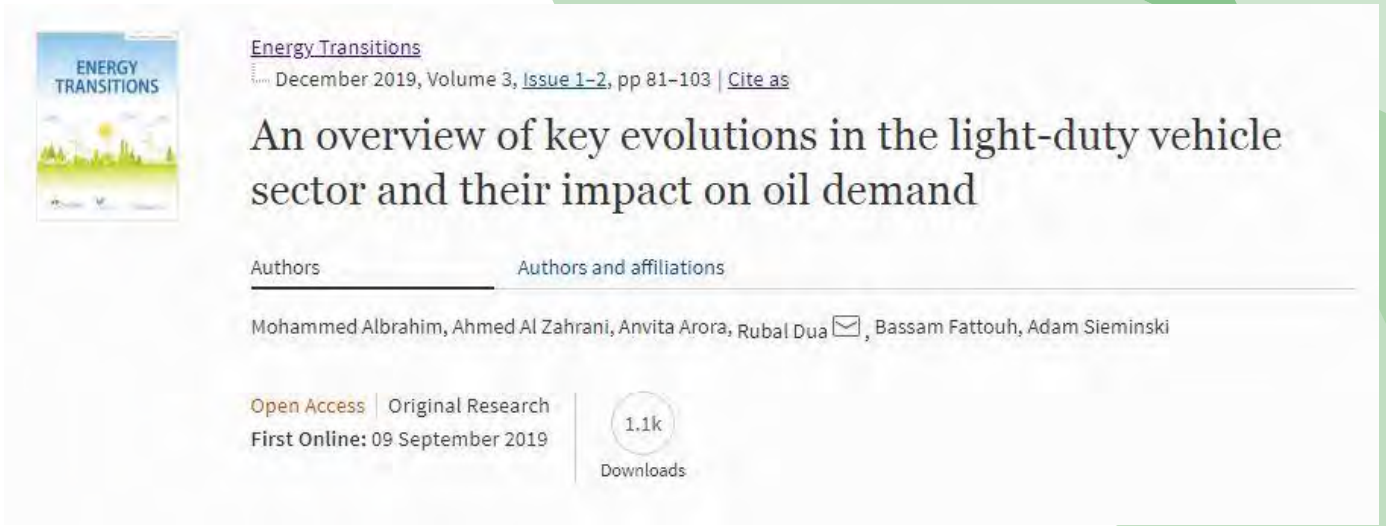
KAPSARC
مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center



Key Evolutions in the LDV sector and Impact on Oil Demand

Presented by: Anvita Arora

Paper by: Mohammed Albrahim, Ahmed Al Zahrani, Anvita Arora, Rubal Dua, Bassam Fattouh, Adam Sieminski

Published in: Energy Transition (2019) 3: 81. https://doi.org/10.1007/s41825-019-00017-7

IEA-IEF-OPEC Symposium on Energy Outlooks, IEF Headquarters on 19 February 2020

The changing LDV sector – key trends and evolutions

KEY TRENDS

1. **Demographic trends**
2. **Technological improvements**
3. **Government policies and regulations**
4. **Evolutions in the electricity generation sector**
5. **Consumer behavior**

KEY EVOLUTIONS

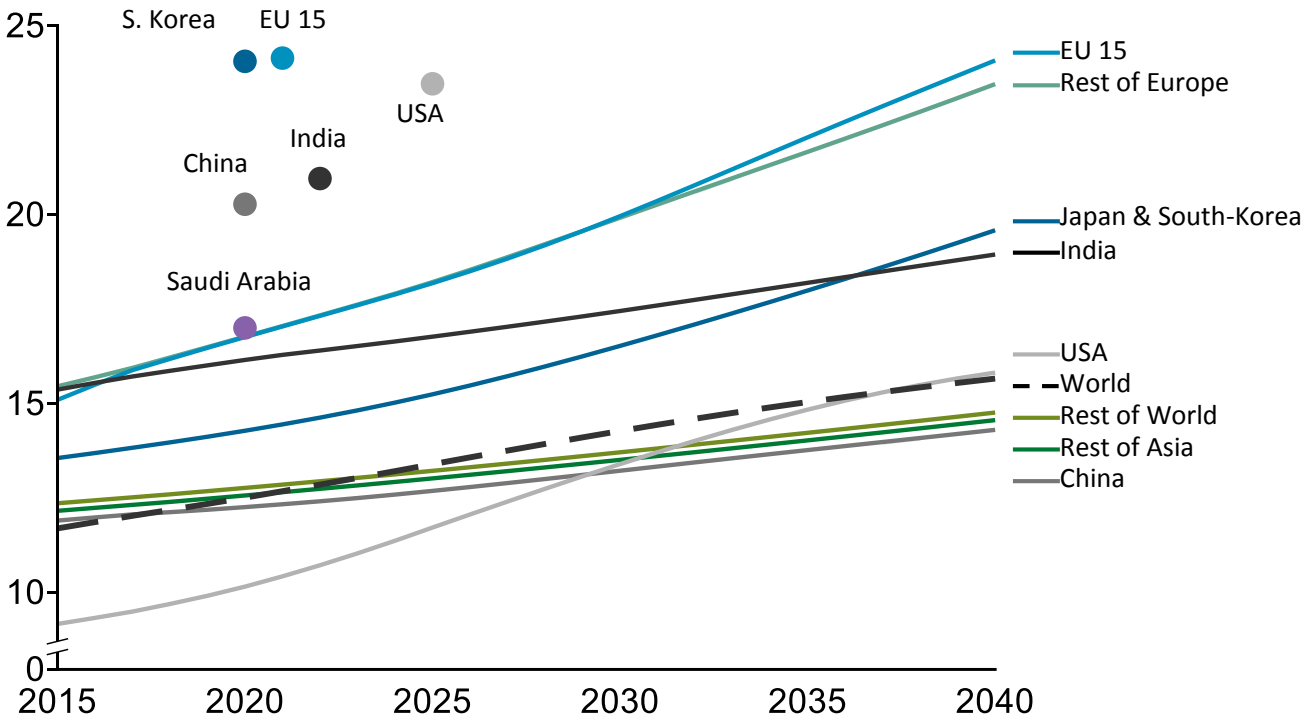
	Trend description	Impact on oil demand
1 **Improvements in fuel economy**	• ICE LDV fuel economy is **constantly increasing** • Improvement in **engine efficiency and vehicle design** (aerodynamics, tires, etc.)	
2 **Penetration of alternative fuels**	• **Increasing penetration** of natural gas vehicles including LPG and CNG • **Higher biofuel blending** mandates	
3 **Vehicle electrification**	• **BEVs and PHEVs** • Improving **battery technology** • Cleaner **electricity sources**	
4 **Vehicle Automation**	• Development of autonomous driving leading to emergence of **self-driving cars and taxis**	
5 **Shared mobility**	• Proliferation of **shared mobility services** like **ride-hailing, car sharing and car pooling**	

Note: Projections based on IEA NPS; EIA and Exxon estimates have been normalized to IEA 2015 baseline, they are 33.3 and 26.6 MMBDOE respectively; 2000 energy consumption is an extrapolation of HDV-LDV ratio growth between 2015-40. Source: "World Energy Outlook 2017", "ETP", IEA extrapolation of data

Fuel economy of LDVs is expected to increase significantly (~34%) by 2040 primarily due to improvements in engine performance

GLOBAL LDV* CAR PARC FUEL ECONOMY FORECAST

Fuel economy of LDV car parc (km per liter**)



TECHNOLOGICAL DRIVERS

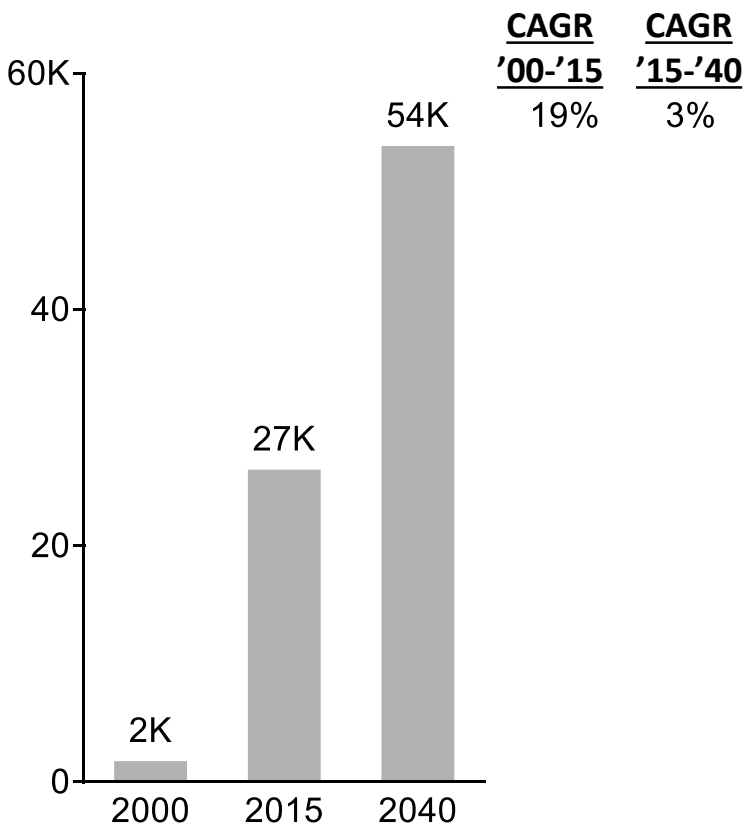
Engine performance improve-ments	• Smaller ICE **engines with fewer cylinders**, enhancing combustion • **Forced induction**, **direct injection** and **advanced valve-train strategies**
Weight reduction	• New materials e.g. **carbon fiber** composites, **make vehicles lighter**
Aero-dynamic improve-ments	• **Increased emphasis on aerodynamics** in the design stage • **New manufacturing techniques** (e.g. 3D printing) will reduce drag
Tire friction reduction	• Proliferation of **tire-pressure management system** • **Low rolling resistance tires**
Engine management software	• Use of **advanced software** in **ECU** to ensure engine is always running at "**fuel-efficient sweet spot**"

Note: Fuel economy of car parc is based on new LDV fuel economy improvement 2.6% in developed countries, 1% in developing countries (USA data is from IEA) and new car sales; (*) Fuel economy of car parc is based on gasoline LDVs since gasoline vehicles are expected to be the majority of LDVs in car parc in 2040; (**) Normalized to U.S. Corporate Average Fuel Economy test cycles. Source: GFEI, IEA, Lit. search

Alternative Fuels: Natural gas vehicles are expected to grow with proliferation of fueling infrastructure, favorable economics and supporting regulations

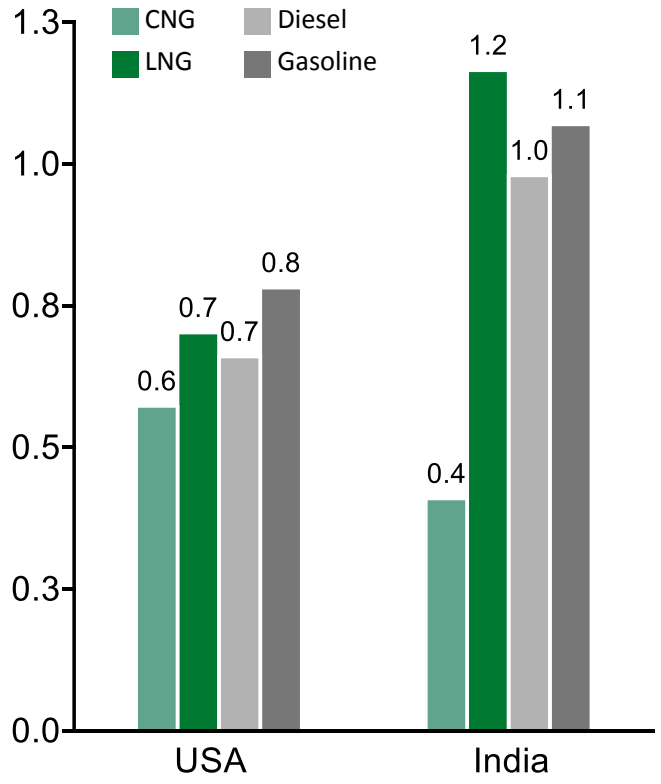
INFRASTRUCTURE GROWTH

Natural gas fueling stations (Thousands)



FAVORABLE ECONOMICS

Retail fuel prices ($ per liter, 2018 January)



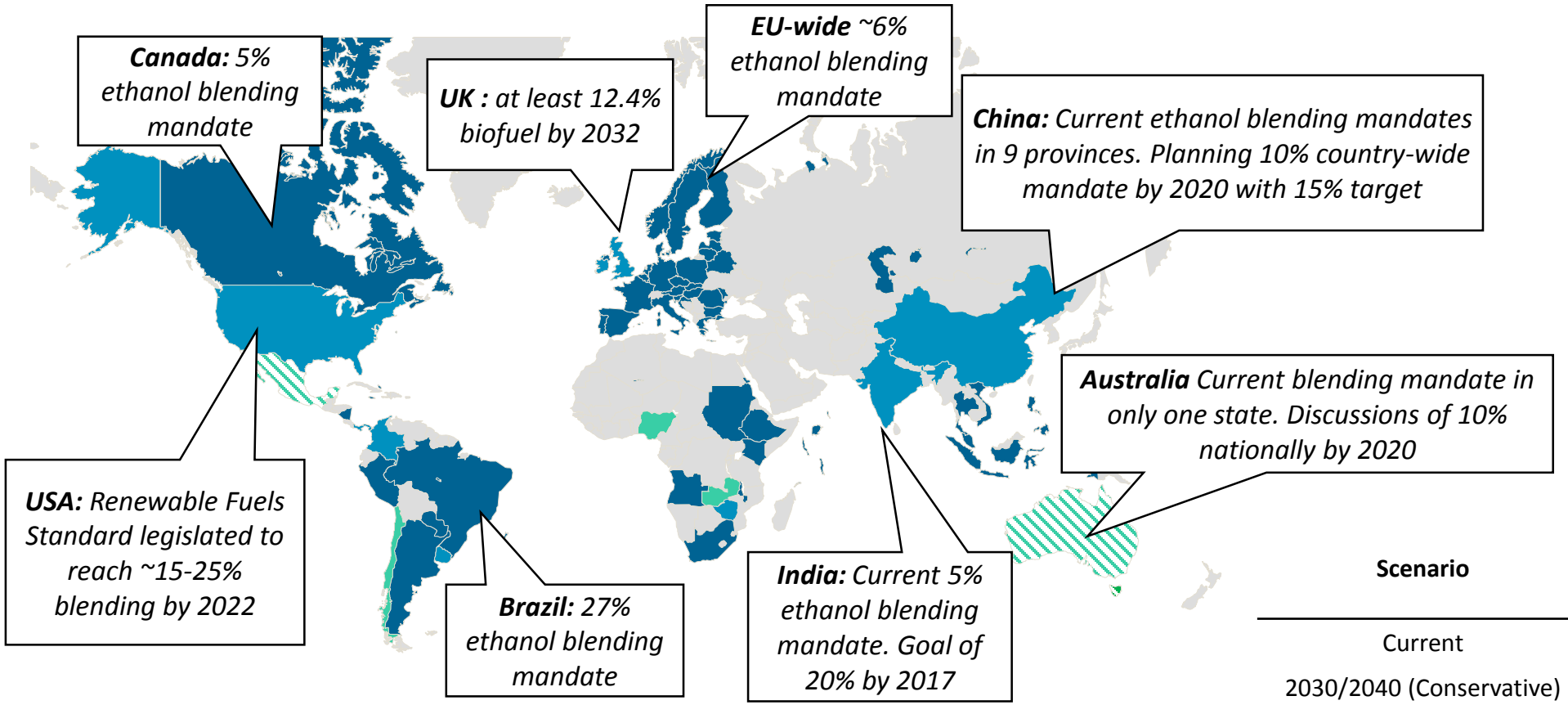
SUPPORTING MEASURES

North America	• **Promotion of infrastructure** development by the **Fixing America's Surface Transport. Act**
Europe	• Alternative Fuels Infrastructure Directive suggesting **minimum density CNG and LNG refueling stations**
China	• **Prioritized adoption** of natural gas vehicles; established **price support polices**
India	• Provides **sales tax exemption** on conversion kits; **prioritizes land allotment** for NG fueling stations
Brazil	• **Investments** in natural gas **pipeline network**, facilitation in building **fueling infrastructure**

Note: 2040 estimate for fueling stations is based on uptake of NGVs
Source: Natural Gas Vehicles Knowledge Base, IEA, extrapolation of data

Alternative Fuels: Main Biofuel application is blending with fossil fuels for vehicles (~5% blending, today)--moderate increases anticipated to 2030/40

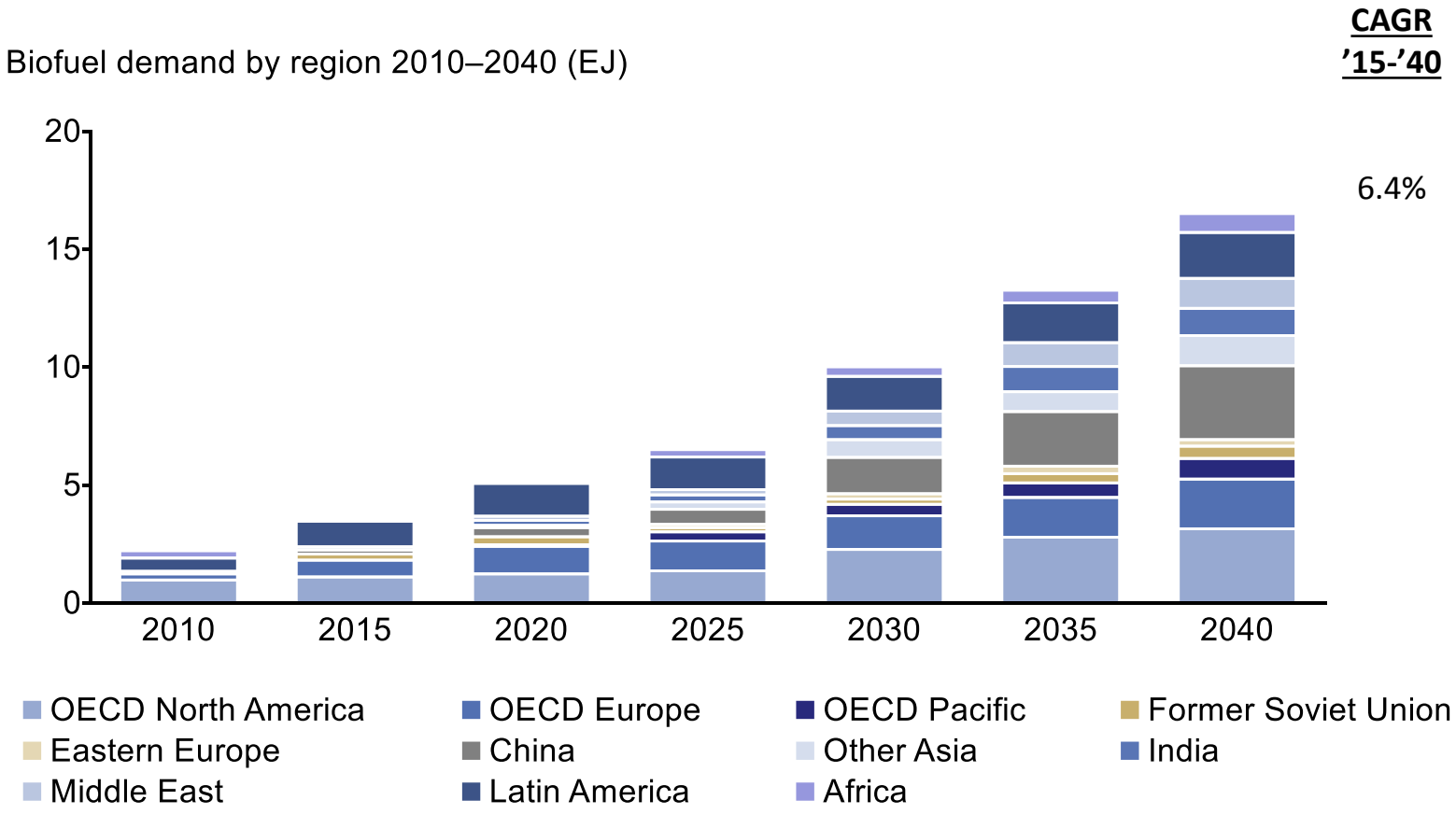
INTERNATIONAL ETHANOL BLENDING MANDATES



Scenario	2030/2040 global average biofuel blending
Current	5%
2030/2040 (Conservative)	10%
2030/2040 (Optimistic)	15%

Alternative Fuels: Biofuel demand is expected to increase significantly by 2040 (~6% p.a.)

BIOFUEL DEMAND BY REGION



GROWTH DRIVERS

- Rapidly growing vehicle fleets
- Emissions reduction targets

HOW DEMAND WILL BE MET

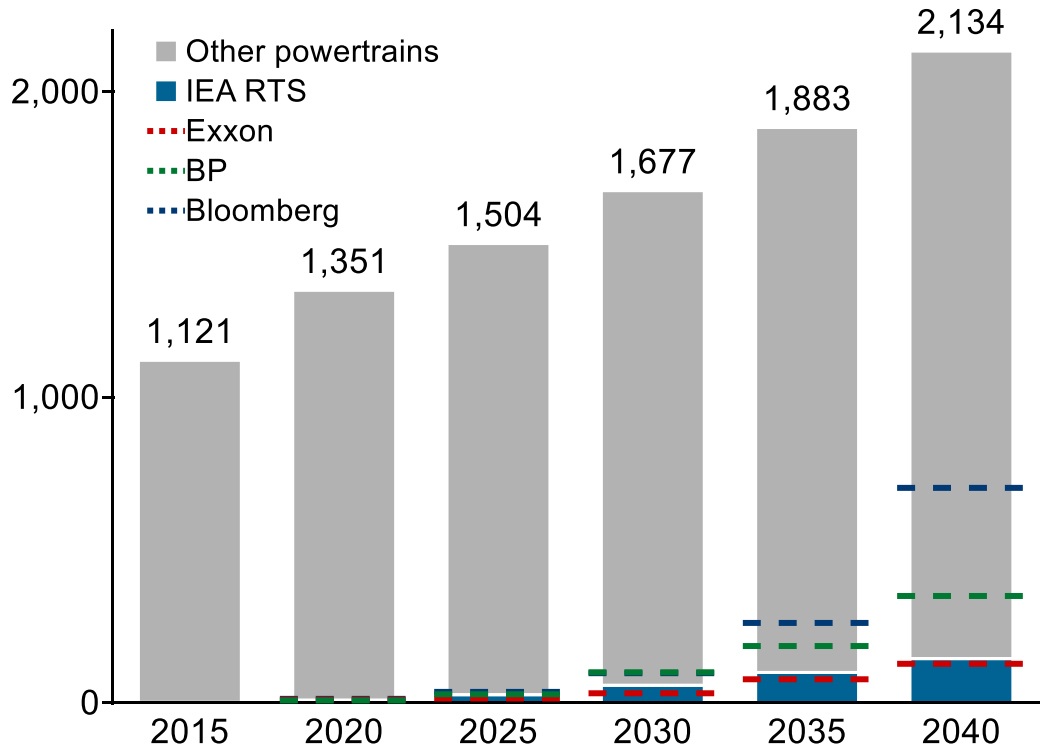
- Conventional biofuels production ramp up
- Advanced biofuel projects in US, EU, Brazil and China

Note: FSU = Former Soviet Union
Source: IEA

Electric vehicle uptake is expected to increase significantly over the next two decades, but the adoption path remains unclear

PATH TO EV ADOPTION REMAINS UNCLEAR…

Electric vehicle uptake (# of electric vehicles in car parc, Millions)



…AS NUMEROUS ISSUES COMPLICATE AN ACCURATE EV PENETRATION FORECAST

Economics	• How **quickly will Li-ion batteries** continue to **move down the experience curve?** • How will **future emissions regulations** affect **comparable ICE costs?**
Technology	• When will **battery technology progress** to permit **adequate driving ranges?** • How will the **charging infrastructure** develop to support **long-distance EV travel?**
Policy	• How will **subsidies evolve** globally to encourage **EV development and adoption?** • Will **governments** aggressively force **carbon reductions?**
Behavior	• How will **consumers respond** to EVs once the **range** and **refueling constraints have been solved?** • How will the **perception of EVs help or hinder adoption?**

Note: Car parc is based on IEA RTS data; Scenarios from BP, Exxon and Bloomberg are normalized to IEA car parc
Source: IEA, BNEF, Exxon, BP

A number of automakers have announced their plans to invest heavily in **electric vehicles** over the coming decade

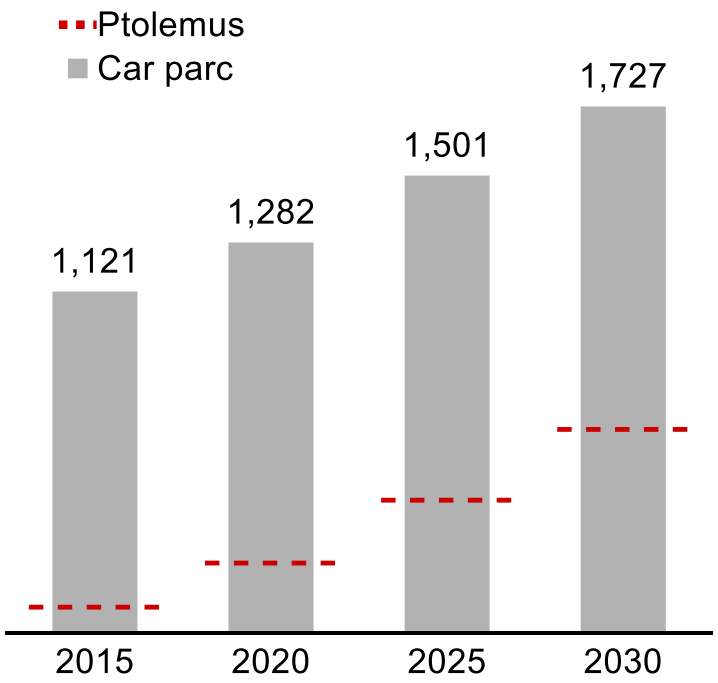
AUTOMAKER	ANNOUNCEMENT
DAIMLER	• Investing **$10 billion** in EV development • Mercedes-Benz plans to **electrify its "entire portfolio" by 2022**, offering **50 electric and hybrid models**
VOLVO	• Plans to **electrify its entire vehicle line by 2019** • Expects to **sell one million electric and hybrid cars** by 2025
VW	• Investing **$84 billion** in EV development (~ **$60bn on battery production**) • Plans to offer electric and hybrid versions of **300 models by 2030**
LAND ROVER / JAGUAR	• Plans to electrify its **entire vehicle lineup by 2020**, with new powertrains ranging from mild hybrid vehicles to all-electric systems

AUTOMAKER	ANNOUNCEMENT
GM	• Plans to **phase out gas-powered** vehicles for an **"all-electric future"** • Announced to release **20 all-electric vehicles** by 2023
Ford	• Created **EV-dedicated "Team Edison"** to focus on the development of all-electric cars, with **13 new models** to be released by 2023 • Pledged to invest **$4.5 billion** over five years
Renault / Mitsubishi / Nissan	• Plan to release **12 all-electric models by 2022** • Some of the EVs will have a **range of over 600 kilometers** on a single charge
TOYOTA	• Developing electric vehicle technologies and building a **$1.6 billion** assembly plant in the U.S, with **300,000 EVs** annual production capacity

Autonomous vehicles are expected to be level 1, 2 or 3 by 2030; level 4 and 5 are expected to capture only a small share of the market

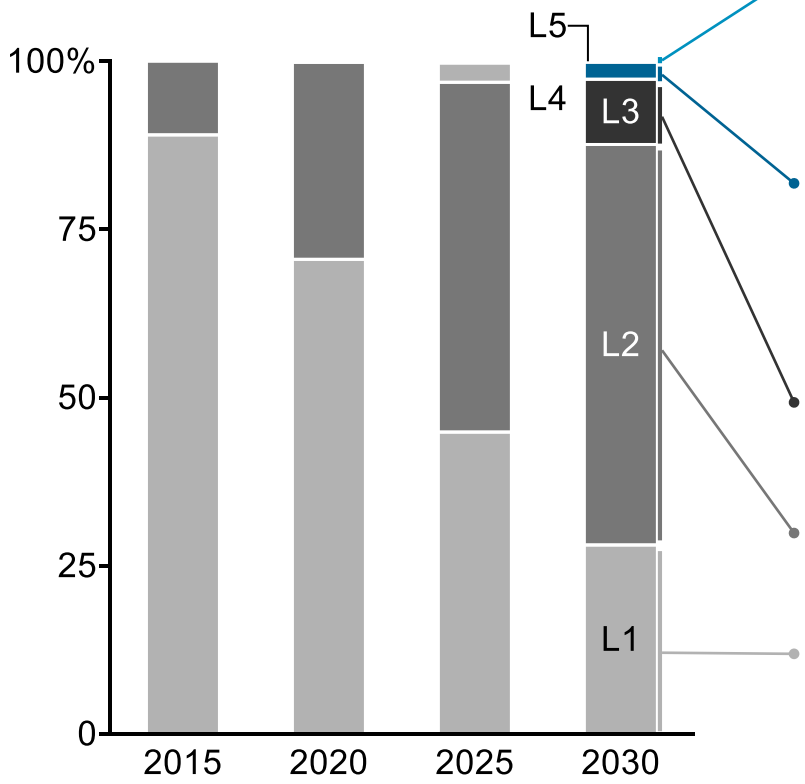
AUTONOMOUS VEHICLE (AV) UPTAKE FORECAST

Autonomous vehicle uptake (# of autonomous vehicles in car parc, Millions)



SHARE OF EACH LEVEL OF AV BY 2030

Autonomous vehicle share by autonomous level (%)



LEVELS OF AUTONOMOUS DRIVING

Full autonomy	• Vehicle controls all driving tasks; no human attention or input is required
High automation	• Vehicle is capable of steering, braking, accelerating, monitoring the vehicle • Driver is responsible for dynamic driving situations
Conditional automation	• Vehicle itself controls all monitoring of the environment
Partial automation	• Vehicle can assist with steering or acceleration functions
Driver assistance	• Vehicle can assist with some functions
No automation	• Human driver performs all operating tasks

Source: IEA, Ptolemus

Shared mobility services: ride hailing, carsharing and car pooling

		RIDE HAILING	CAR SHARING	CAR POOLING
Definition		**Car and driver** offered at **time and location** that **customer wants**	**Car rental for shorter time** than general car rental service (e.g. for a few hours / minutes)	Platform **connecting individuals who will take similar trips** between cities
Key Attributes	Professionally driven	*Varies by geography*	*Not applicable*	✗
	Personally owned vehicle	*Varies by geography*	✗	✓
Examples		lyft, UBER, careem, DiDi	zipcar, CAR2GO, autolib'	scoop, BlaBlaCar

Car/ride sharing expected to make mobility more affordable and **increase km/inhabitant** hence increase energy consumption. Pooling will have the opposite effect

Assessment of oil demand from LDVs in 2040 - A Scenario Based Model

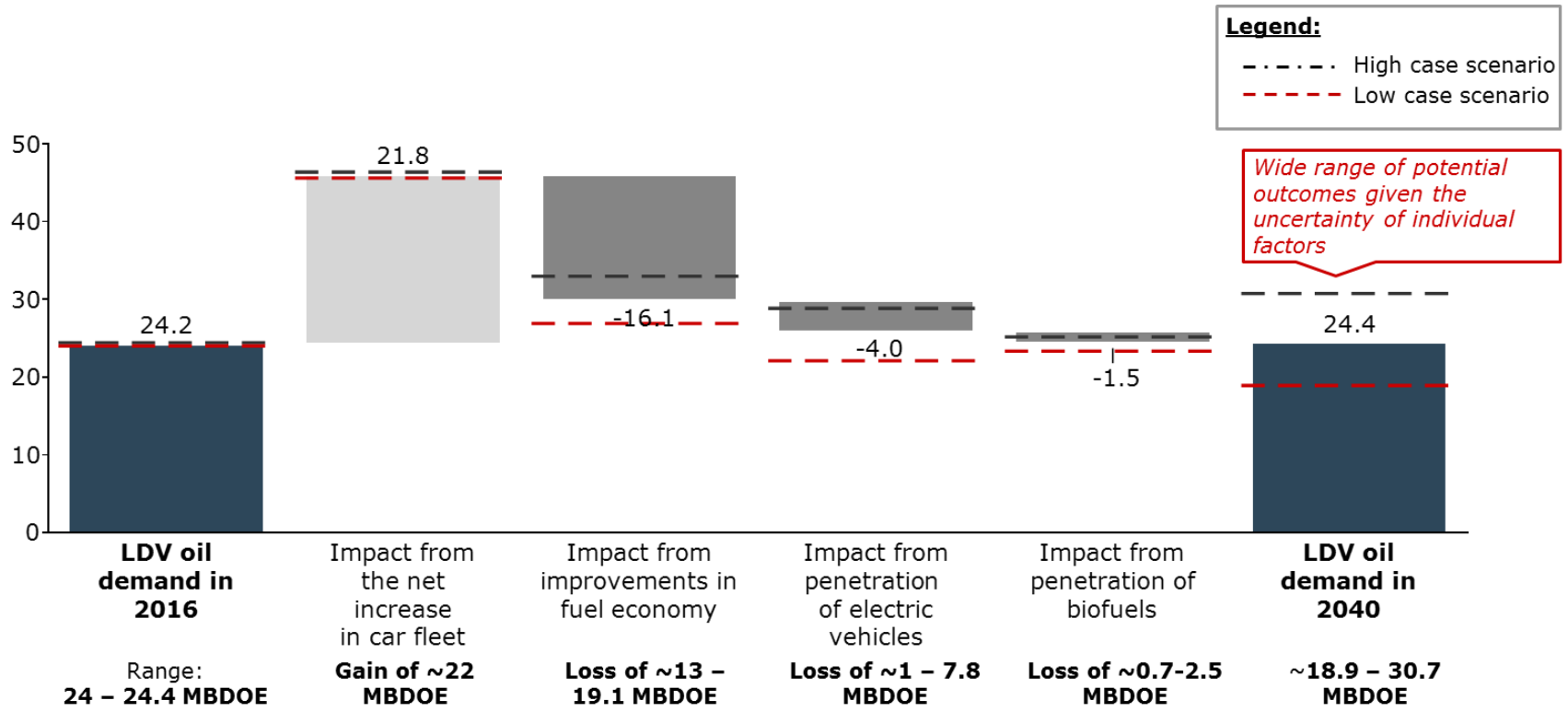
Main Drivers of Oil Demand Modelled

- **Increase in the global LDV fleet size**
- **Improvement in the fuel economy of ICEVs**
- **Penetration of electric vehicles**
- **Penetration of alternative fuels (focus on biofuels) and biofuels blending mandates**

The model uses three boundary scenarios (maximum, average, minimum) as input values for parameters (2), (3) and (4) above in addition to the three scenarios for the 2016 baseline oil demand from LDVs. We determined the ranges for each of those parameters based on a review of forecasts from other institutions and existing literature, referenced in various sections of this paper

Compounding the scenarios for each of the drivers of oil demand resulted in 81 possible scenarios for oil demand by 2040 (i.e., 3 x 3 x 3 x 3 scenarios).

Oil demand from LDVs: A view to 2040



Our analysis indicates that in the average scenario, oil demand from LDVs would be relatively unchanged by 2040. However, a wide range of outcomes is possible. The minimum scenario would see oil demand from LDVs shrink by ~5.3 MBDOE from the baseline of 24.2 MBDOE in 2016. The maximum scenario would see oil demand from LDVs increase by ~6.5 MBDOE from the same baseline

Critical remaining uncertainties and the way forward

- **Consumer acceptance and adoption**
- **Future oil prices**
- **Technological advancement and speed of the mobility revolution**
- **Government policy targets and their achievability**
- **Interaction with the existing energy system**

The results presented in this paper suggest that, for the next two decades at least, oil will likely remain the primary fuel for LDVs. The fuel economy of ICEVs is increasing, and uncertainties remain regarding the scale of electric, autonomous and shared vehicle adoption. As such, an appropriate action plan for the next two decades for key stakeholders, including governments, entrepreneurs, OEMs, and oil producers among others, would be to develop a basket of solutions that take into account a range of projected technological, social, and economic conditions, rather than rely on specific outcomes

Please access and read!

https://link.springer.com/article/10.1007/s41825-019-00017-7#Sec12