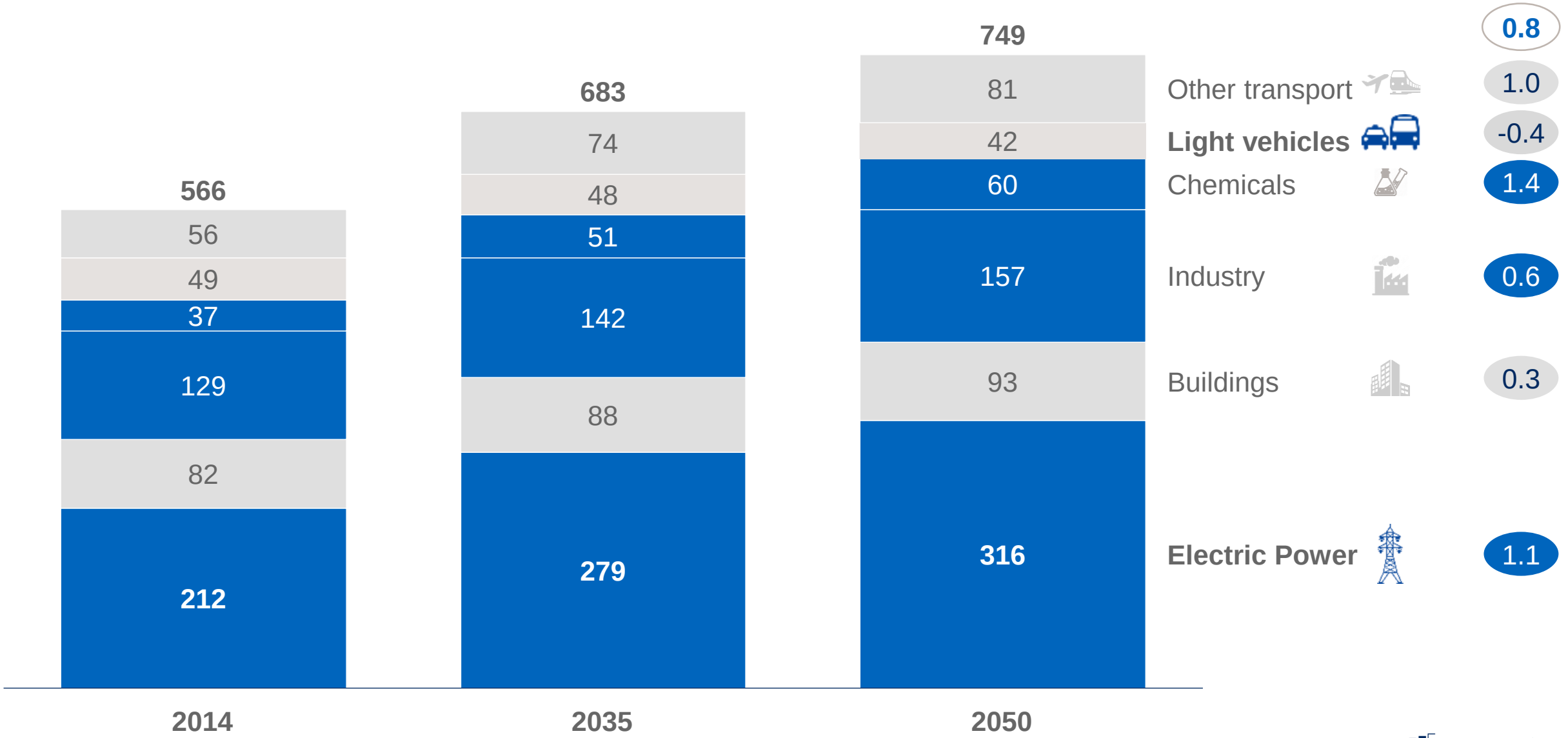


1 Includes primary energy consumed in transformation processes (e.g. power generation) and end-uses 2 Compound annual growth rate (average)
3 Includes heat, geothermal and marine

SOURCE: Generated by McKinsey Energy Insights' Global Energy Perspectives Model for CPPIB, September 2017

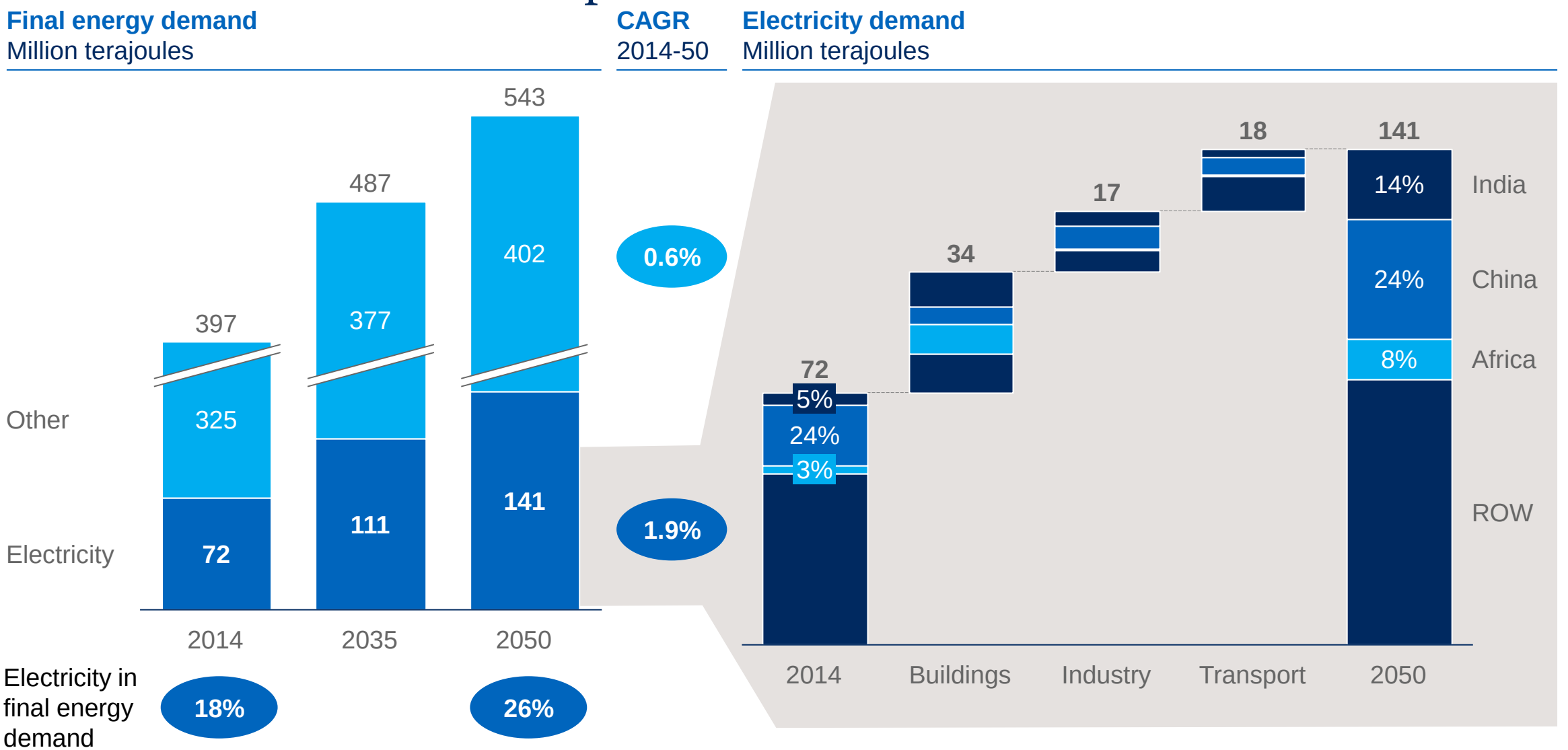
Power, industrials, and chemicals are main drivers of growth

Primary energy demand, Million terajoules



SOURCE: McKinsey Energy Insights' Global Energy Perspective, July 2017

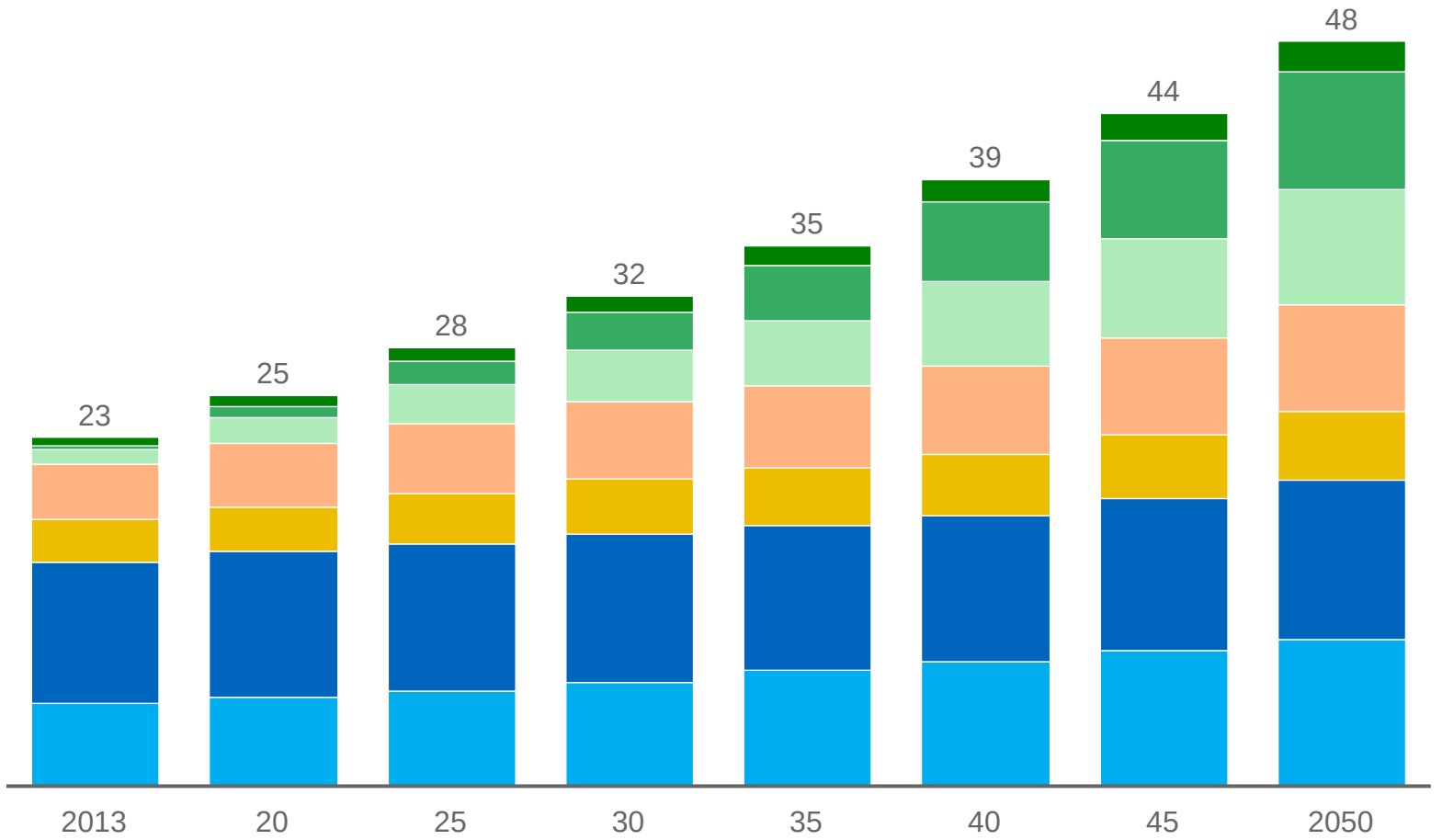
Global demand for electric power will almost double by 2050 as electrification continues to spread



SOURCE: McKinsey Energy Insights' Global Energy Perspective, July 2017

A cleaner, more diverse power mix evolves in the longer-term as a result of increasing renewables penetration

Global electric power generation[1] by source
Thousand TWh



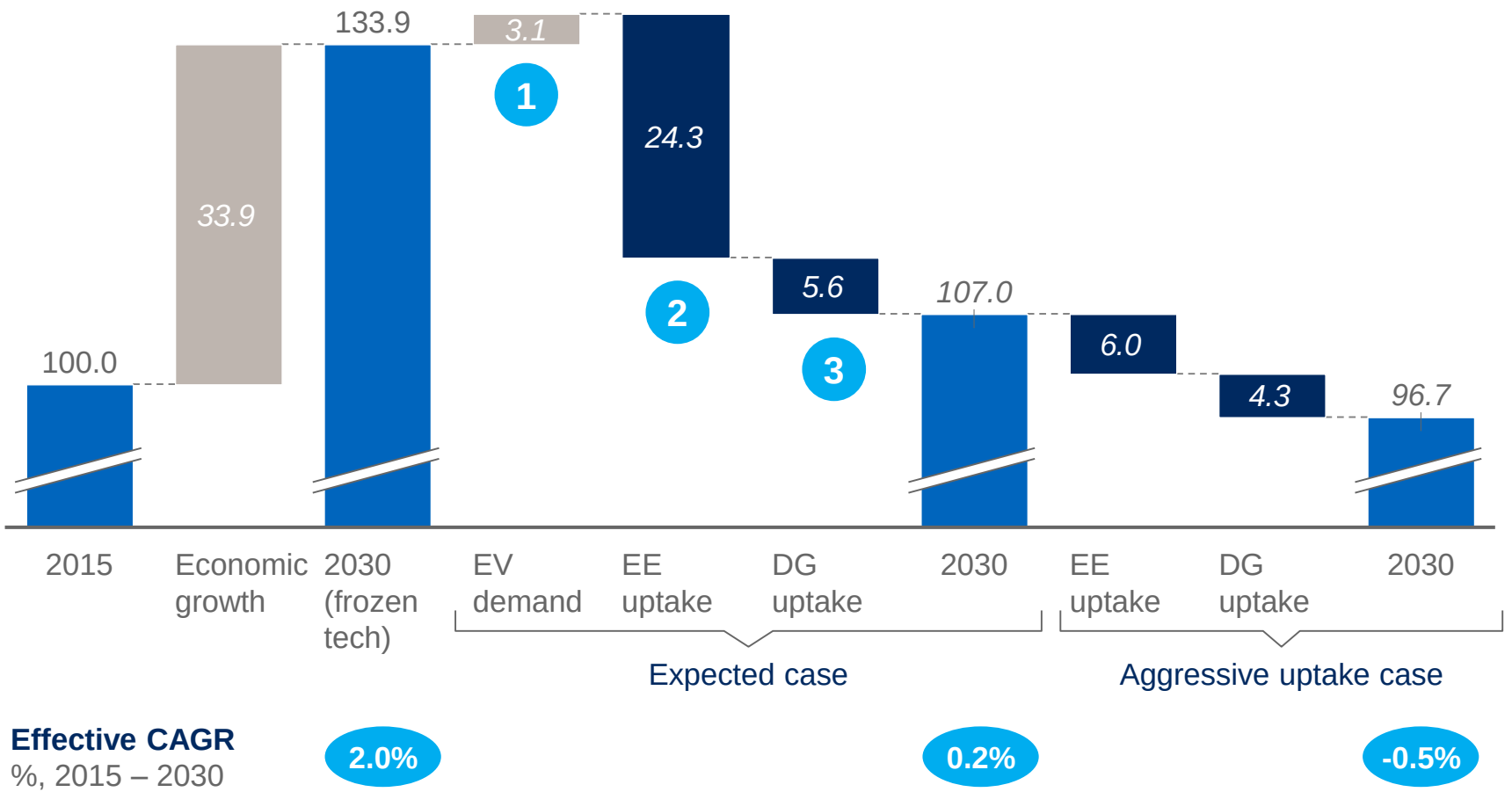
	CAGR[2] 2014-50	Share 2013	Share 2050
Total	2.1%		
Other[3]	3.8%	2%	4%
Solar	9.7%	1%	16%
Wind	6.1%	4%	16%
Hydro	1.8%	16%	14%
Nuclear	1.4%	12%	9%
Coal[4]	0.3%	40%	21%
Gas	1.6%	24%	20%

1 Power generation is projected on the basis of policy plans, expert views and third-party sources. It is not driven by explicit assumptions about the economics of different sources 2 Compound annual growth rate (average) 3 Includes oil, bioenergy, geothermal and marine 4 Assumes no breakthrough in carbon capture and storage

SOURCE: Generated by McKinsey Energy Insights' Global Energy Perspectives Model for CPPIB, September 2017

However, electricity demand in the developed world will be nearly flat, driven by accelerated DG and EE adoption

Example retail sales load forecast, Canada
% of 2015 actual retail sales



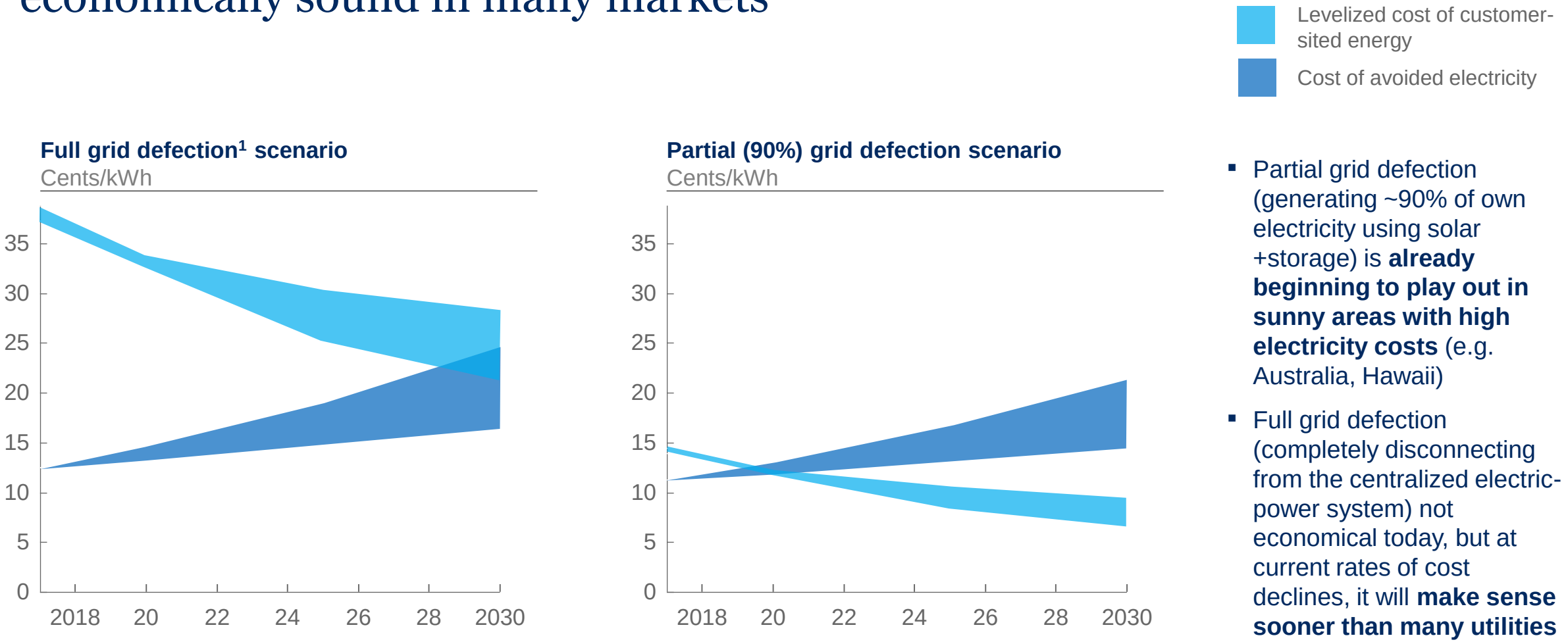
Effective CAGR
%, 2015 – 2030

2.0%	0.2%	-0.5%

1. Electrification of vehicles drives **slight increase in demand**, but the increase is offset by the combined effects of EE and DG
2. Energy efficient technologies such as **LED lights, high-efficiency air conditioners, and smart thermostats** drive a significant decline in electricity demand
3. Distributed generation of electricity (e.g., **solar panels for residential use**) further decrease daily demand on the grid

SOURCE: McKinsey PowerIQ electricity demand model

Decreasing costs of solar plus battery storage will soon make load defection economically sound in many markets

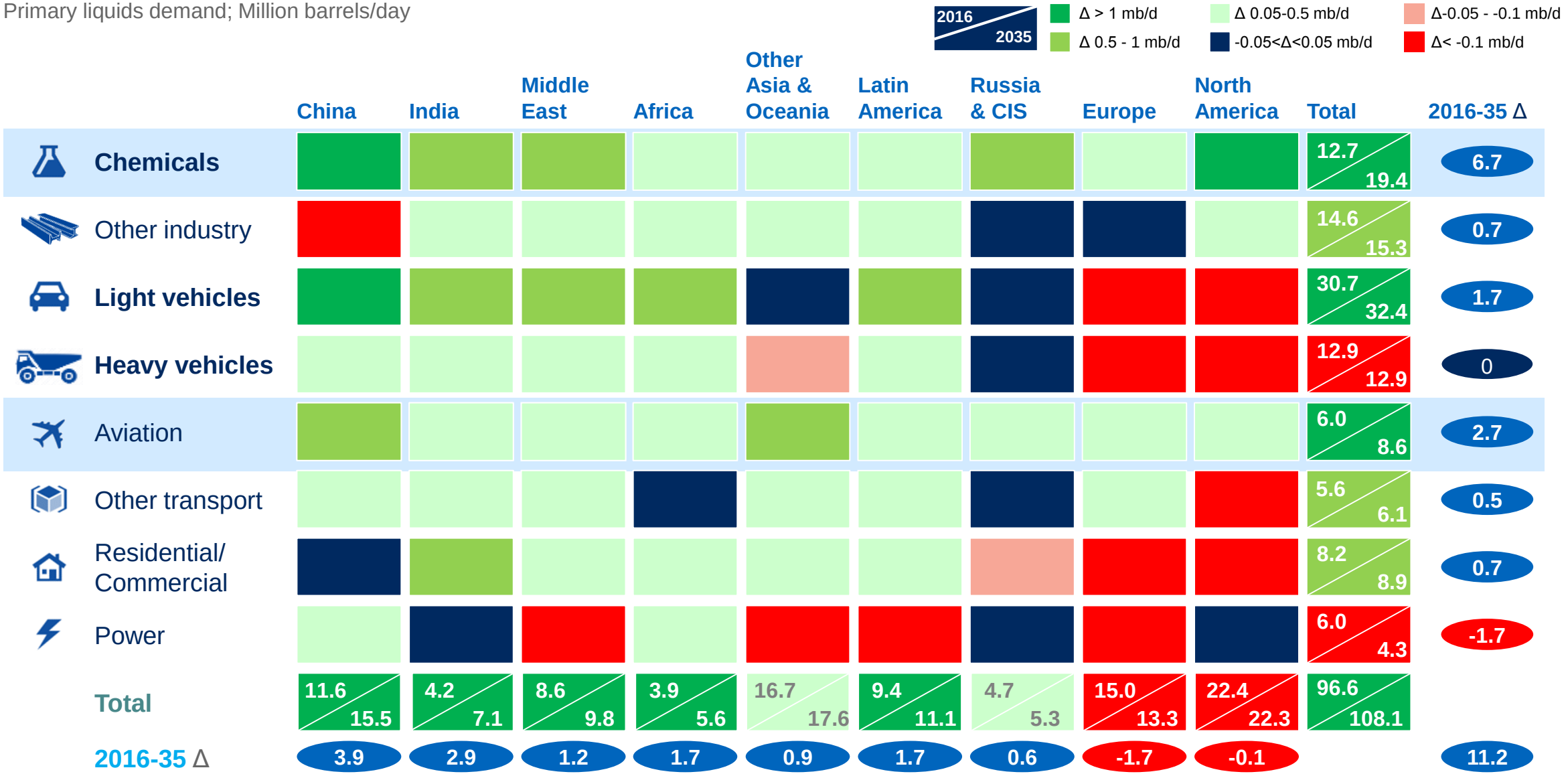


- Partial grid defection (generating ~90% of own electricity using solar +storage) is **already beginning to play out in sunny areas with high electricity costs** (e.g. Australia, Hawaii)
- Full grid defection (completely disconnecting from the centralized electric-power system) not economical today, but at current rates of cost declines, it will **make sense sooner than many utilities expect**

1 Grid-defection-economics estimates are based on Arizona residential customer. Full grid defection includes diesel generator backup.
SOURCE: McKinsey DER valuation tool and analysis

Liquids demand grows through 2037, driven by chemicals and aviation

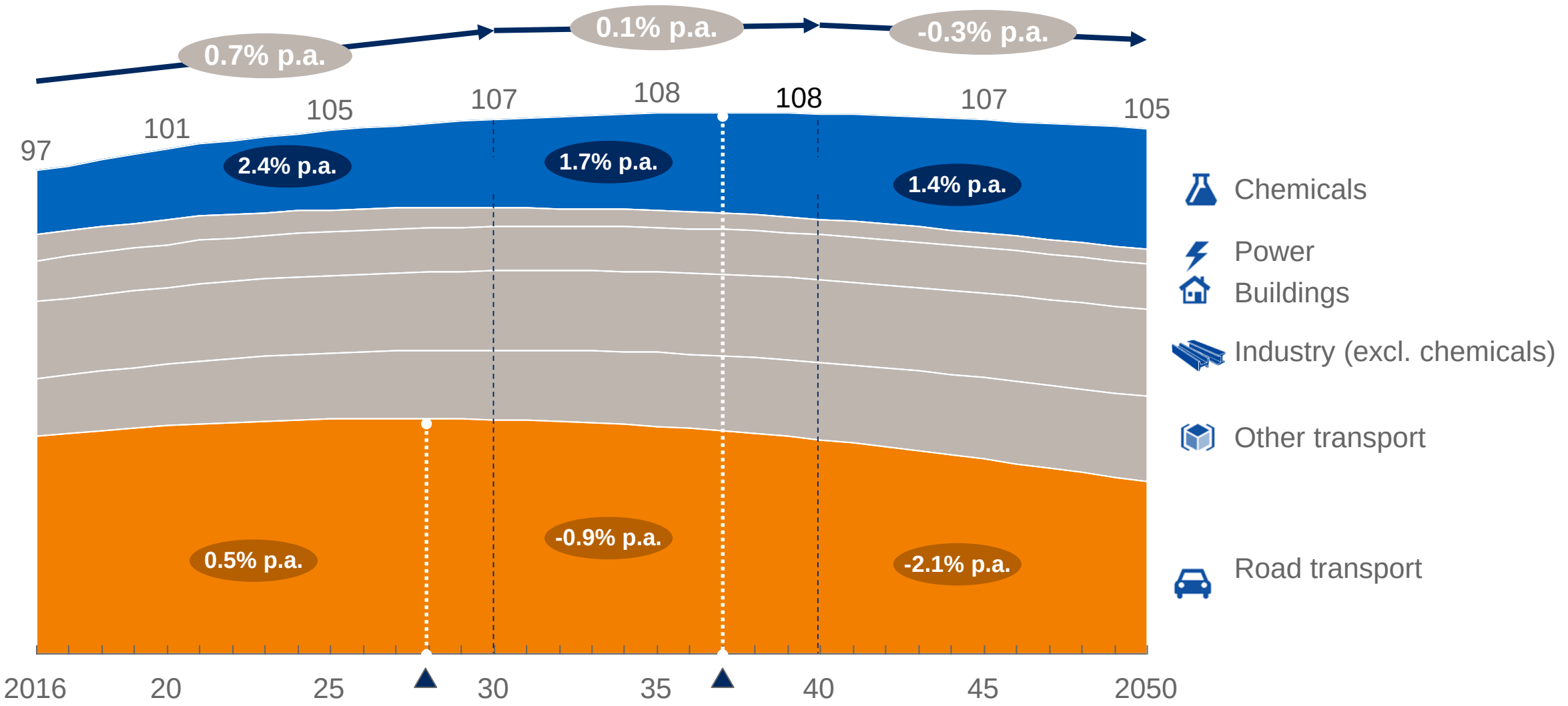
Primary liquids demand; Million barrels/day



SOURCE: McKinsey Energy Insights' Global Energy Perspective, July 2017

At this point global liquid demand is expected to peak, driven by electrification of the transport sector

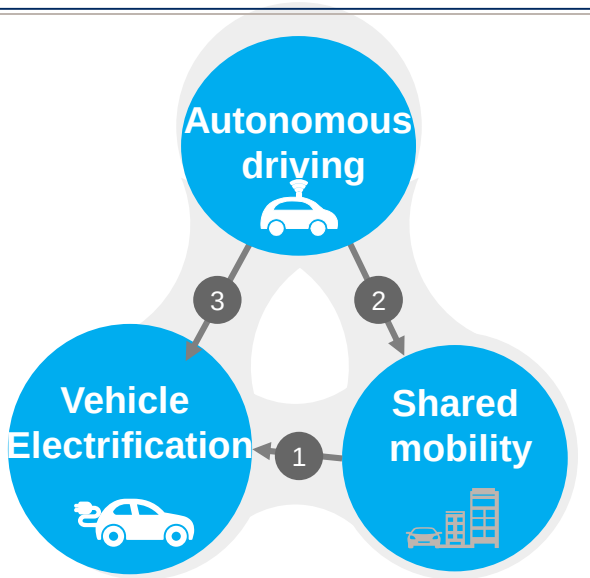
Global oil demand, Million barrels per day



SOURCE: McKinsey Energy Insights' Global Energy Perspective, July 2017

Ride sharing and autonomous operations compound with electrification to accelerate mobility disruptions

Majority of the trends impacting the future of mobility…



1. Increasing shared mobility increases utilization, accelerating electrification,
2. Self-driving functionality accelerates sharing
3. Self-driving electric vehicles offer lower TCO
4. An uptake in shared mobility reduces public transit
5. Electric vehicles at scale accelerate battery cost reductions
6. Self-driving electric vehicles have advantaged infrastructure
7. Increasing renewable penetration generation make electric vehicles more attractive
8. Self-driving vehicles accelerate the uptake of IoT applications

…will also radically change the oil and gas industry

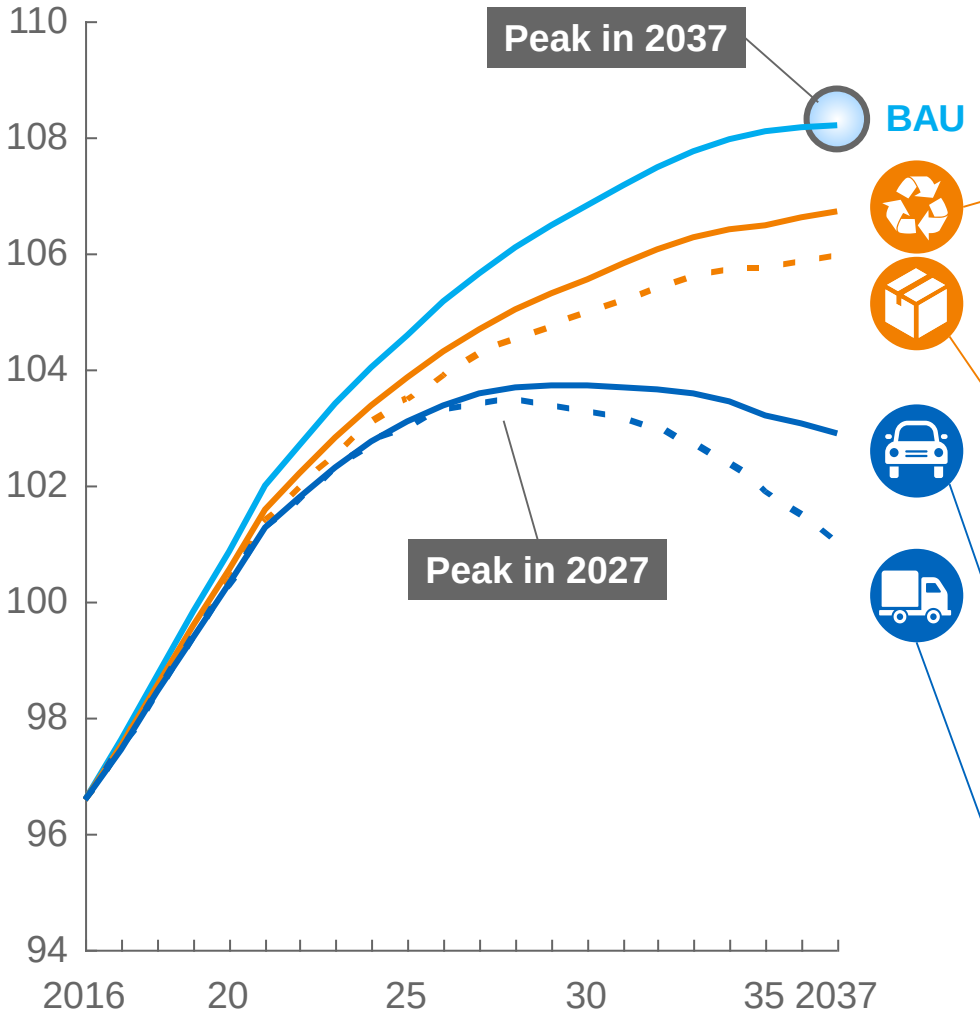
- Changes in **mobility behavior**
- **Connectivity** and **optimization** will lower fuel demand
- Uptake of **electric vehicles** and continuous **improvement** of **ICE technology** will **lower demand** for oil and oil-related products (e.g., lubricants) from vehicles
- New **competition** and **cooperation** with new players entering the market
- **Shifting markets** and **revenue pools**

SOURCE: McKinsey

In oil, several additional disruptors could lead to an even earlier peak

Disruption
Base case

Impact on global liquids demand mb/d

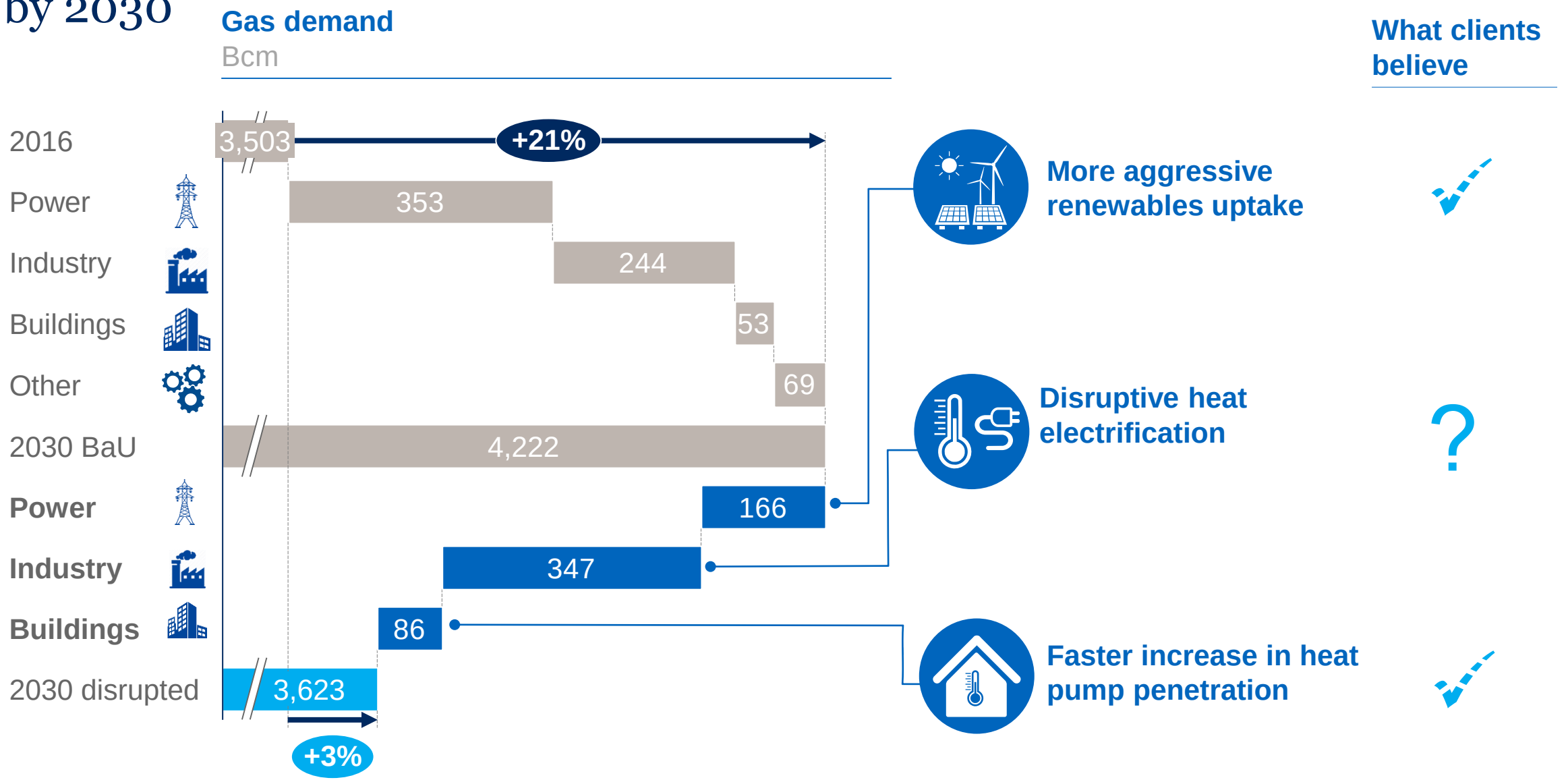


Assumption (%, global)

	2016	2035
Increased plastics recycling rate	7	25
Plastics savings through packaging efficiency	0	5
Increased share in sales of electric passenger cars	1	66
Increased share in sales of electric trucks and buses	0	49

SOURCE: McKinsey Energy Insights' Global Energy Perspective, July 2017

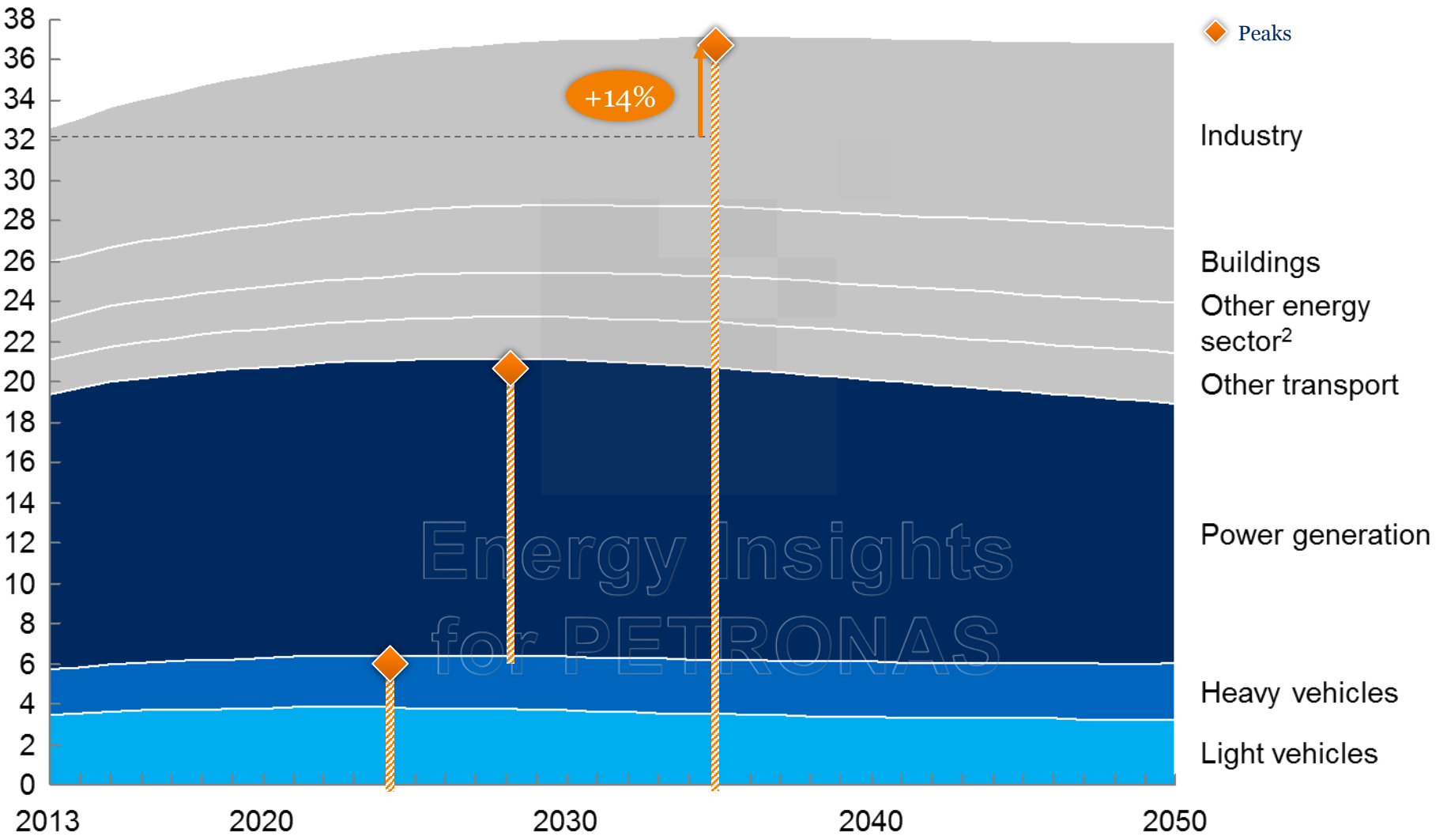
In gas, the debate is whether emerging disruptions offset demand growth by 2030



SOURCE: McKinsey Energy Insights' Global Energy Perspective, July 2017

Energy-related CO_2 emissions reach a peak around 2035

Global energy-related CO_2 emissions[1], Gigatonnes CO_2-equivalent



1 Does not include any CCS assumptions

2 Includes emissions from oil and gas extraction, mining and other energy sector own uses

SOURCE: McKinsey Global Energy Perspective

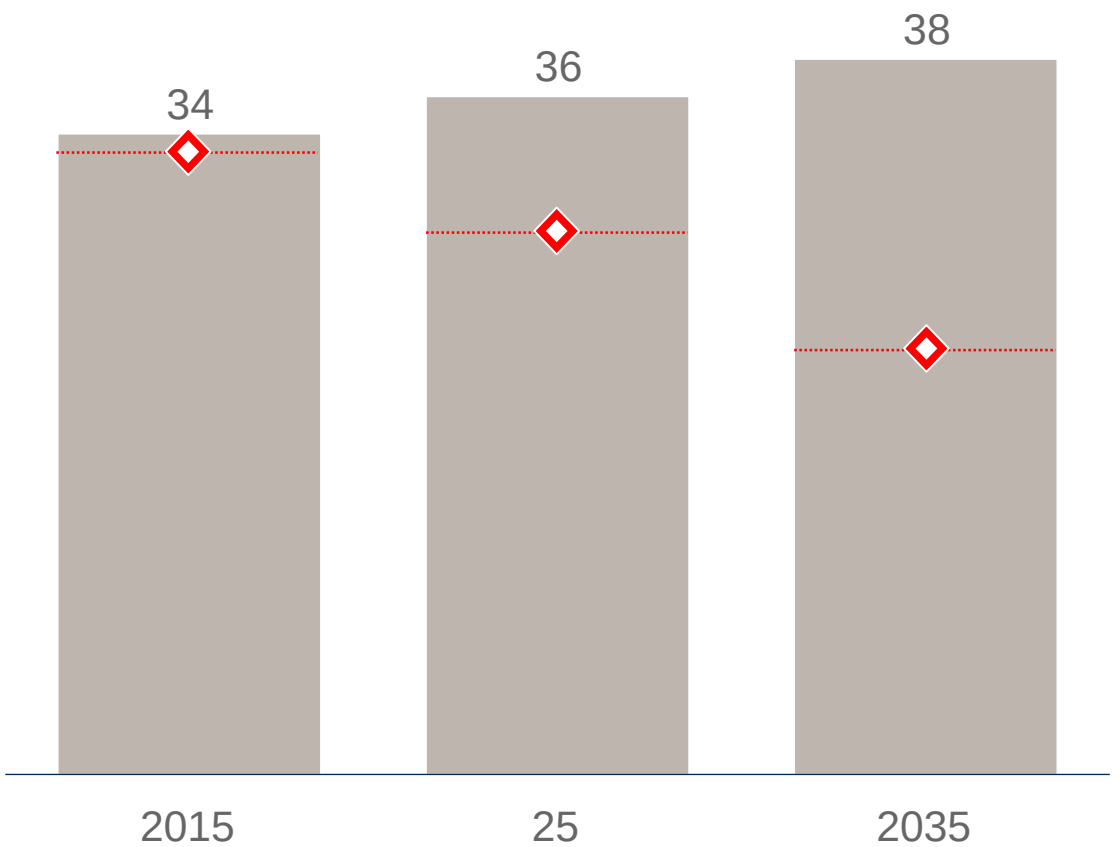
However, even with the high renewables growth, emissions will miss current targets by a wide margin

Greenhouse gas emissions by scenario; Gigatonnes CO2 equivalent

Emissions in line with 2 degree scenario (IEA 450)

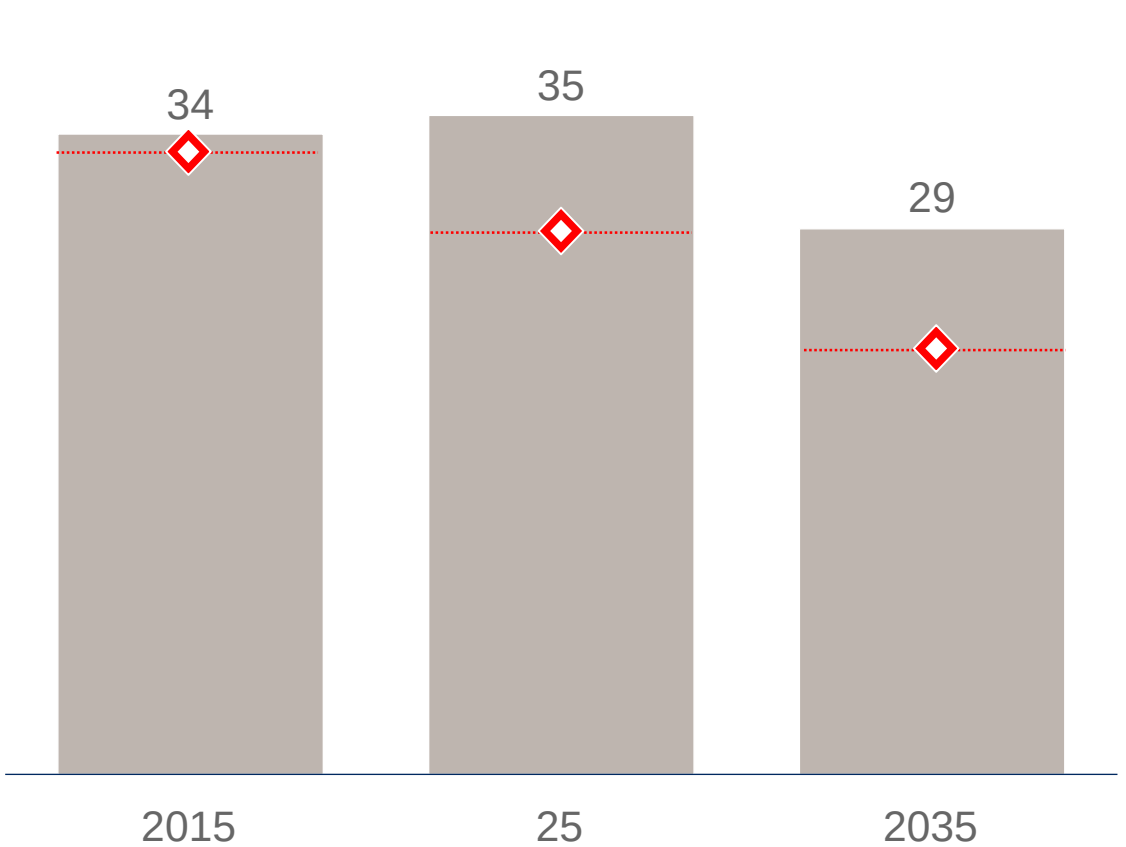
Business-as-Usual scenario

Emissions continue to grow until 2035



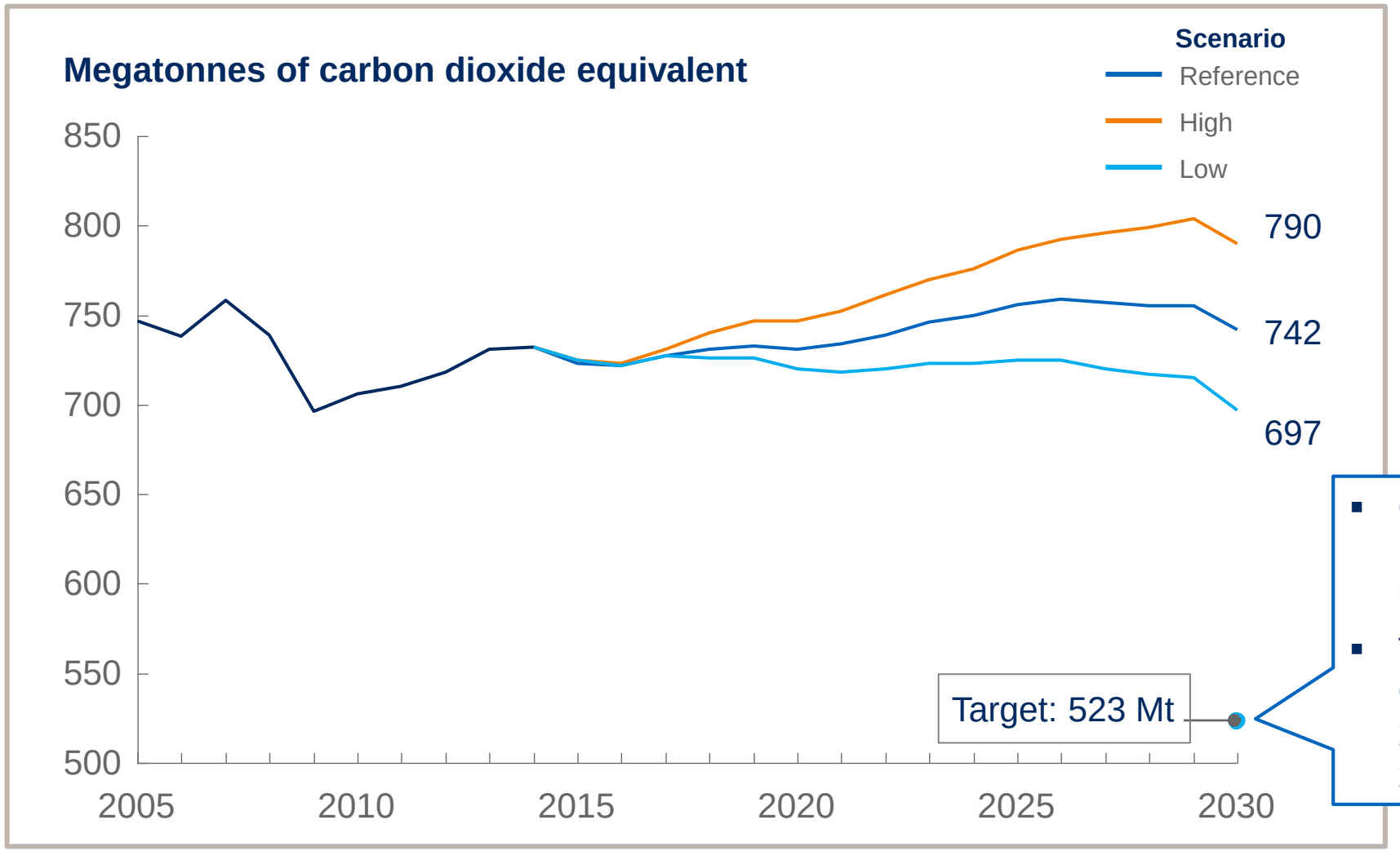
Tech disruptor case

Emissions peak in 2025



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

Canada, too, is not on track to meet 2030 emissions targets



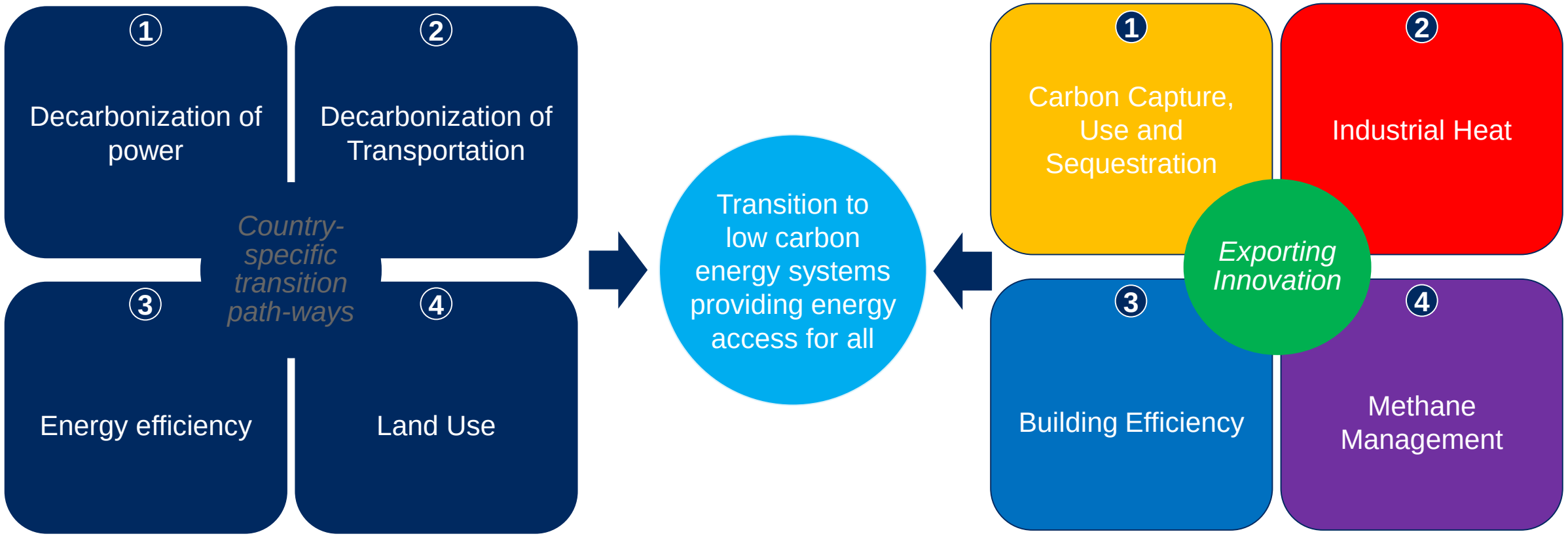
- Canada set target in 2015 to reduce 2030 emissions to 30% lower than 2005 levels
- Target is more aggressive than Copenhagen target to reduce 2020 emissions to 17% lower than 2005 levels

SOURCE: Environment and Climate Change Canada

Addressing Greenhouse Gas Emissions Requires Broad Innovation, Creating Opportunities for Canada

The 4 basic transition strategies

Major Opportunities for Innovation



Many initiatives have been launched already to reduce GHG emissions

Business-led innovations

Recent innovations

1. SaskPower: world's first commercial-scale Carbon Capture and Storage (CCS) unit at a coal-fired power plant, reducing its emissions by 90%
2. Shell Canada's Quest facility captures and stores one million tons of CO2 underground per year
3. Paraffinic Froth Treatment (PFT) improves the quality of bitumen from mining operations and allows for a 6% reduction of GHG emissions

4. Imperial Oil has replaced steam for in-situ oil sand productions by injecting solvents under high pressure but at much lower temperatures
5. Suncor began testing melting bitumen with microwaves in 2014

New initiatives

1. Direct-contact steam generation (DCSG) project, backed by COSIA, could reduce water requirements and production of pure CO2
2. Alberta Carbon Trunk line, developed by Enhance Energy, will transport 15mm tons of CO2 per year to EOR (Enhanced Oil Recovery) sites
3. Vancouver-based Inventys Thermal Technologies will deploy a low cost CCS technology at Husky's Pikes Peak South Lloyd thermal project

Federal support for Clean Growth going forward

- **A $2-billion low-carbon economy fund was launched in June 2017, as part of the *Pan-Canadian Framework on Clean Growth and Climate Change***
- **The federal government announced several measures to support innovation in the 2017 budget**
  - **About $1.5 billion to support the clean technologies sector over the next 5 years**
  - **Launch of the Innovation Superclusters Initiative to foster collaboration between industry, academia and federal agencies**

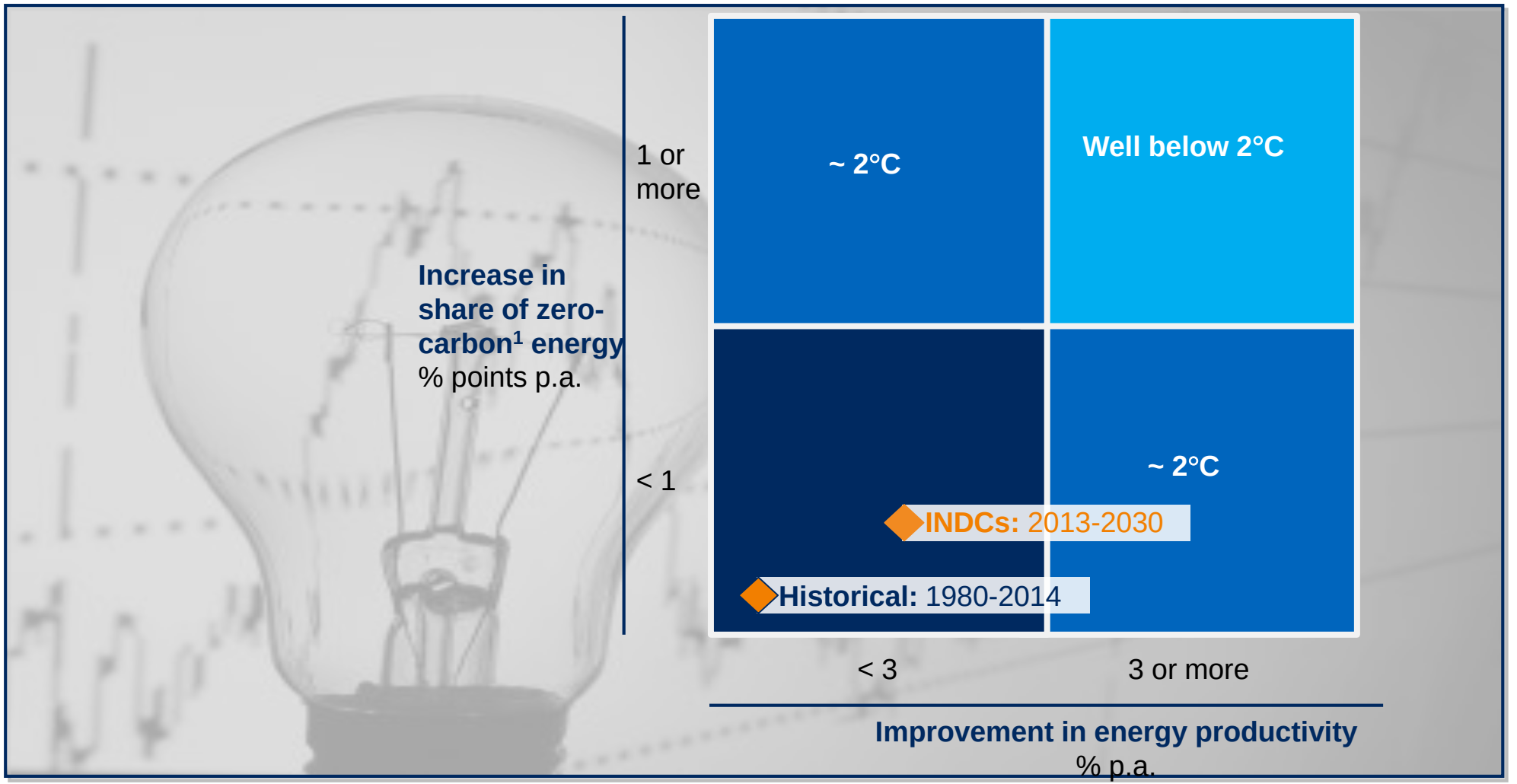
SOURCE: Natural Resources Canada, Alberta oil magazine, The Economist

And the early stage innovation pipeline offers promise as well

ALTERNRG	Converts the biogenic portion of organic waste into renewable natural gas for distribution in municipal power grids or for fleet vehicle fuel
Anaergia	converts the biogenic portion of organic waste into renewable natural gas for distribution in municipal power grids or for fleet vehicle fuel
CARBON CURE	Uses this waste carbon dioxide to make greener concrete products by chemically converting it into a limestone-like mineral.
corvus energy	Designs, engineers and manufactures a proprietary advanced lithium energy-storage technology that can provide sustained power
dpoint technologies	Develops and sells membranes and energy recovery technology that significantly improve the energy efficiency and air quality in buildings
electrovaya	Manufactures lithium ion batteries and systems for electric vehicles, portable power for industrial electronics and energy storage for smart grids
HYDROSTOR	Converts electrical energy to compressed air that is then sent to a series of flexible accumulators located between 50 metres and 500 metres underwater
morgansolar	Holds more than 60 granted and pending patents worldwide on multiple innovations
nexterra	Developed the most commercialized energy-from-waste gasification technology in the world. It has completed seven commercial projects in North America
OSTARA	Protect water resources by changing the way cities manage excess nutrients both in wastewater streams and due to fertilizer runoff
Saltworks	Advanced water treatment solutions provider. It designs, manufactures and assembles systems for desalination, brine management and chemical recovery applications
solantro SEMICONDUCTOR CORP.	Solantro's chipsets and platforms turn solar panels into integrated power generators and allow for the management and storage of renewable energy.
tempora high-performance energy storage	Designs, manufactures and services the world's leading flywheel energy-storage technology
Woodland Biofuels Inc. The Future of Fuel™	Lowest cost producer of automotive fuel globally, producing cellulosic ethanol at less than half the cost of producing the gasoline its biofuel hopes to replace

At the end of the day, energy productivity and the share of zero-carbon energy will define system change

Global primary energy demand, 2012-2050



1 We include here renewables, nuclear, biomass and fossil fuels if and when their use can be decarbonized through carbon capture and use or storage (CCS/CCU). However, if a large share of the increase is from the latter, a higher share is required since this does not reduce emissions to zero completely

SOURCE: Enerdata (2015), Historic actuals

Key take-aways for today

1. 

   Structural deceleration in energy demand growth as population ages; Non-OECD countries drive all the growth

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   Electrification continues to expand as renewables start to outcompete fossil fuels

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   Peak oil demand may be in sight. What will happen to gas demand?

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   Despite high renewables growth, the world (and Canada) are not on pace to achieve emission reduction targets

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   Significant opportunities for innovation driven productivity gains ahead—defining the new basis for competition