

FUTURE OF AUTOMOTIVE MOBILITY

CESEE countries in (e-)motion: trends in the automotive industry and individual mobility: Key Note Address

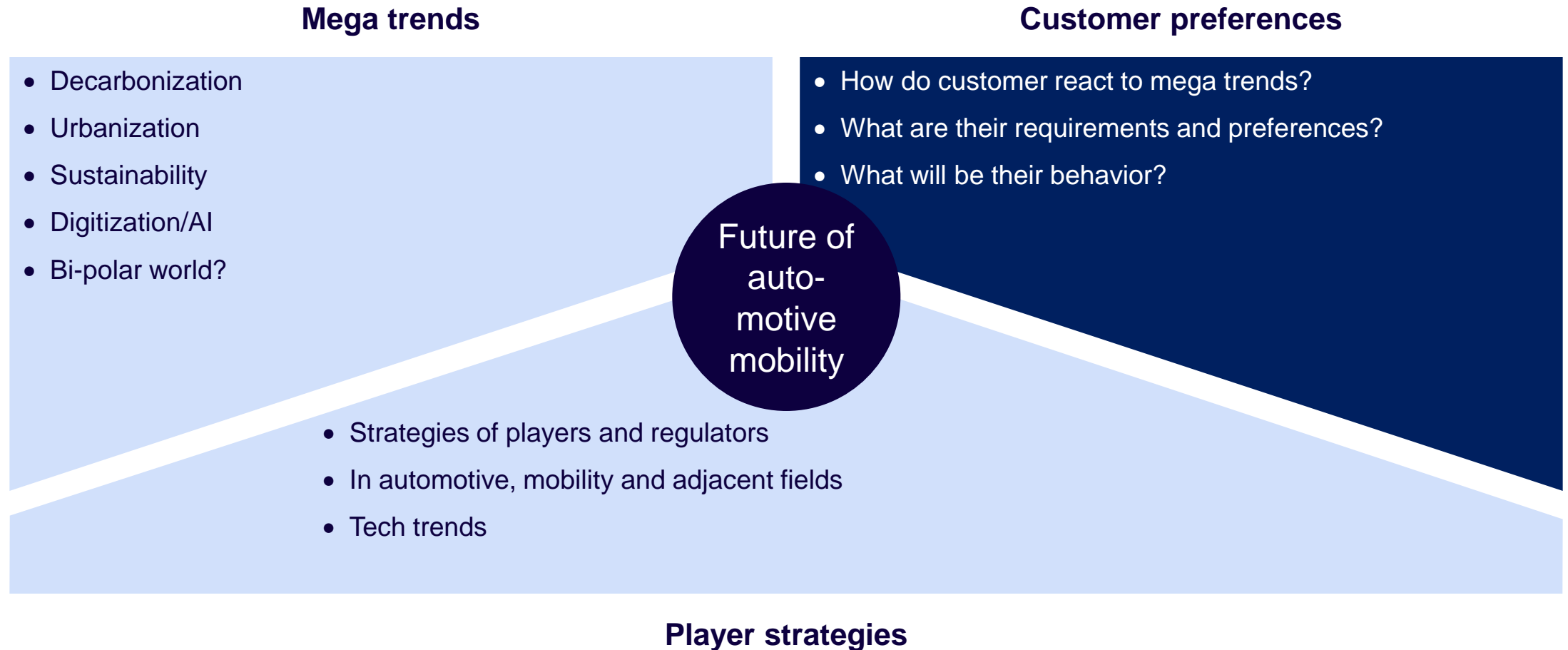
Dr. Klaus Schmitz, Arthur D. Little

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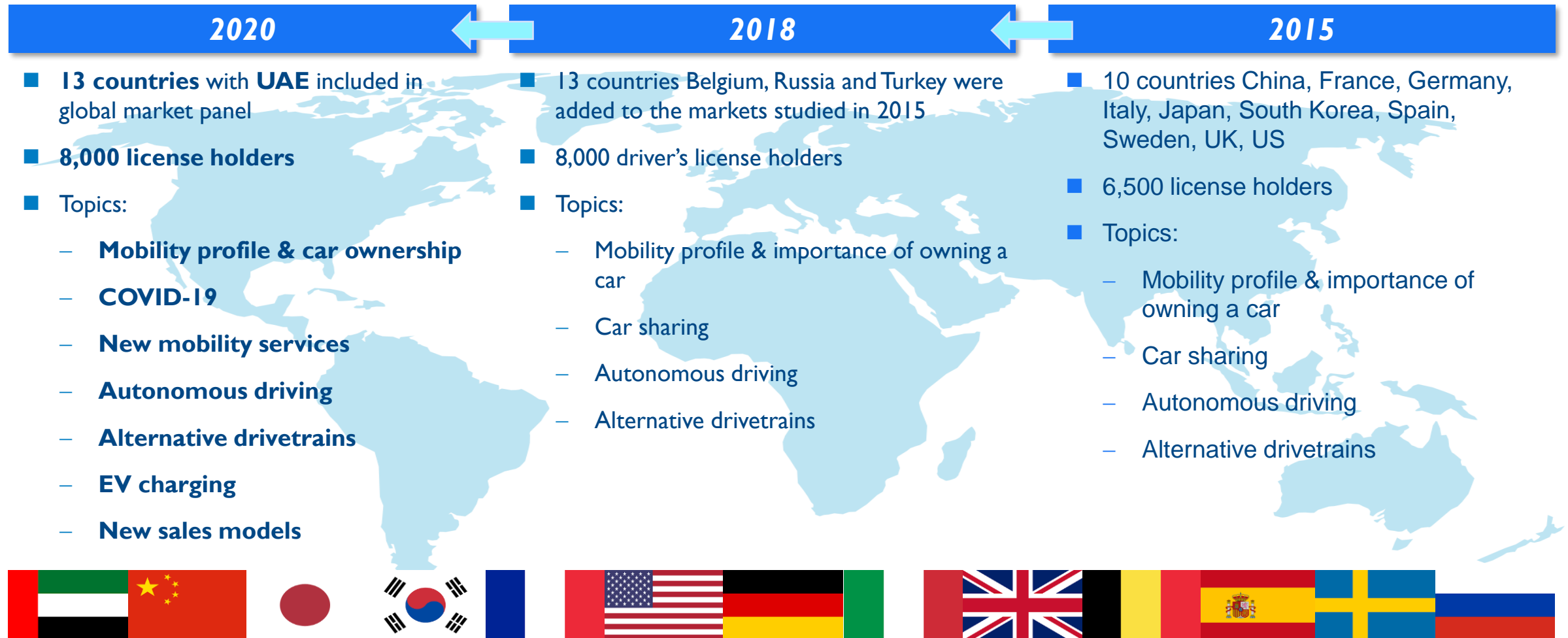


ARTHUR D LITTLE

The future of automotive mobility is driven by mega trends, customer preferences and actions of the players – Today we focus on the customers but touching all



In 2021 with the third release of the Arthur D. Little Global Automotive Mobility Study, we have again found several patterns beyond common belief in industry

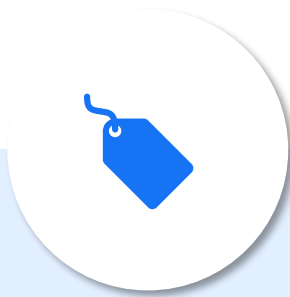
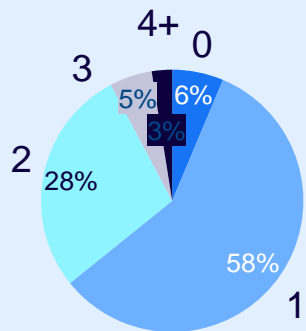


Source: Arthur D. Little Global Automotive Study

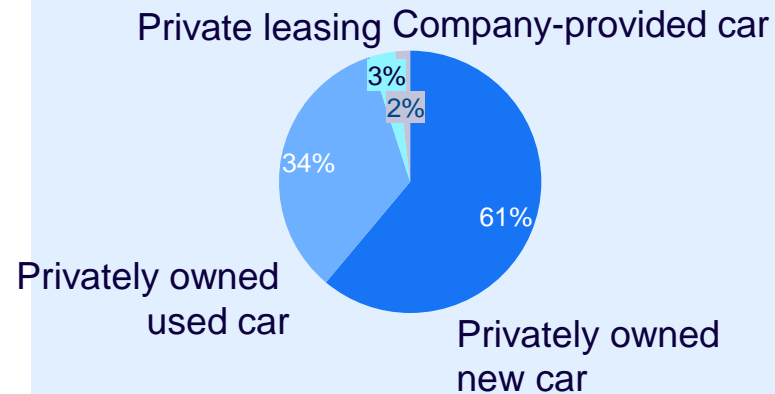
The study analyzes trends, attitudes and preferences relevant for the future automotive mobility mainly from a car user's perspective



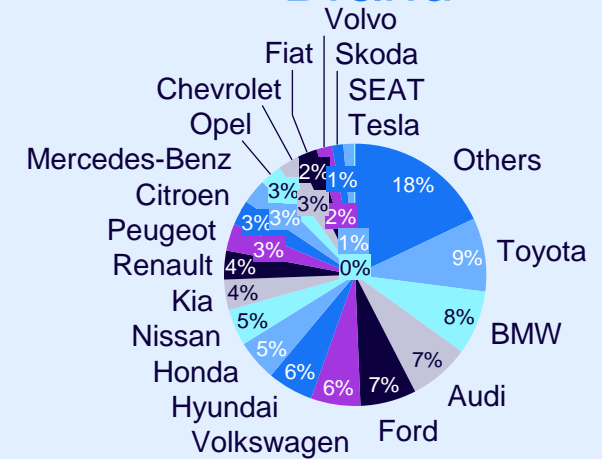
Cars in Household



Type



Brand



Source: Arthur D. Little, shares / numbers not weighted by market size, actual share of global sample

AGENDA

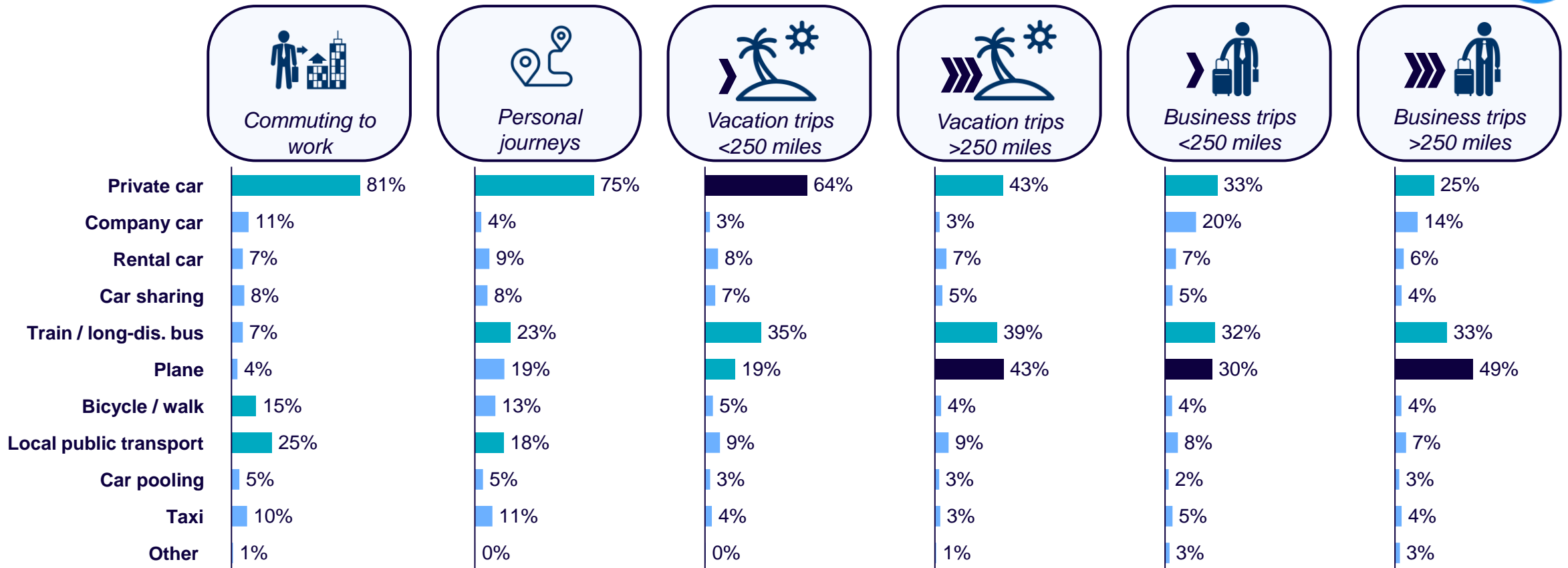
- 1 Initial situation: Mobility patterns today
- 2 Autonomous driving and robo taxis
- 3 Alternative drive trains
- 4 Conclusion

INITIAL SITUATION: MOBILITY PATTERN TODAY

Automotive mobility is dominant today especially for commuting in and around cities which is the prior reason for journeys

Please indicate which mode(s) of transportation you typically use for...

% of respondents; Multiple Choice

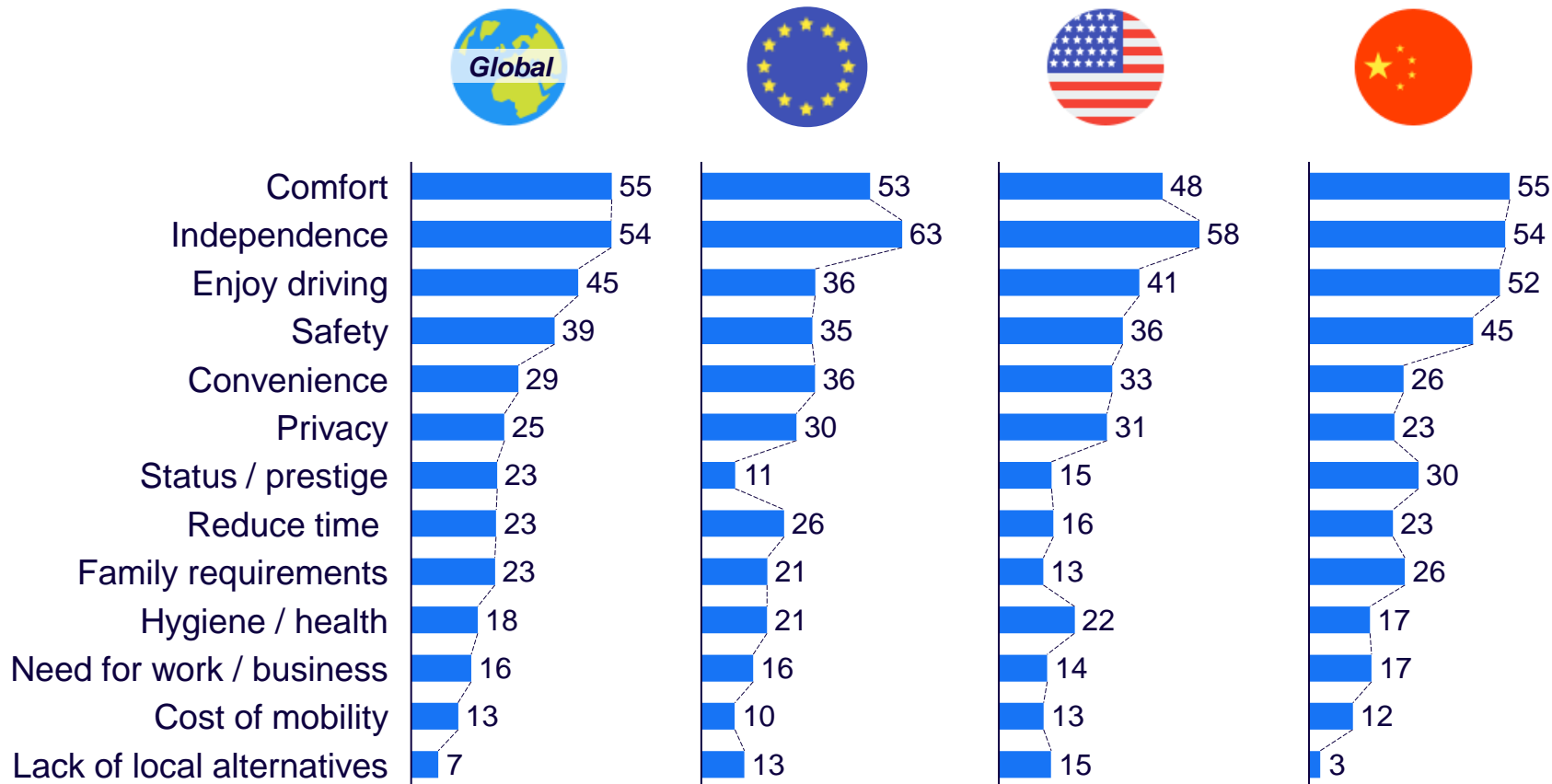


Source: Arthur D. Little analysis
 Note: Values weighted by population

Comfort, independence, fun and convenience are major reasons for owning and using cars

Reasons to possess (own or exclusively use) a car

% of respondents; Multiple Choice



Source: Arthur D. Little analysis

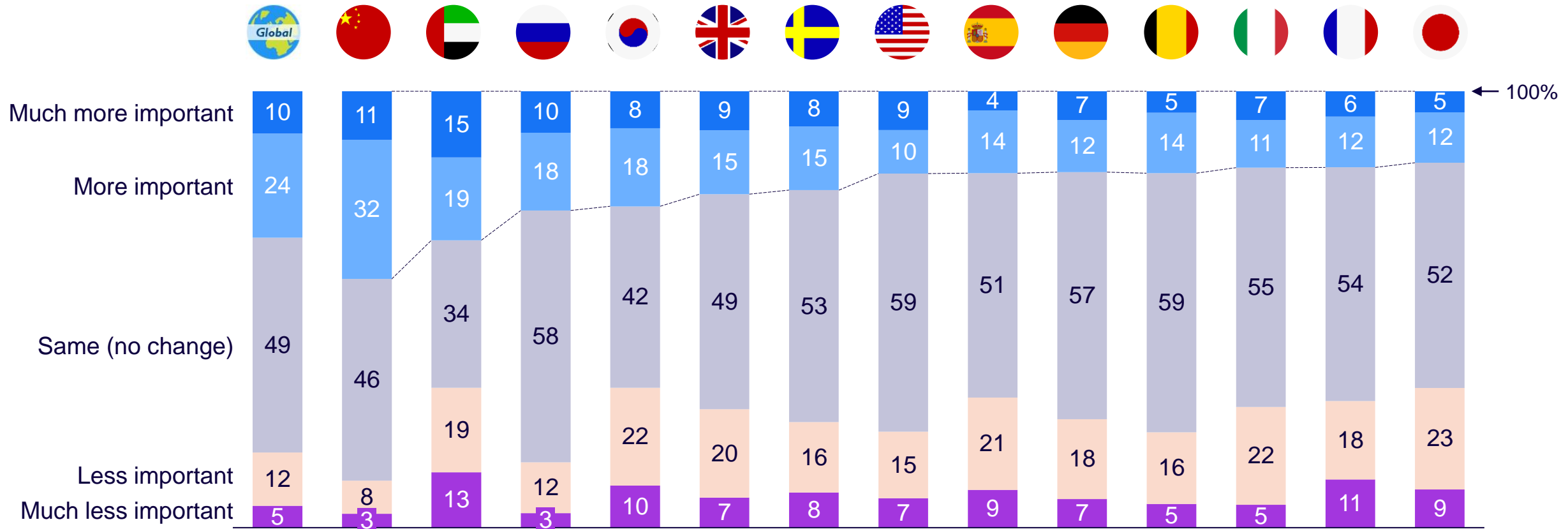
Note: Global and European values weighted by population of markets included

- **Similar motivational patterns** for **car ownership** across all major markets – with few significant **regional variations**
- **Independence, comfort and joy of driving** are broadly recognized as **main reasons** to possess a car across all major regions
- **Prestige** of possessing a car is significantly **more important in China** than in USA and Europe
- **Privacy** of own car appears to be **more relevant to US and EU** consumers than to Chinese drivers

People expect the car to get even more important in future

Do you expect that in 10 years, possessing a car will be as important to you as it is today?

% of respondents; Single Choice

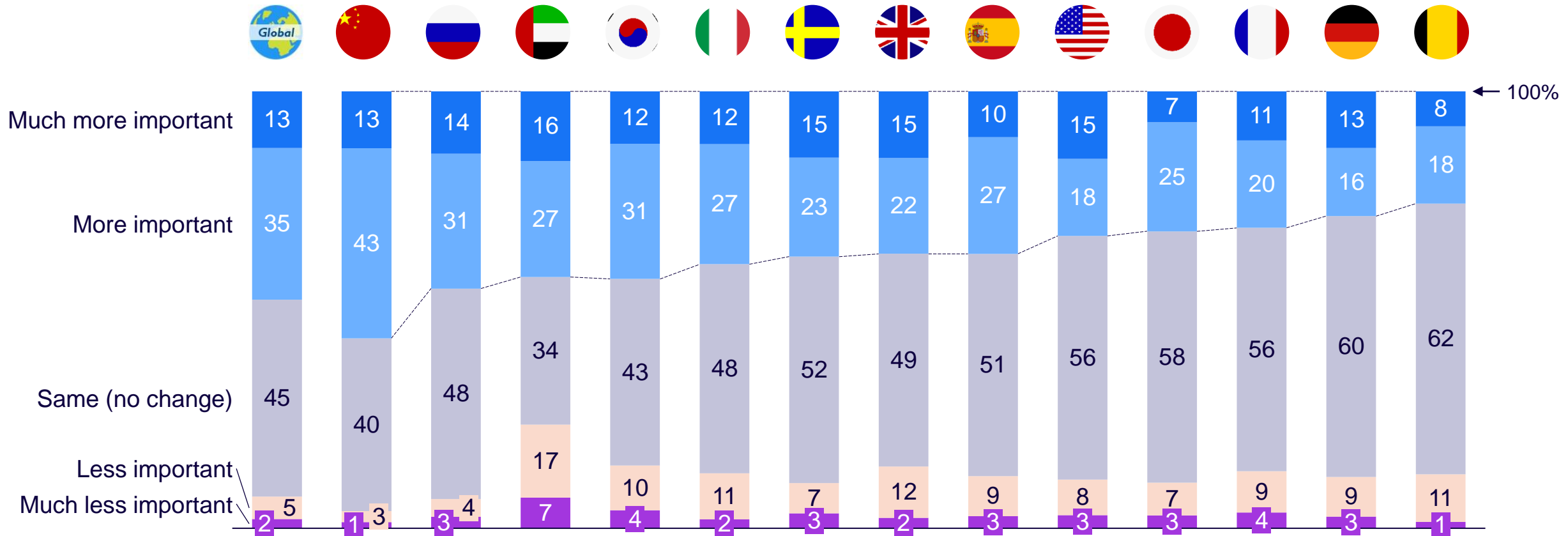


Source: Arthur D. Little analysis
 Note: Global average weighted by population

Covid seems to have an effect on the growing importance of cars for mobility customers

How does the current Covid-19 crisis affect your opinion on the importance of having a car?

% of respondents; Single Choice

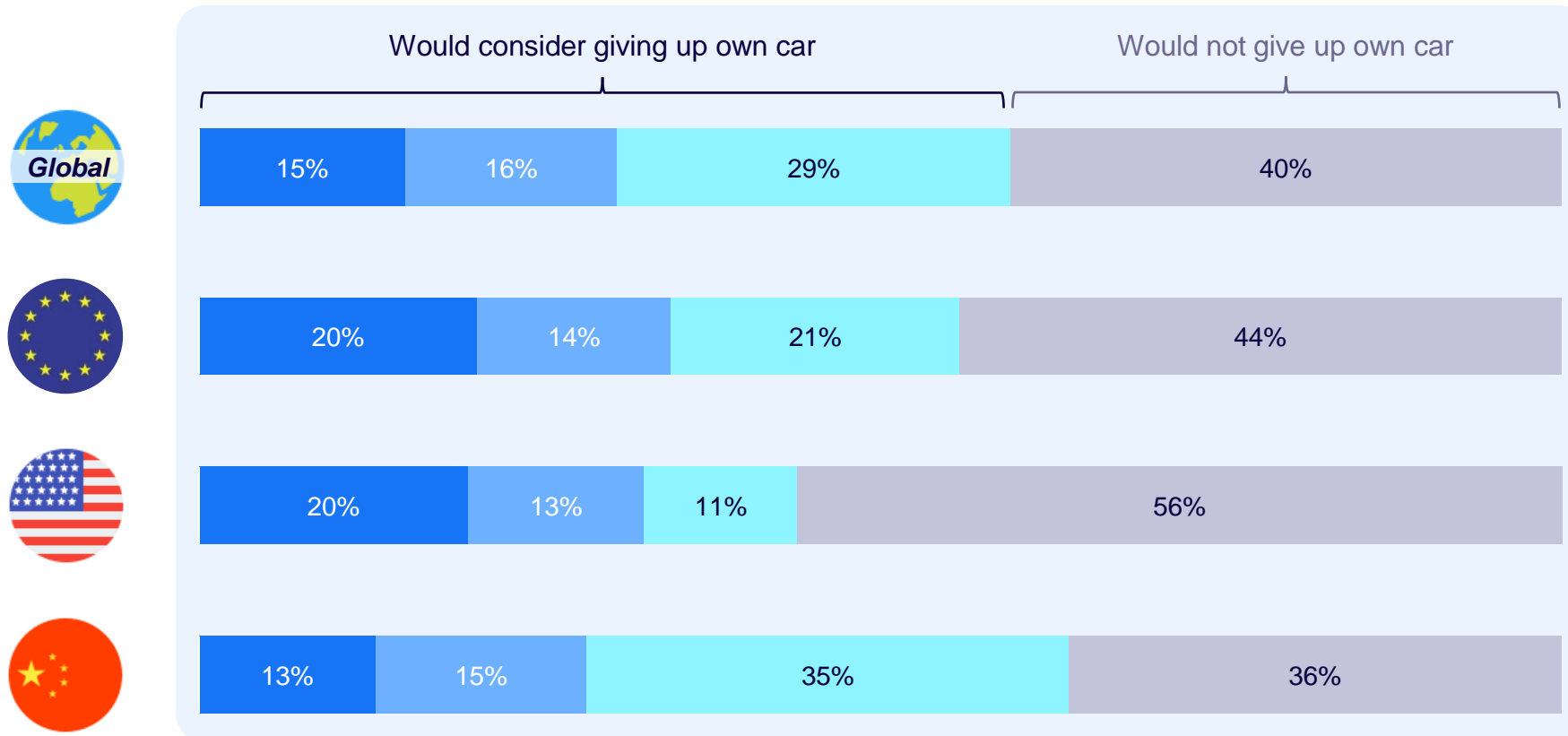


Source: Arthur D. Little analysis
Note: Global average weighted by population

Despite the importance of owning a car, a third of all respondents are ready to give up their car for new mobility services if they match their need

Given the new mobility services that are available today, would you consider giving up your own car?

Single Choice



- **60% of respondents** would consider giving up one own car for new mobility services
- Most **persistent car relationships in the US** with **>50%** of respondents unwilling to release their car

Source: Arthur D. Little analysis

Note: Global and European values weighted by population of markets included

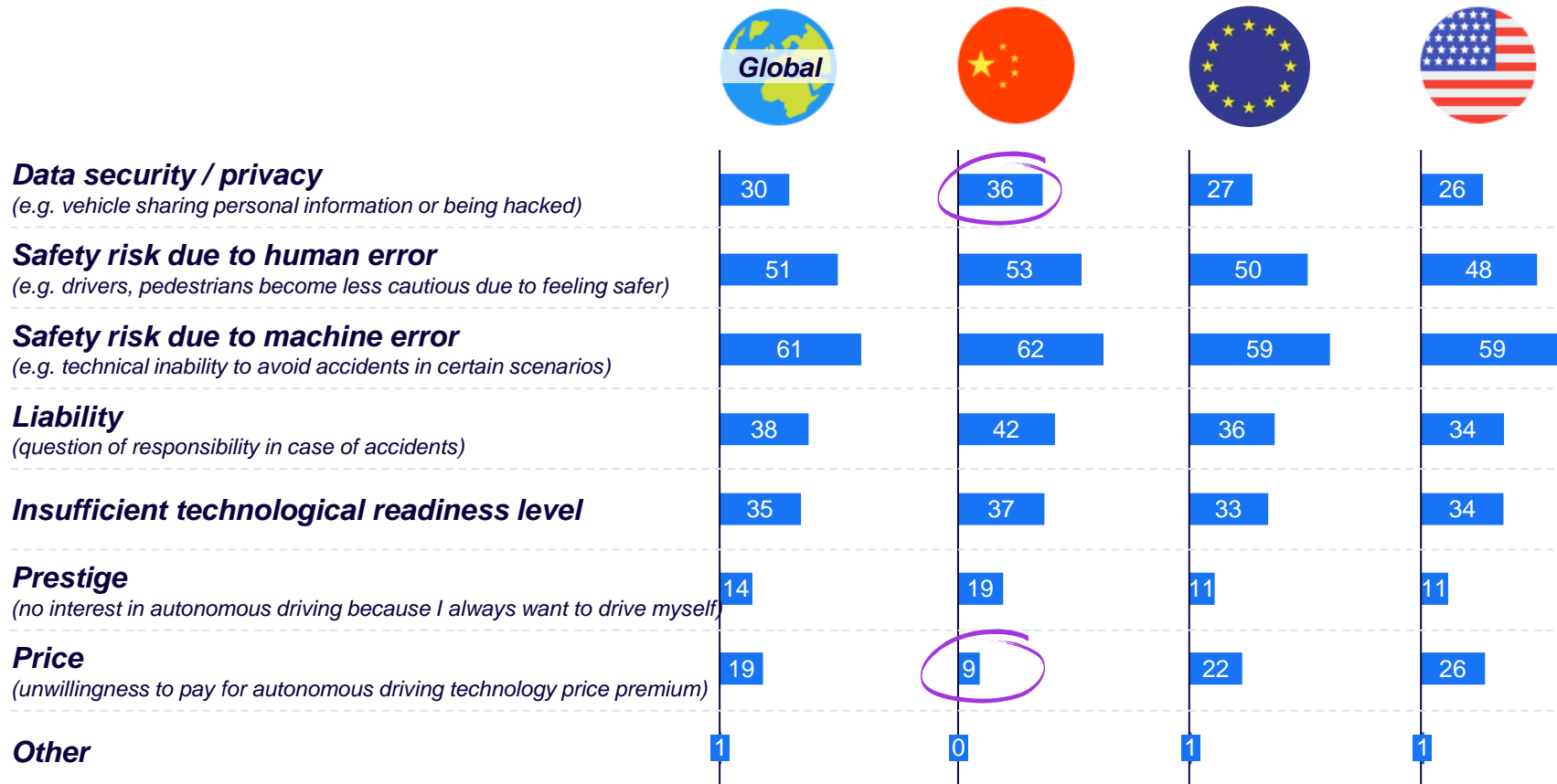
■ Yes, for all cars in my household ■ No
■ Yes, for secondary car - but will keep primary car
■ Perhaps

AUTONOMOUS DRIVING AND ROBO TAXIS

Respondents across all regions are currently most concerned about the safety of autonomous vehicles

What are your concerns regarding autonomous driving?

Multiple choice, hypothetical in %



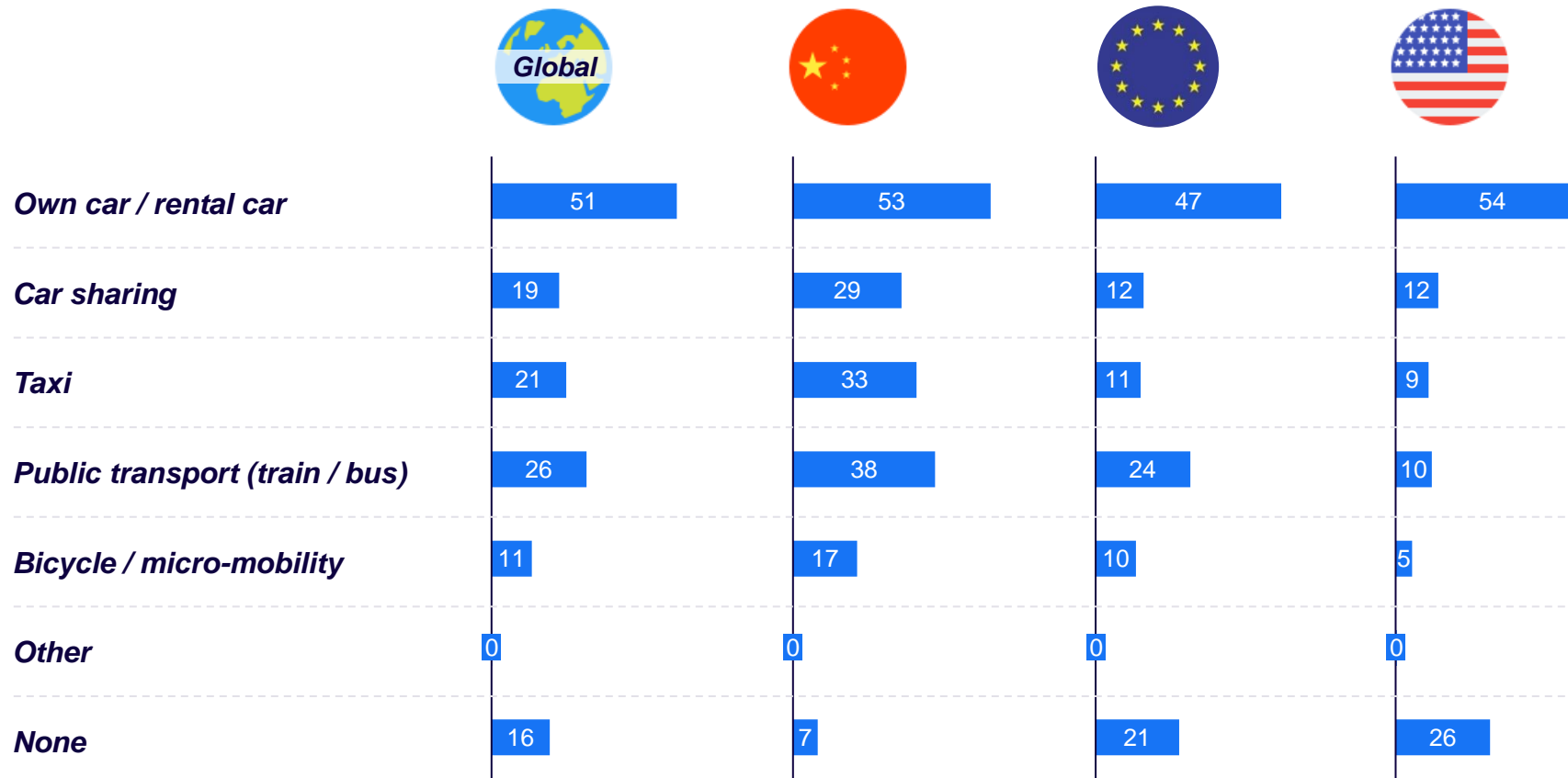
- Respondents across all regions are **most concerned about safety risks** implicated with AD (>50%) – trend could be an implication of latest accident news
- **Price is not a significant criteria in China** (9% only), whereas it is especially **important in Europe and US**
- Interestingly, **Chinese respondents are most concerned about security of their private and personal data**
- In general very **homogenous results across all regions**

Source: Arthur D. Little analysis
 Note: Global and European values weighted by car sales of markets included

If available, robo taxis will replace various short-distance transport modes – own vehicles and public transport are most threatened to be substituted

For short journeys (< 20 minutes travel time), if you would use a semi / fully AV, which form(s) of transport would it typically replace?

Multiple choice, hypothetical in %



- **Homogenous results** across regions for replacement of **own car** – roughly half of the respondents from EU, US, and China would replace their own car with AV
- More than a third of respondents in China would **replace taxi and public transport by AV**
- Besides own car replacement, **public transport** is currently the most “threatened” transport form, especially in China and Europe
- Except own cars, **US** respondents show **low willingness** to replace any other transport form

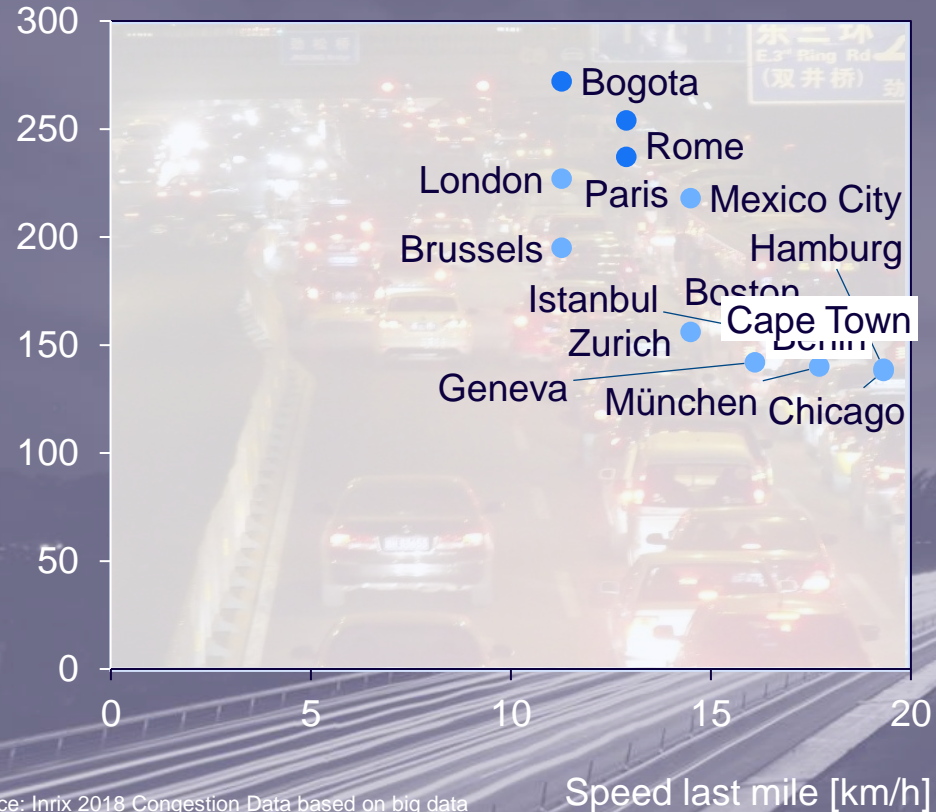
Source: Arthur D. Little analysis

Note: Global and European values weighted by car sales of markets included

But congestion is already hindering car use today – Will future automotive mobility be blocked by congestion?

Congestion levels in selected cities

Hours per year spent in congestion



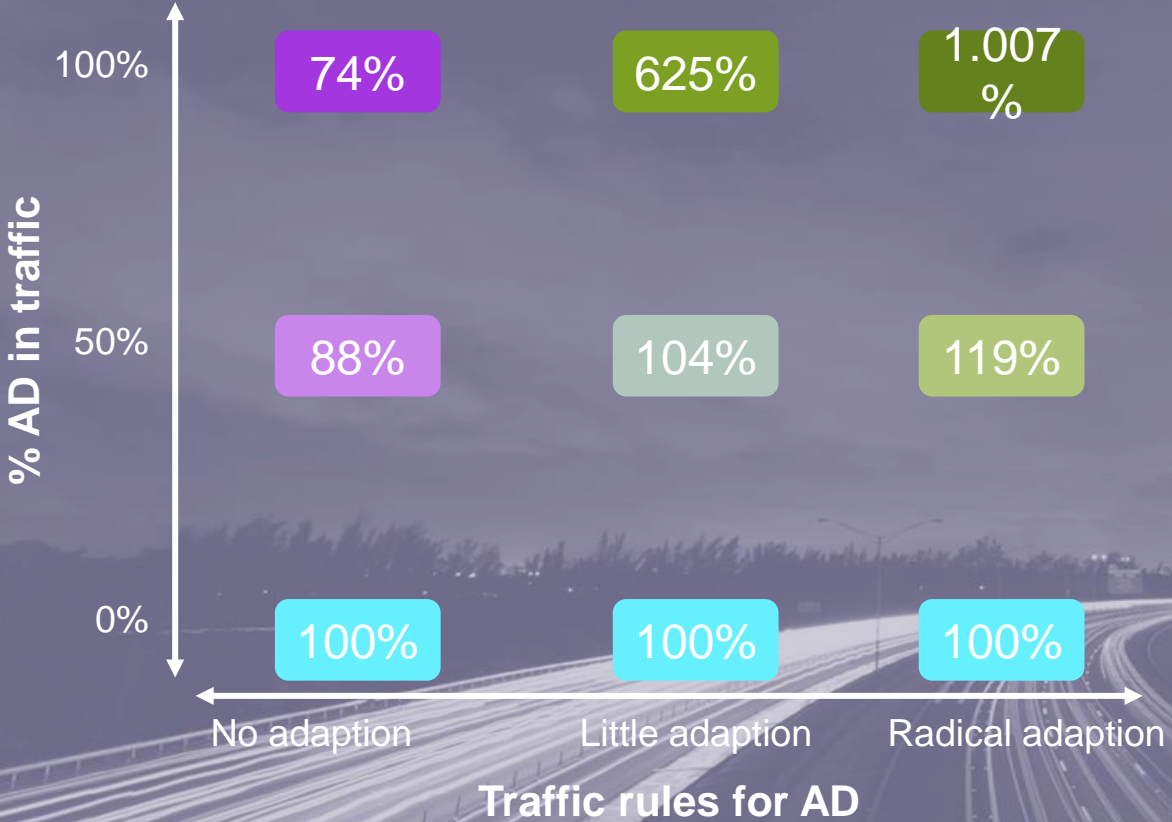
Source: Inrix 2018 Congestion Data based on big data

Regulative counter measures

-  Congestion charge
-  Number plate restrictions
-  Parking space restrictions
-  Road diets and closures
-  ...

In mixed robo-human traffic capacity will decrease – but with 100% AD and optimized rule adaption capacity factor can be as high as 5-10

ADL micro simulation of real world intersection

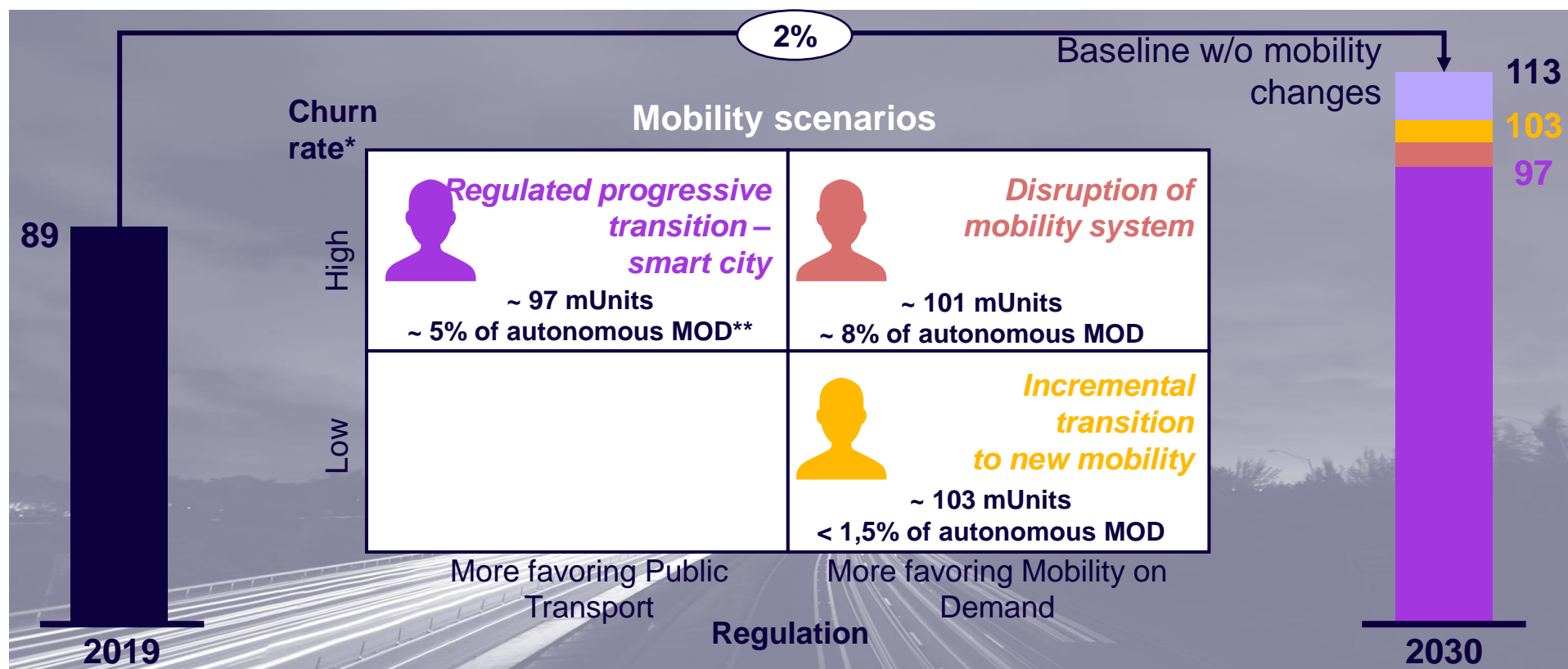


- Without radical regulation AD will decrease street capacity
- Which society will be ready to pay the price for congestions-free traffic?

Source: Arthur D. Little

If cities really migrated to robo taxis, there will be an impact on car sales – How drastic depends on regulation: Will Public Transport users be allowed to partly migrate?

Impact of robo taxis on car sales

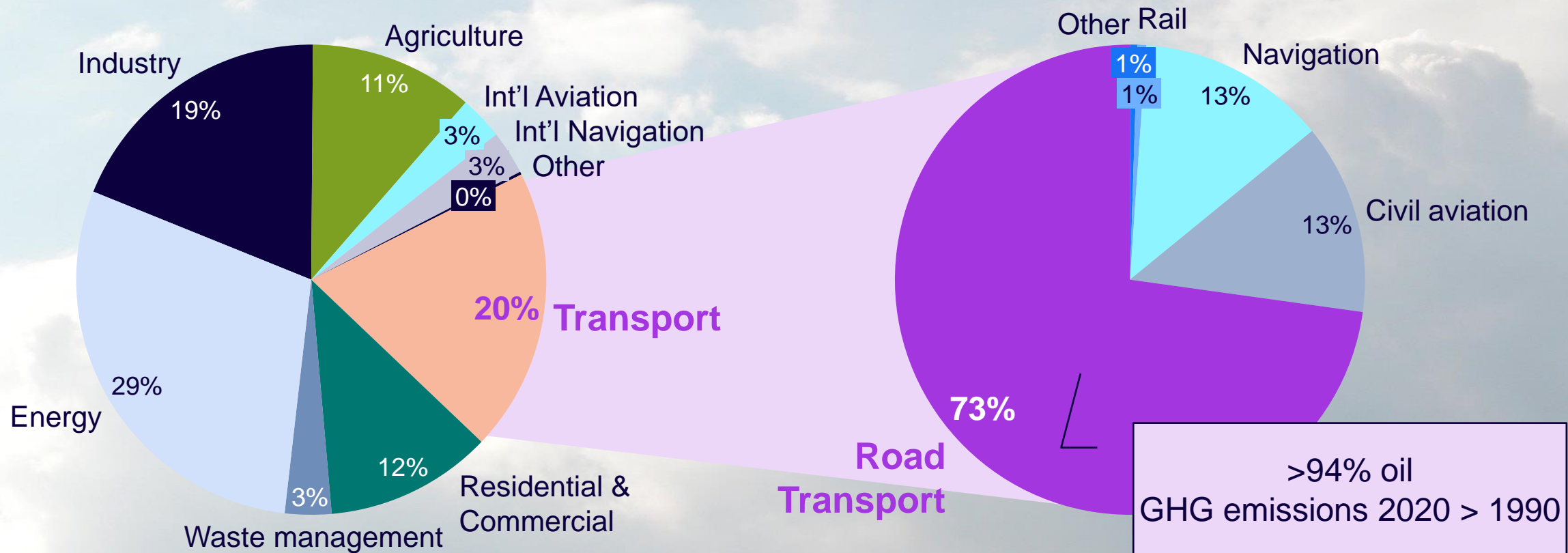


* from traditional vehicles to autonomous, shared mobility models; ** MOD = Mobility on Demand
Source: Arthur D. Little analyses

ALTERNATIVE DRIVETRAINS

Transport sector plays an important role for CO2 reduction goals – But it is the only sector with still higher emissions than 1990 and is still highly relying on oil

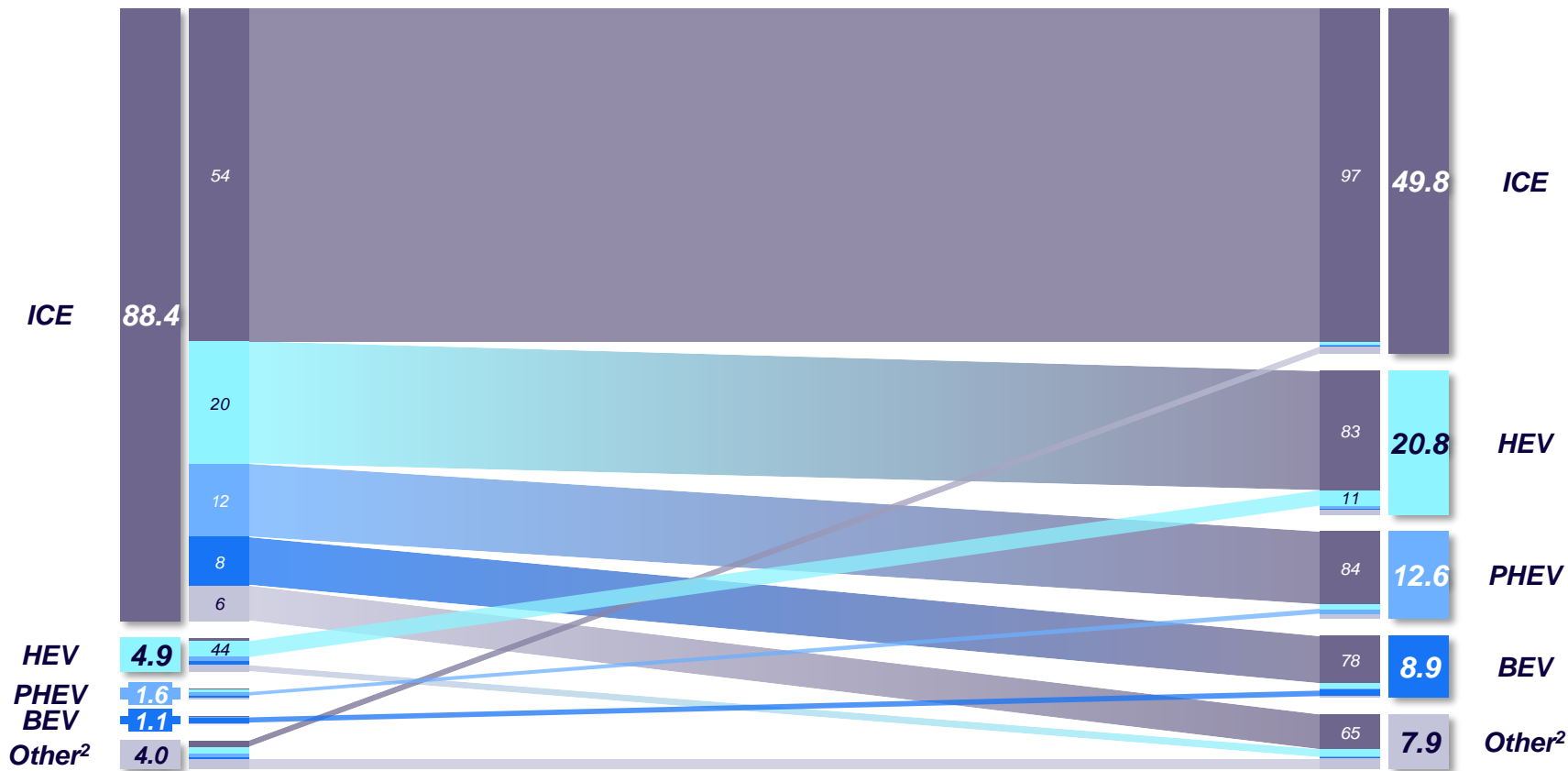
Sectoral GHG emissions from transport by mode



There is a clear accelerating trend towards BEV but with still a lot of support for ICE or hybrid

Replacement trend, based on respondents' likely drivetrain selection for next car

In %, EU + UK ¹



- Although traditional drivetrains will remain important for the foreseeable future, **46% of European ICE owners say they are likely to choose an alternative drivetrain** when replacing their car
- Among ICE drivers, few are willing to go fully electric – **hybrids are at a clear advantage**
- Drivers of **fully electric** vehicles are most satisfied – nearly **73% say they would choose a BEV again**
- **Other drivetrains** such as H2 or natural gas, **remain peripheral** in the view of customers

Source: Arthur D. Little analysis

Notes: 1) Weighted according to car sales; 2) Other includes natural gas & hydrogen

Price, charging and range are the most discouraging factors to go BEV

BEVs – discouraging factors

In %, by market (global ranking)

Relative importance (rank)

EU¹

USA

China

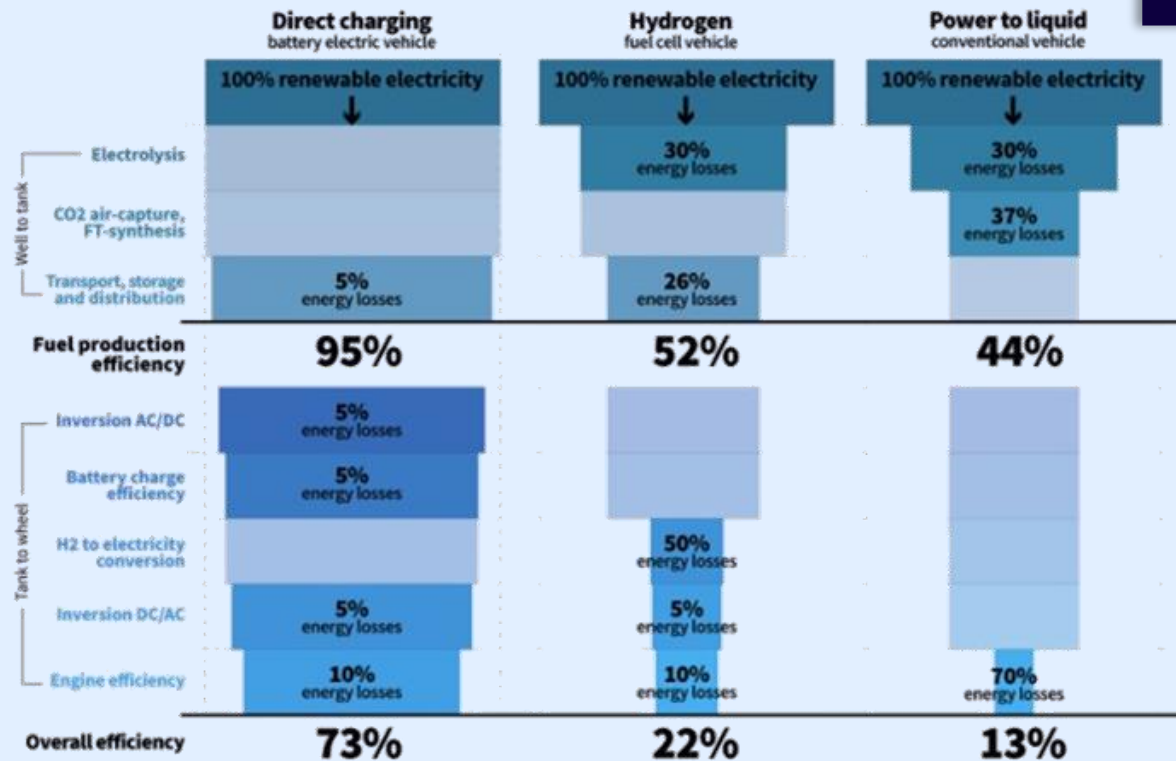
	1	2	3	4	5	6	Outside top-6
1 Limited battery life	50.9 %	45.1 %		41.2 %			
2 Charging takes too long		43.7 %	44.0 %	38.5 %			
3 Limited operating range		49.8 %	42.3 % 43.4 %				
4 Lack of charging possibilities <u>when travelling</u>				38.4 %	27.1 %	31.8 %	
5 Lack of charging possibilities <u>at home</u>					34.3 % 34.9 %	25.0 %	
6 Price	62.5 % 56.8 %						14.6 %

Source: Arthur D. Little analysis; Notes: 1) Weighted according to car sales; 2) Other includes natural gas & hydrogen

Strong opponents of hydrogen argue with the bad efficiency, which is especially misleading if you go green energy: Where to get the electric power from when needed where needed?

Common perspective on BEV vs FC efficiency

Cars: Battery electric most efficient by far

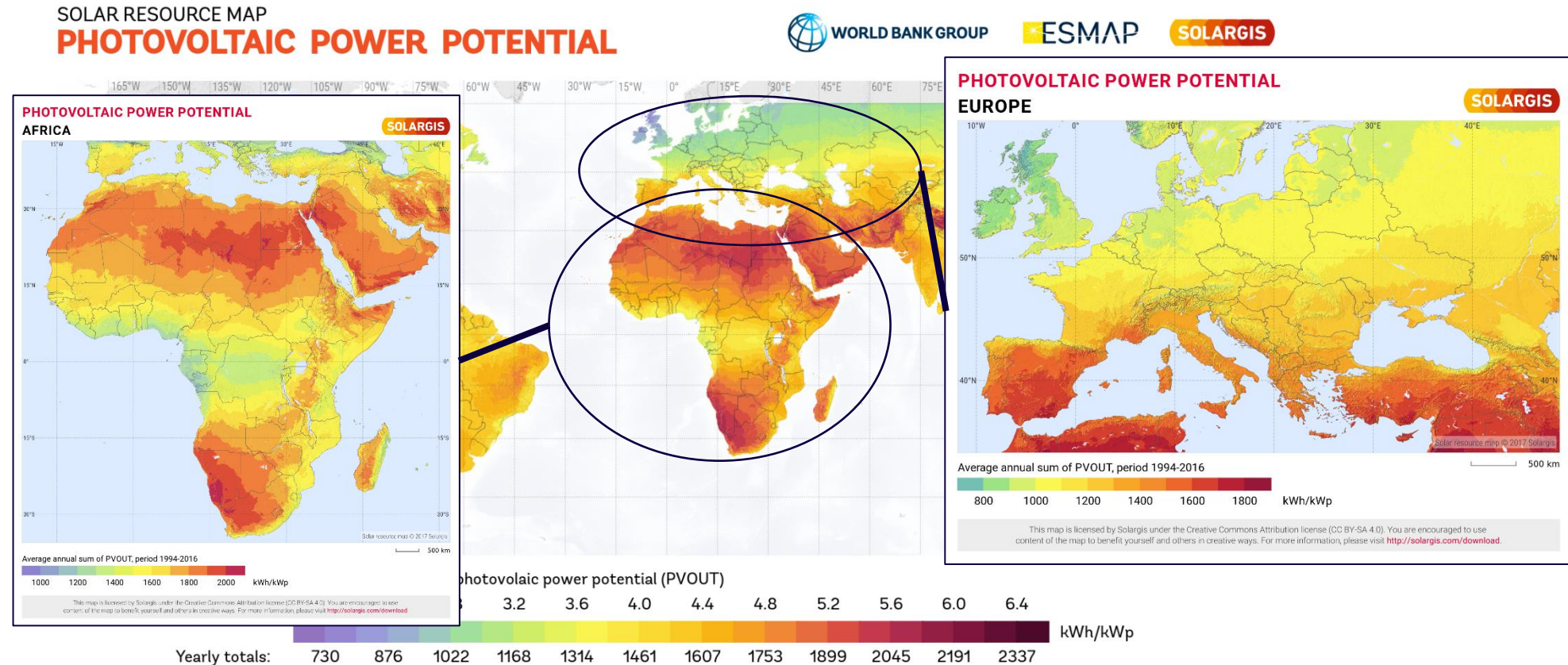


„Fuel cells = fool sells“
„Staggeringly dumb“



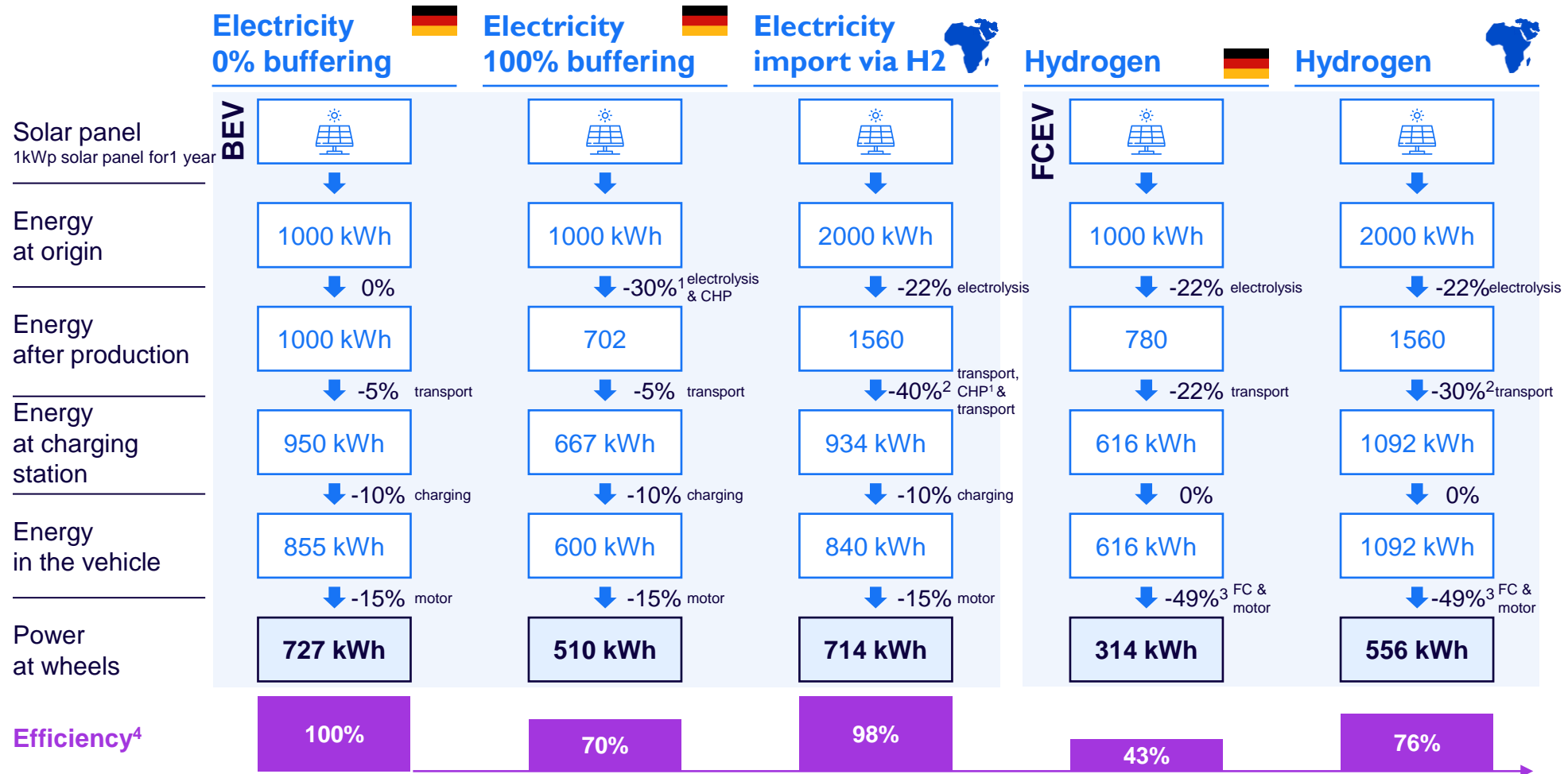
(Elon Musk about FCEV)

Europe is not a favorable location to produce green energy like by solar – The yield in top locations is easily double allowing for transport and buffering so it is there when needed



Source: SOLARGIS

Example calculation: The proposed efficiency gap closes with renewable generation in global top locations like Africa

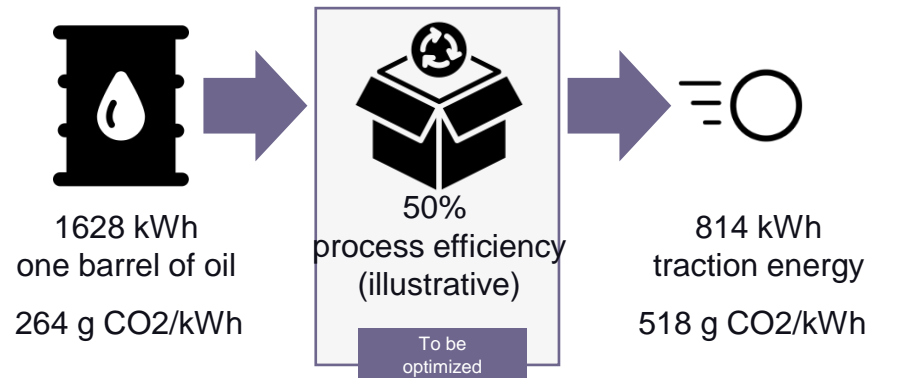


1) 78% electrolysis and 90% CHP efficiency, assuming that heat is utilized and counted as efficient and not lost
 2) Long range transport of hydrogen highly uncertain, here assumed with 10% loss for hydrogenation and dehydrogenation via MCH, so far only shown in experiments (Popov et al 2016)

(<https://www.ingaa.org/file.aspx?id=10929>)
 3) 60% efficiency of fuel cell and 15% efficiency loss of DC/AC inversion and motor
 4) Compared to base case no buffering Germany

When moving from fossils to renewables the understanding of efficiency must change. One needs to start with the yield and not a barrel - and it is CO2 free anyhow

Efficiency with fossil fuels

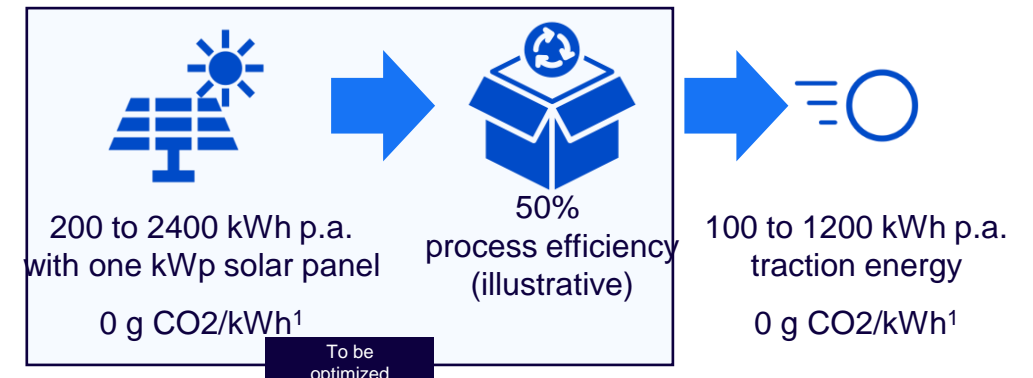


- The input is fossil oil; thus, efficiency is defined as ratio between input of oil and traction energy
- With an increase in efficiency, CO₂ emissions reduce, and finite oil resources get conserved
- Efficiency is directly linked to energy costs



Efficiency is crucial and linked to the process with direct CO₂ impact

Efficiency with renewables



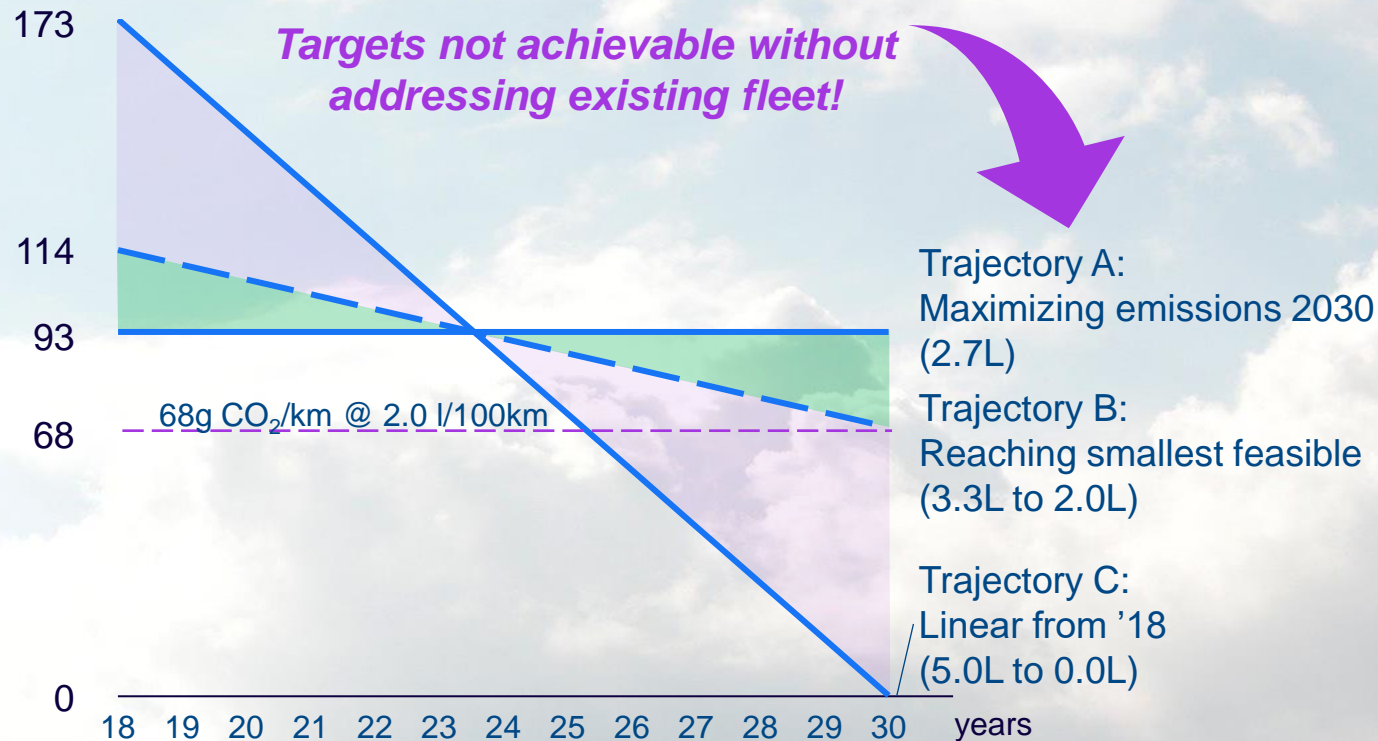
- Renewable energy is collected from renewable resources and is carbon-free replenished; thus, input are collection resources
- Efficiency is either increased by higher yield of the collection resource or a better process; in any case CO₂ is not emitted
- Cost are more linked to renewable energy collection and processing, and less to the efficiency of energy use



Efficiency is less important and is linked to the renewable collecting resources with no CO₂ impact

Hydrogen is needed yet for another reason: To achieve EU Paris goals 2030, the existing fleet needs to decarbonize and thus H2 based reFuels are needed

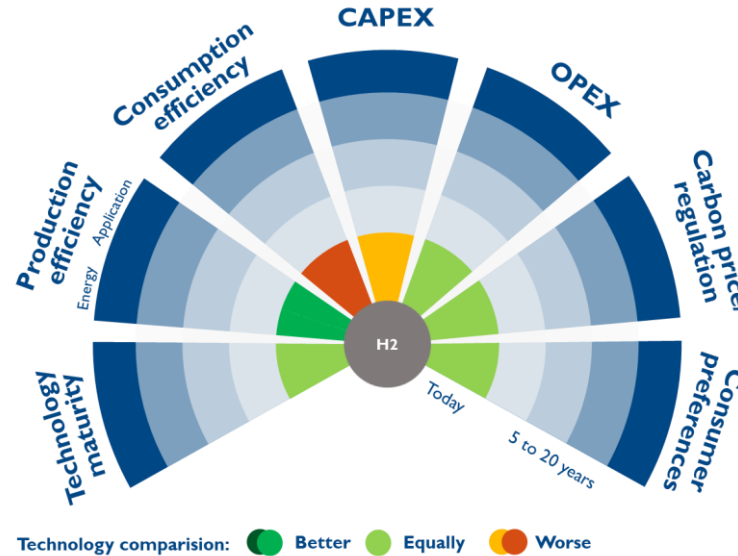
g CO₂/km (real ICE consumption)



- Trajectories show *average emission of car sales* each year to reach Paris-based EU 2030 CO₂ emission targets
- Trajectory A shows avg. emissions of sales '18 to '30, which are needed to compensate for existing fleet and achieve the target of 97g
- Trajectory B calculates a theoretic starting point for '18 to go linear towards tech optimum
- Trajectory C shows avg. sales emissions, when reducing linearly from '18 down to zero
- *Without addressing the old fleet, even the older EU targets can't be met*

H2 and eFuels will be a win-win for the climate and industry

Holistic assessment model



Science based approach

Goal for stopping Climate change

55% CO2 reduction 2030 to 1990 (all sectors)

- Existing fleet partially CO2-free with green e-fuels
 - Open technology mix for sales fleet operated by green energy
- +
- Industrial production incl. cells with green energy (H2-based)
 - Sustainable use of resources

Economic wealth

Sustained industrial value generation in Europe

- Smooth not disruptive powertrain transition (eFuels, H2ICE, ...) while going consequently zero emission and leading edge
- +
- Industrial production incl. cells, electrolyzers, carrier ships, fuel cell systems and vehicles kept in Europe and leading edge

CONCLUSIONS FOR IMPULSE

The future of mobility will need to be sustainable beyond green only – Will it be an automotive mobility and what does it mean for the car industry?



Green

- Zero emission
- Customers are open, the more practical the better
- To really meet climate goals in Europe green H2 is needed



Safe

- (Near) Zero fatalities will be possible by autonomous driving
- When will it come?



Smooth

- No congestion, space for e.g. pedestrians
- Will cities use the potential of AD and go 100% AD and robo taxi?
- Or continue to go away from cars?



Affordable & reliable

- Affordable mobility for the masses
- Today by subsidies for Public Transport (PT)
- Robo taxis have the potential for cheap and reliable transport

Currently it rather seems that due to electrification and sustainability industrial value shrinks at OEMs and suppliers – But there is another option

- Going **green** is **mandatory** and BEVs increasingly accepted by customers
- To really meet climate goals the **existing fleets** needs to be addressed be refuels based on **global green H2**
 - When green H2 is available, H2 FuellCell cars and eFuel ICE are good solutions
 - Electrolyzers will become a great **industrial market** as well providing infrastructure
- Autonomous driving will be there (**sooner** or later) and be a real game change for mobility
- AD will enable robo taxis and can avoid congestions if applied 100% with optimized rules
 - It is important for the car industry to **win the AD battle**
 - Cars can be an **ideal sustainable mobility solution** for the future if we allow so

ARTHUR  LITTLE

THANK YOU

Arthur D. Little has been at the forefront of innovation since 1886. We are an acknowledged thought leader in linking strategy, innovation and transformation in technology-intensive and converging industries. We navigate our clients through changing business ecosystems to uncover new growth opportunities. We enable our clients to build innovation capabilities and transform their organizations.

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Contact

Dr. Klaus Schmitz
Partner

schmitz.klaus@adlittle.com
+49 175580629

Nymphenburger Str. 4
80335 München
Germany