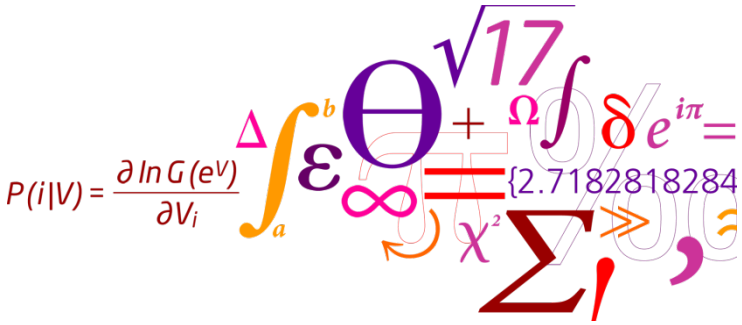
Future mobility

- Challenges of driverless vehicles and shared economy

Otto Anker Nielsen
Professor
Head of Transport DTU



Transport Modelling
Department of Management Engineering

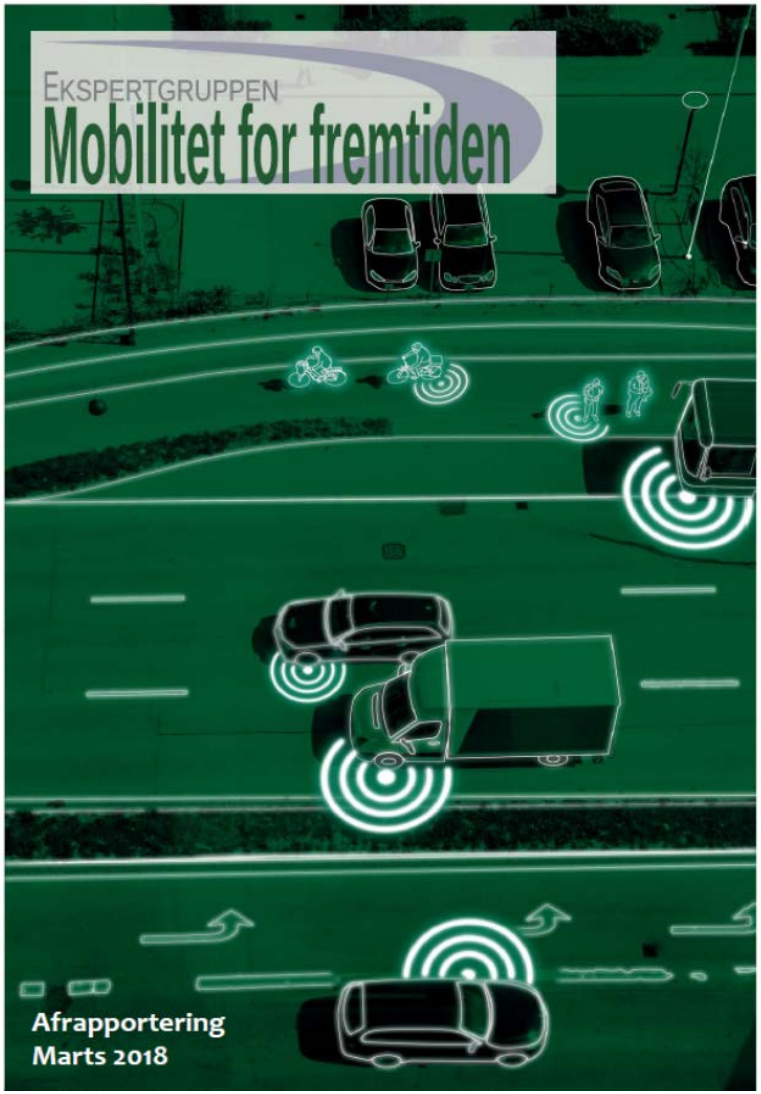
Danish transport minister expert group

Transport-, Bygnings- og Boligministeriet

Forside / Nyheder / 2017 / Ole Birk Olesen: Ny ekspertgruppe skal se på fremtidens transport

Ole Birk Olesen: Ny ekspertgruppe skal se på fremtidens transport

Transport-, bygnings- og boligminister Ole Birk Olesen (LA) nedsætter ny ekspertgruppe, s
skal komme med anbefalinger til, hvordan vi bliver klar til fremtidens transport.



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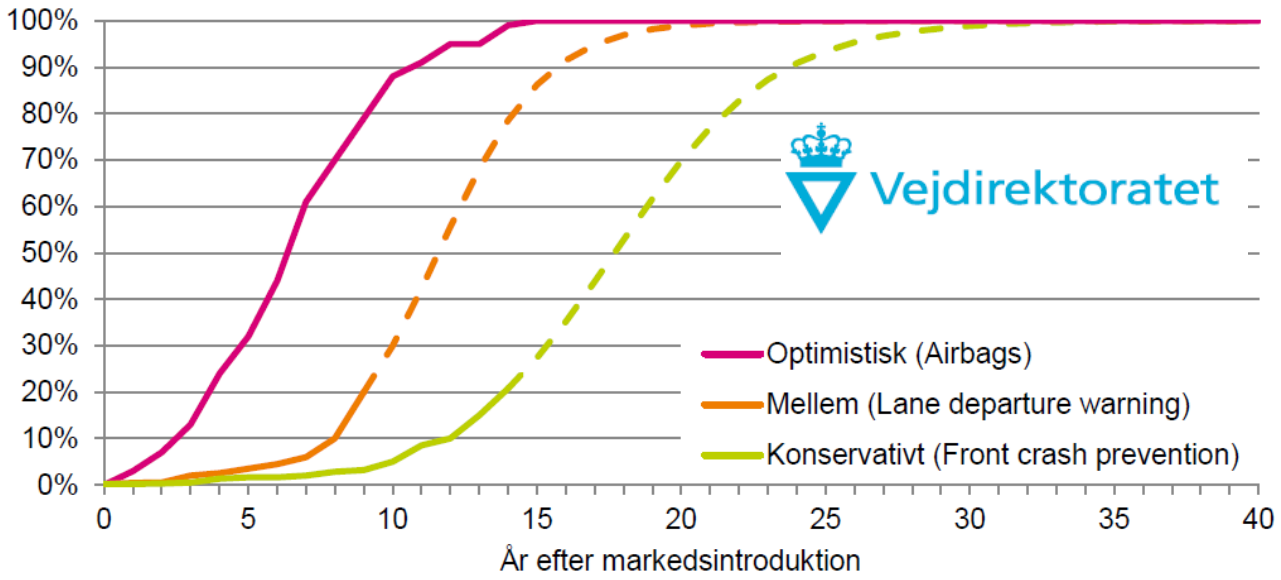
Timely concern

- Lifespan of decisions
  - Traffic contracts 7-12 years
  - Train rolling stock 20-30 years
  - Bridges/tunnels ~100 years
  - Railways/roads 100+ years
- Expected introduction of autonomous cars

Figur 6. Scenarier for indfasningen af automatiserede biler i MOTOBA



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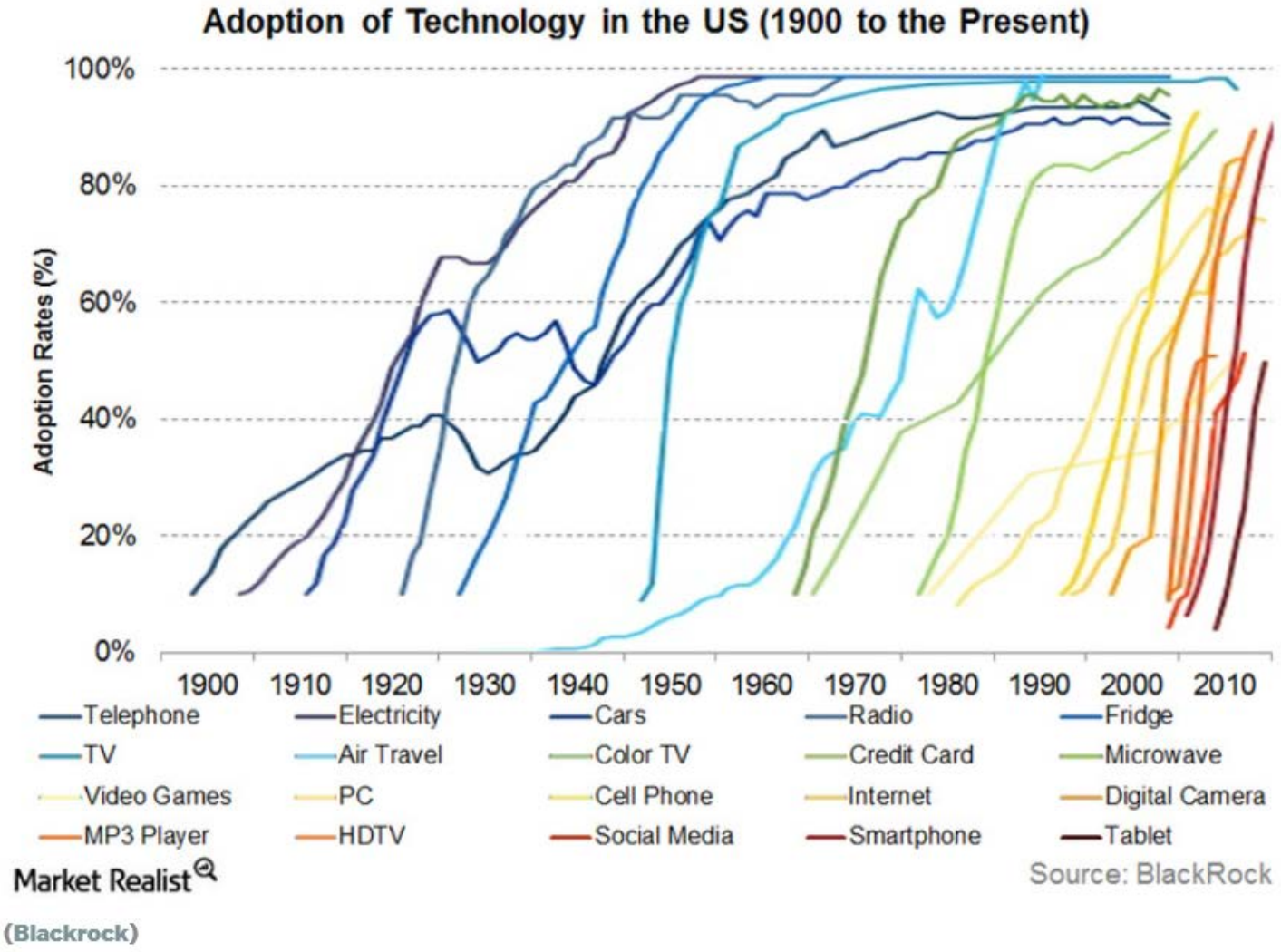
Adoption of new Technologies



https://www.vox.com/2016/3/4/11161758/electric-cars-oil-crisis

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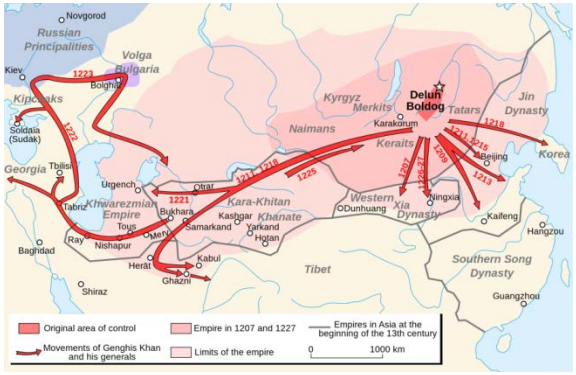
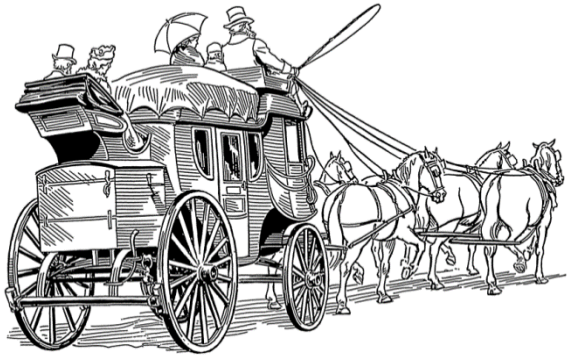
The first transport revolution

- Use of animals for transport
  - Gradually developed over thousands of years
  - Speed, distance, load





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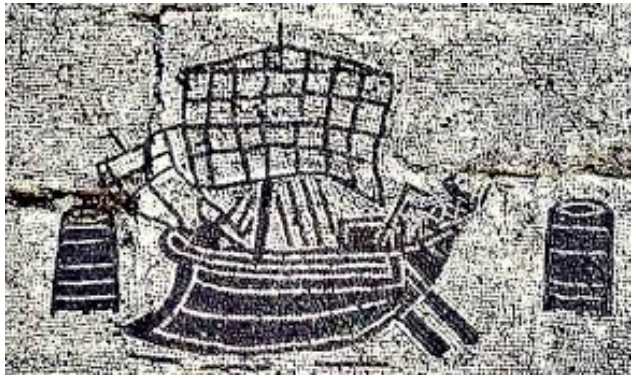
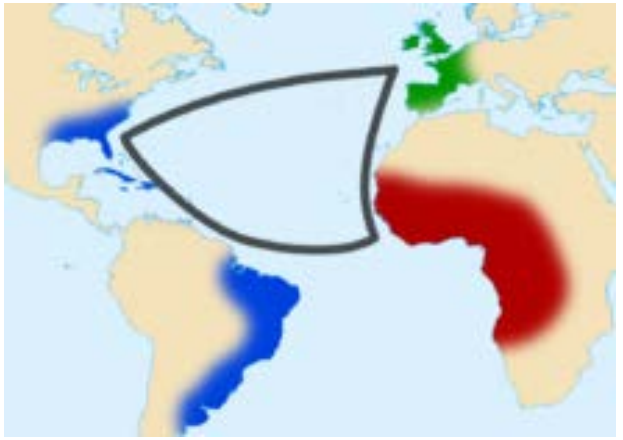
The second transport revolution

- Use of wind for sea transport
  - Gradually developed over thousands of years
  - Improved ship building technology and navigation





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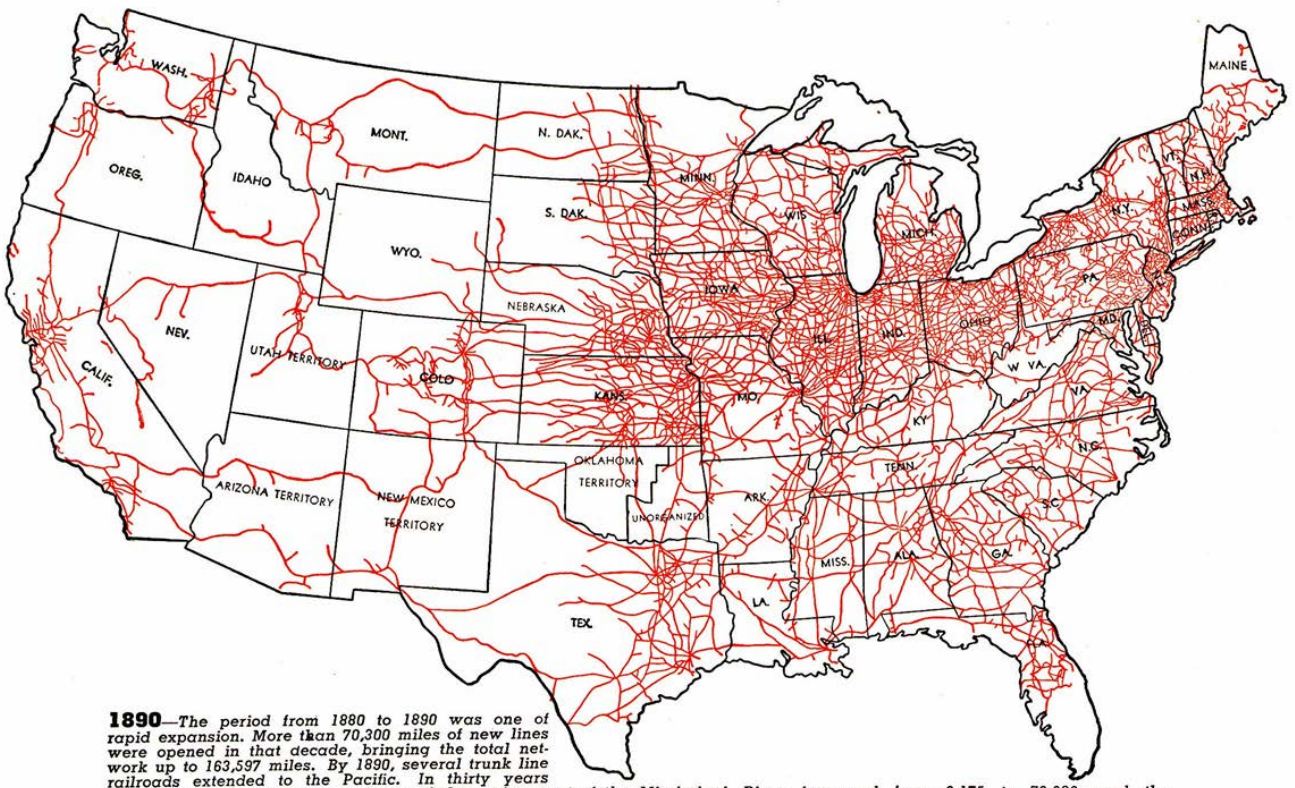
The third transport revolution

- Machines as power source
  - Fast technology development, US rail network development 1880-1890



1890—*The period from 1880 to 1890 was one of rapid expansion. More than 70,300 miles of new lines were opened in that decade, bringing the total network up to 163,597 miles. By 1890, several trunk line railroads extended to the Pacific. In thirty years from 1860 to 1890, the total mileage of the region west of the Mississippi River increased from 2,175 to 72,389, and the population of that area increased fourfold.*

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Easter morning 1900: 5th Ave, New York City. Spot the automobile.

http://www.businessinsider.com/5th-ave-1900-vs-1913-2011-3?r=US&IR=T&IR=T

Easter morning 1913: 5th Ave, New York City. Spot the horse.

Source: George Grantham Bain Collection.

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General transport options today

- Faster
- Larger volumes
- More reliable
- Cheaper (per unit)

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...but capacity problems in the transport networks

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Challenged urban transport infrastructure, space and land use

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The fourth transport revolution

- Digital age transportation with self driving Autonomous vehicles

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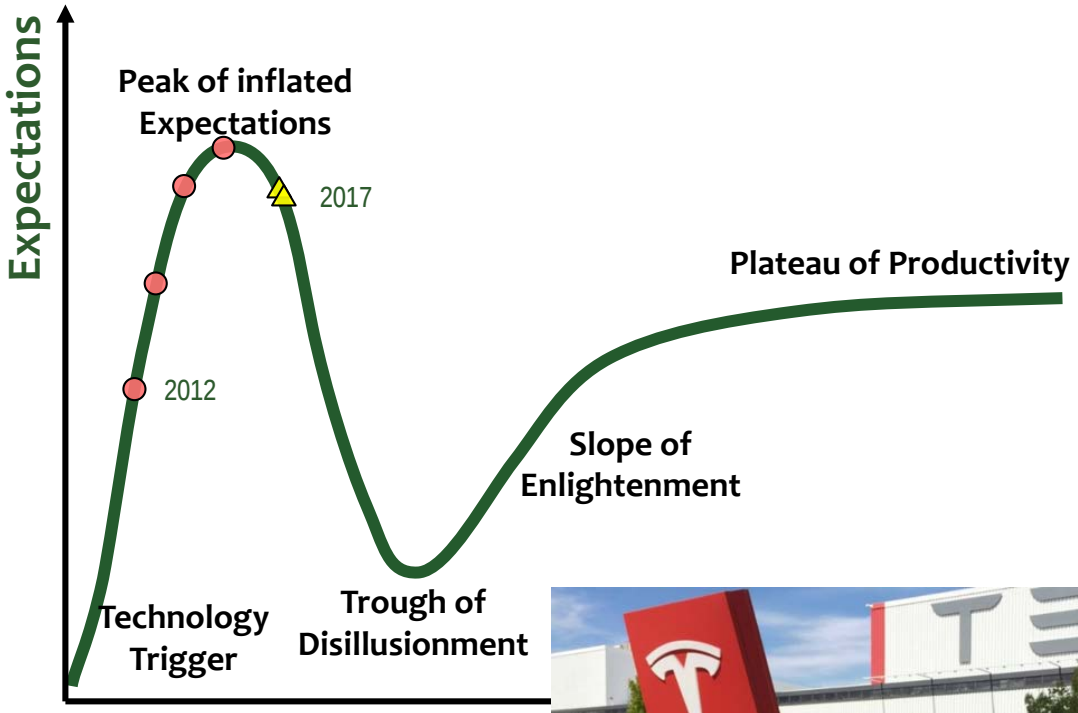
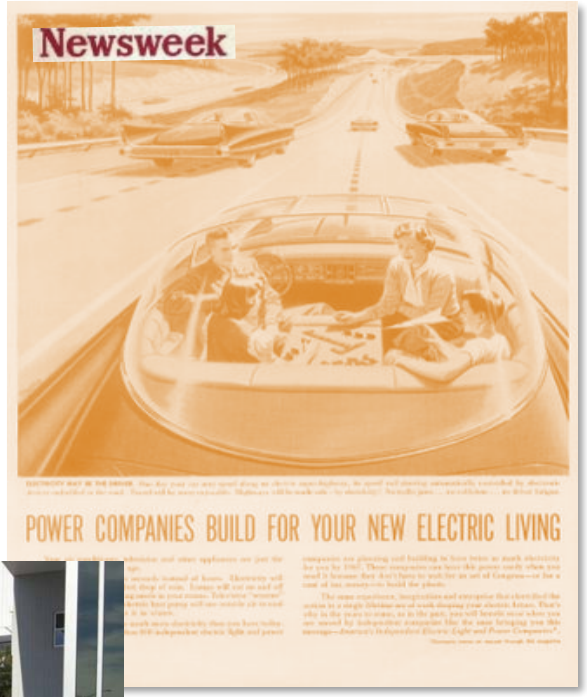
Gartner's Hype Cycle for emerging Technologies …





Newsweek, Dec-1956

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Past Visions of Future Transport

1949 ConvAIRCAR Flying Car

Segways

Jet Pack

2001 Moon Service

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Supersonic Concord (1976-2003)

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Technological trends in the fourth transport revolution

1. Electrification
2. Shared economy+ MaaS
3. Autonomous vehicles
4. Digitalisation and big data + the cloud/www

1 Electrification

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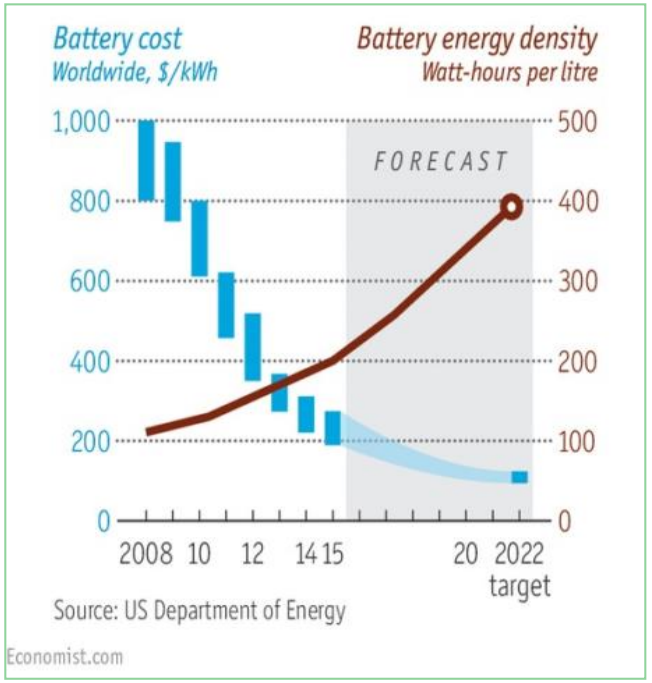
The climate agenda's consequences for the transport sector

- New passenger cars have to be CO2-free from approximately 2035 to reach the 2050-target for Denmark's CO2 emissions
- Economically competitive electric cars with sufficient range within 5-10 years
- Change to sustainable energy realistic – not a crucial barrier for future traffic growth
- Note though that electric cars are not CO2 free seen from a production and life-cycle perspective



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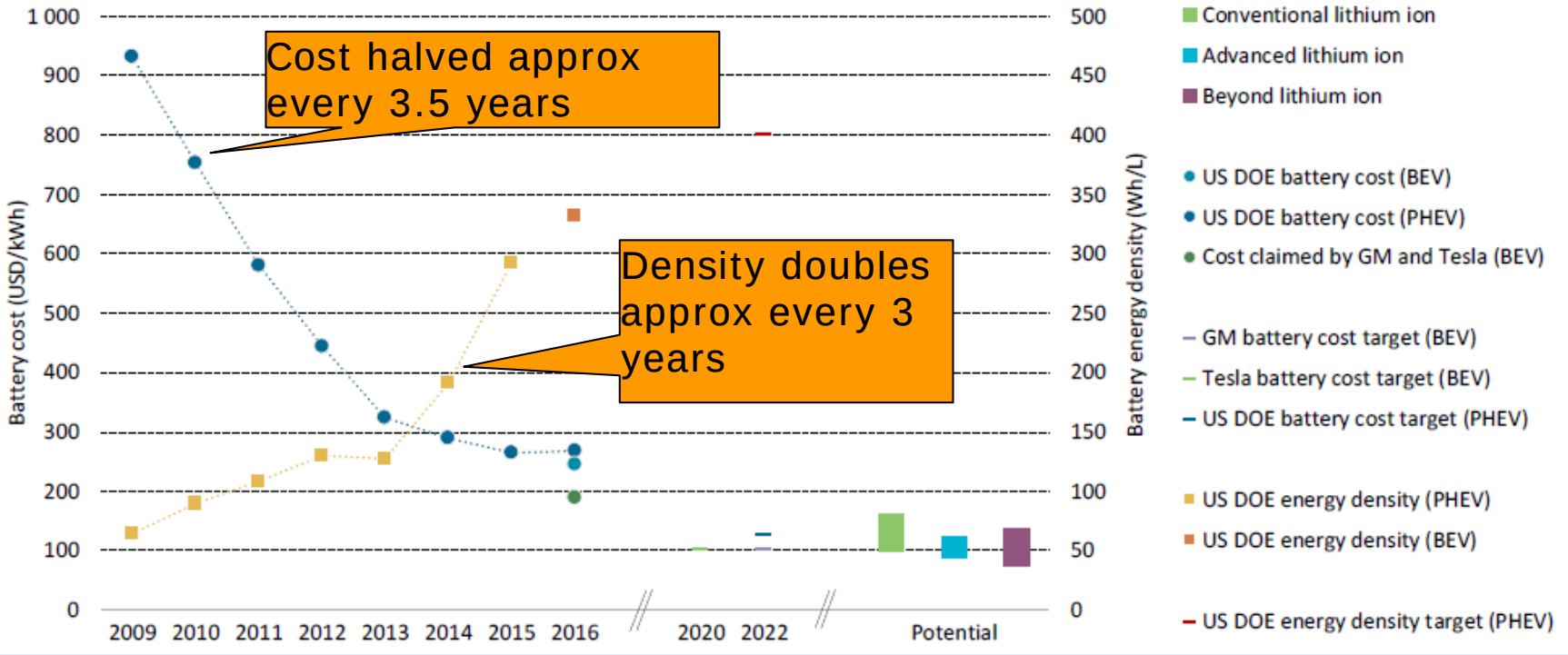
Moores law on battery cost and density

Figure 6 • Evolution of battery energy density and cost



Global EV Outlook 2017
Two million and counting

International Energy Agency
Secure Sustainable Together

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Transportmagasinet ▾ Log ind ▾ Bliv

Ny el-lastbil imponerer: Letkørt og lydløs

24. januar 2018 1 ...iner | Tip redaktionen om en historie

New electric truck impress:
Easy to drive and soundless

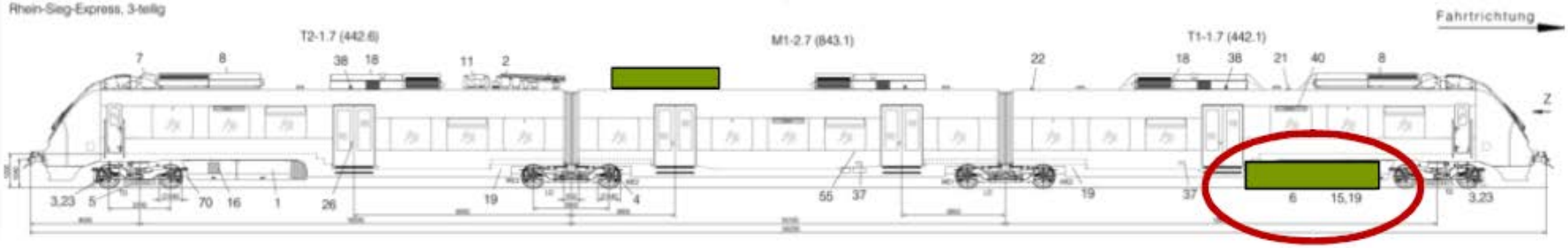
9 Billeder

Fuso's eCanter er blevet mødt med stor spænding. Der er tale om en elektrisk lastbil, som har en passende rækkevidde. Foreløbig er den købt af en række tyske transportvirksomheder, som bruger den til forsøg med distribution i storbyerne Berlin og Stuttgart.

Battery trains

- Can charge at stations and at terminals
- Can charge along sections with power supply
- Can be achieved by retrofit diesel trainsets

Available space in Talent 2 EMU



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Electric feries

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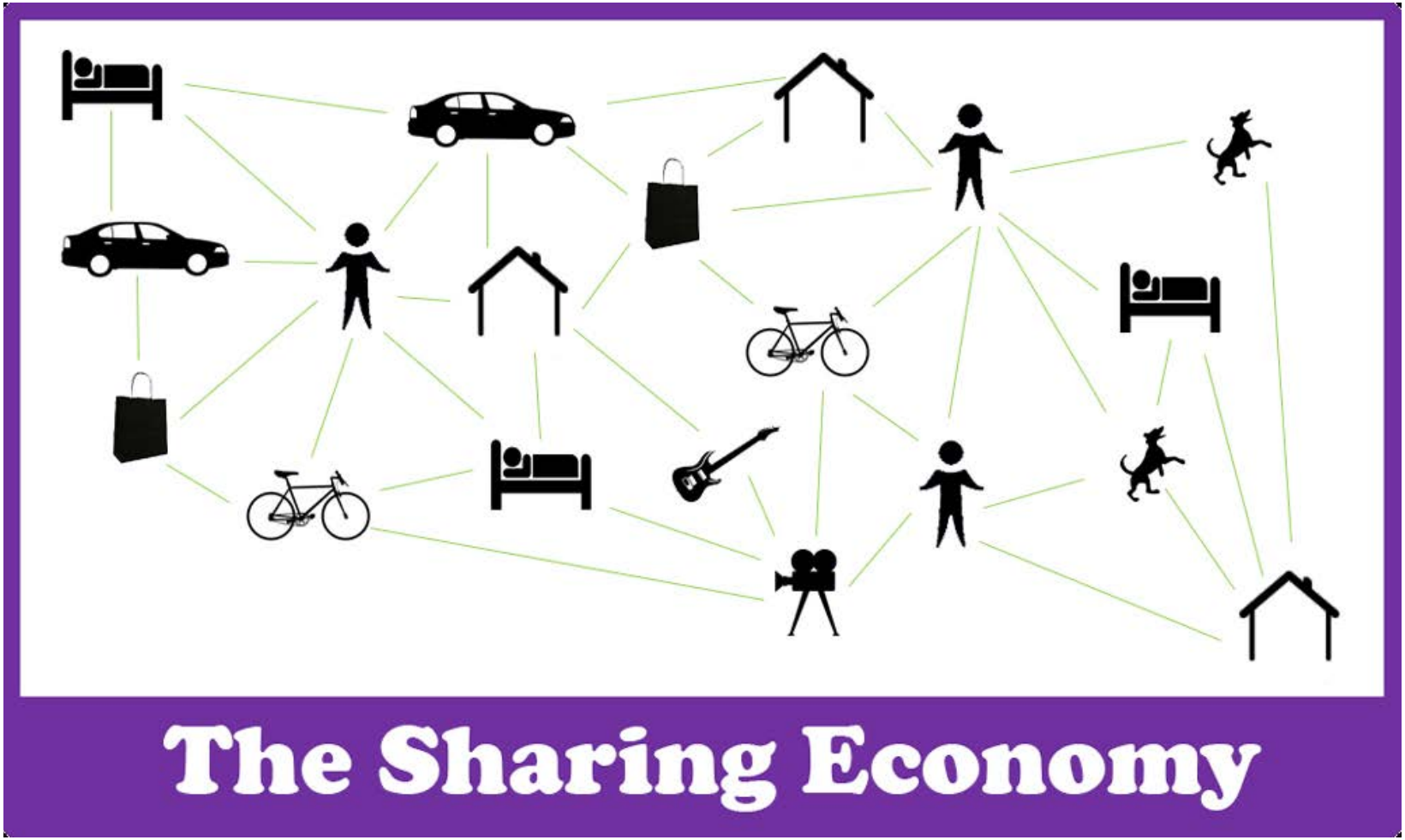
2 Shared economy



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Mobility as a Service (MaaS)
Shared Economy

- Taxi variants

- Co-driving
- Carpooling

- Rented cars /shifting drivers

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Shared economy is not new,…

They all had high transaction costs measured with the scale of today,…

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Shared economy of today

- Low transaction costs
- Eller seldom use with large benefit…
- Sometimes “creative” with regards to regulation, rules and taxes

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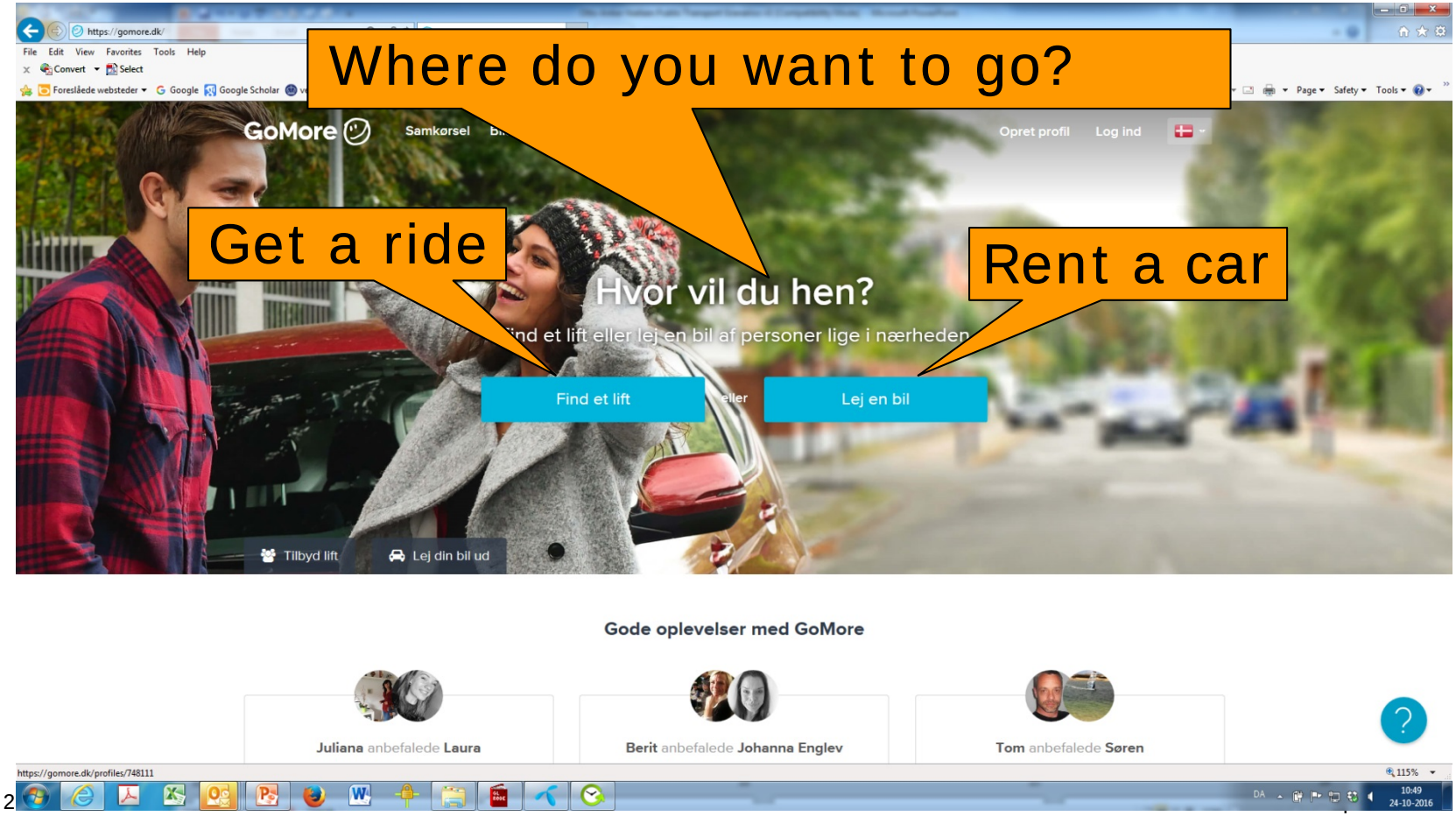
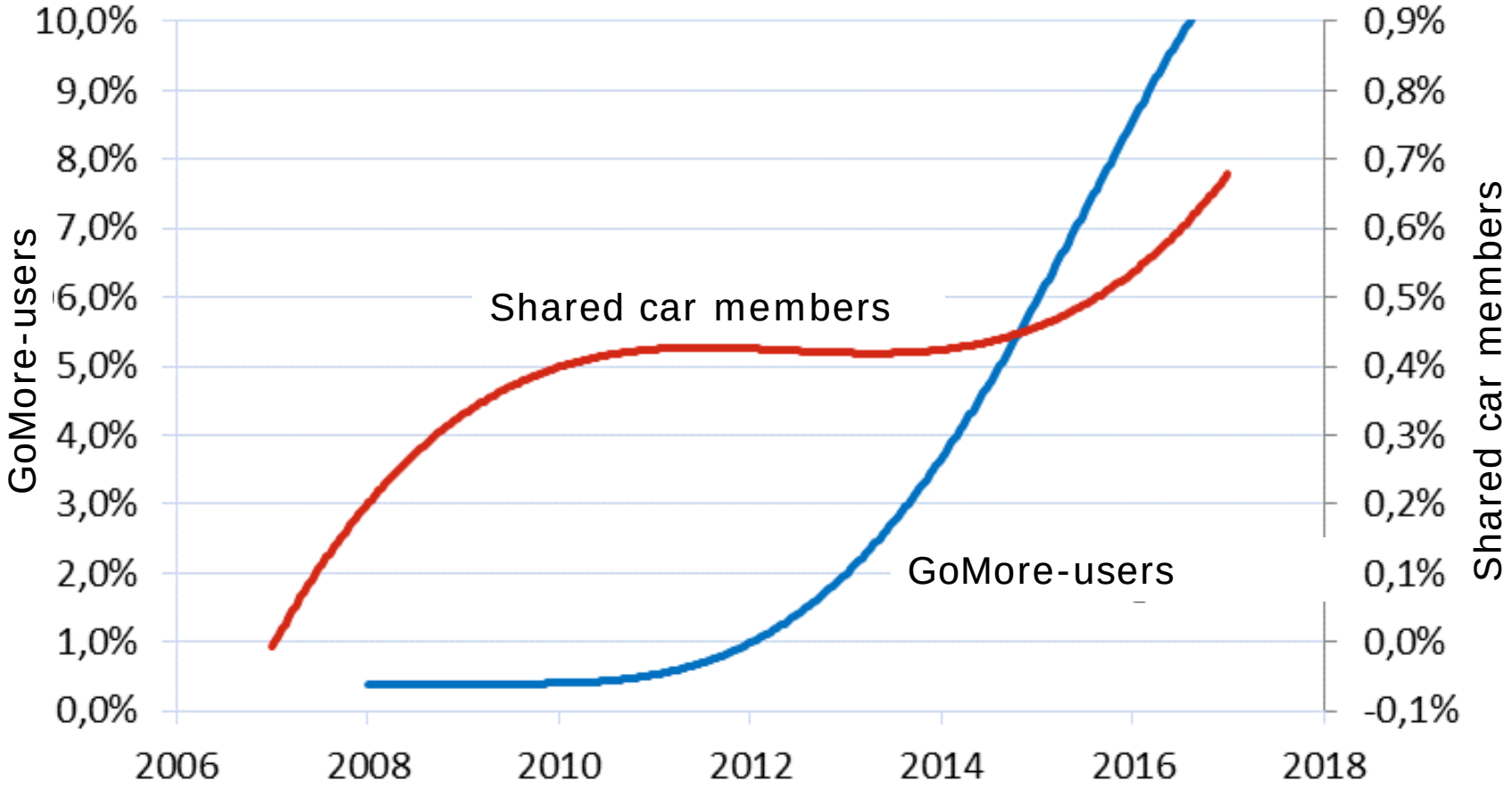
Different concepts by same provider

- 10% of the Danish population is member of GoMore



Rapid growth in shared economy for car transport



Source: GoMores press releises on members and the national transport survey (TU).

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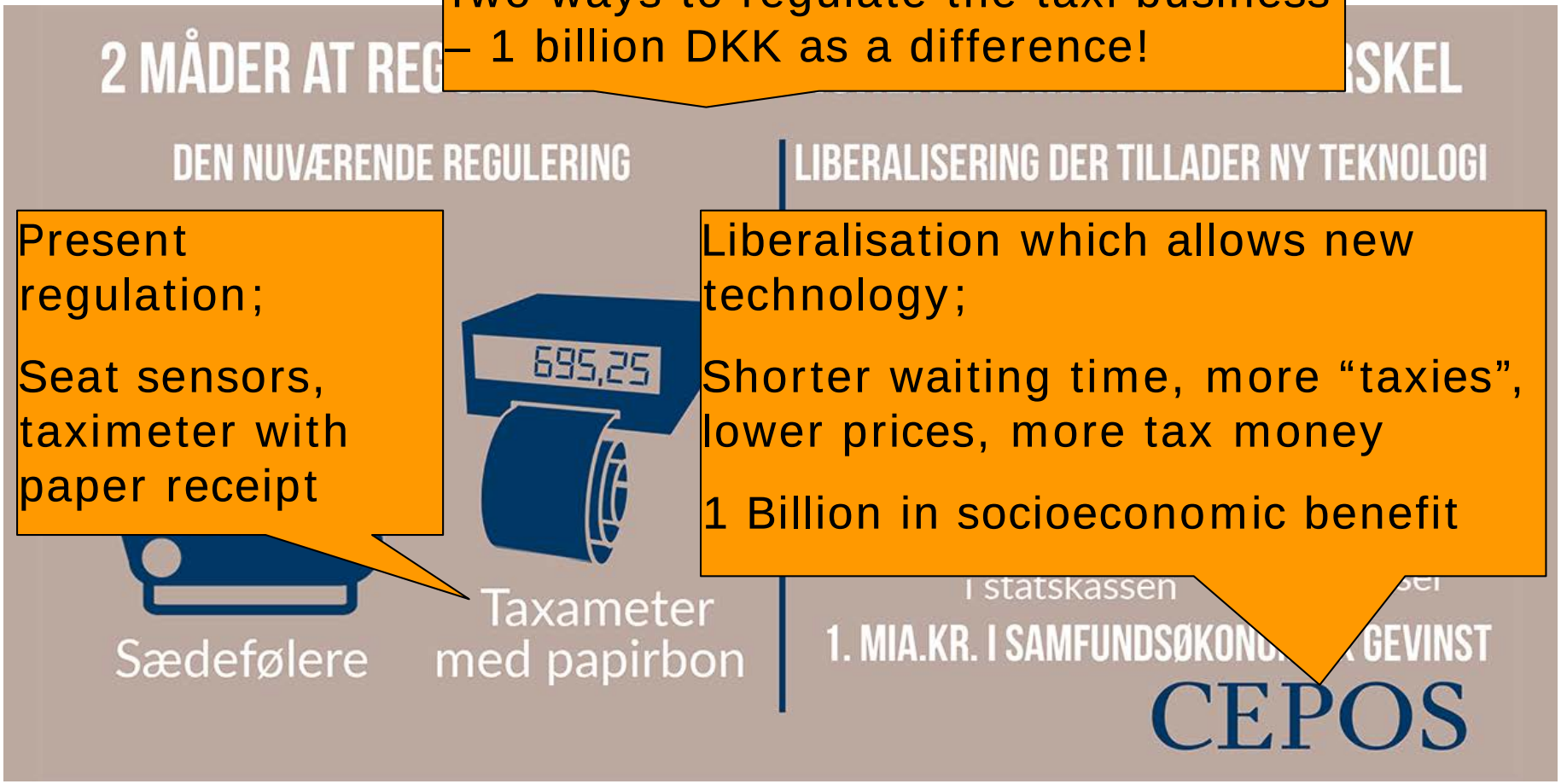
Shared economy and new business concepts

Two ways to regulate the taxi business – 1 billion DKK as a difference!



Present regulation;

Seat sensors, taximeter with paper receipt

Liberalisation which allows new technology;

Shorter waiting time, more “taxies”, lower prices, more tax money

1 Billion in socioeconomic benefit

Public transport – a bit provocative

- Drives from a place, where you are not located
- To a place, where you are not going
- At another time than you need

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Shared economy provide more flexibility, but require critical mass

…, balancing trip patterns for car sharing

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When we are not using a benefit ourselves, then somebody else can rent it,...

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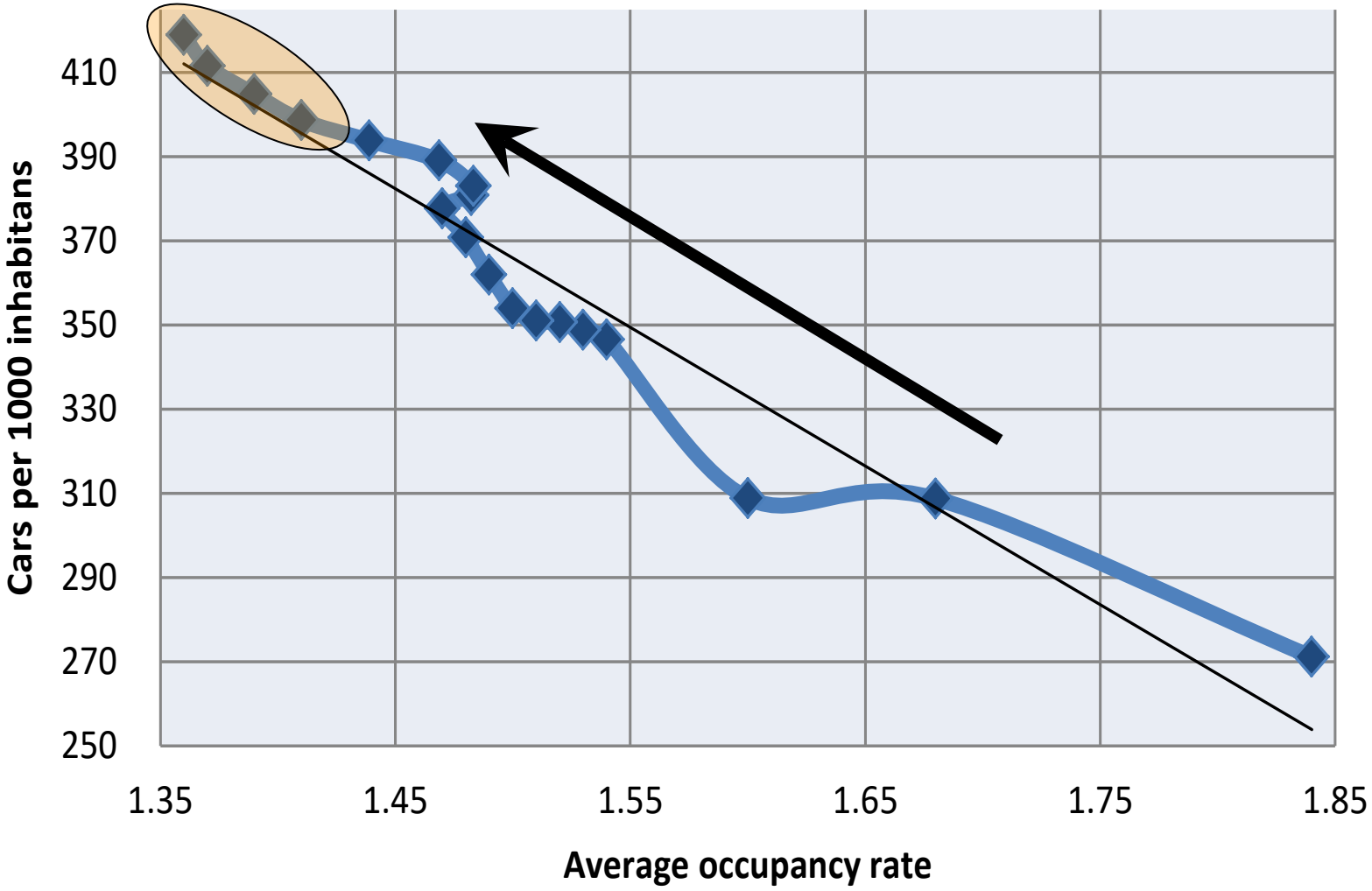
Development of car ownership and the average number of persons per car in Denmark the last 25 years



Economy and willingness to share,…

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Visions,...

And,...

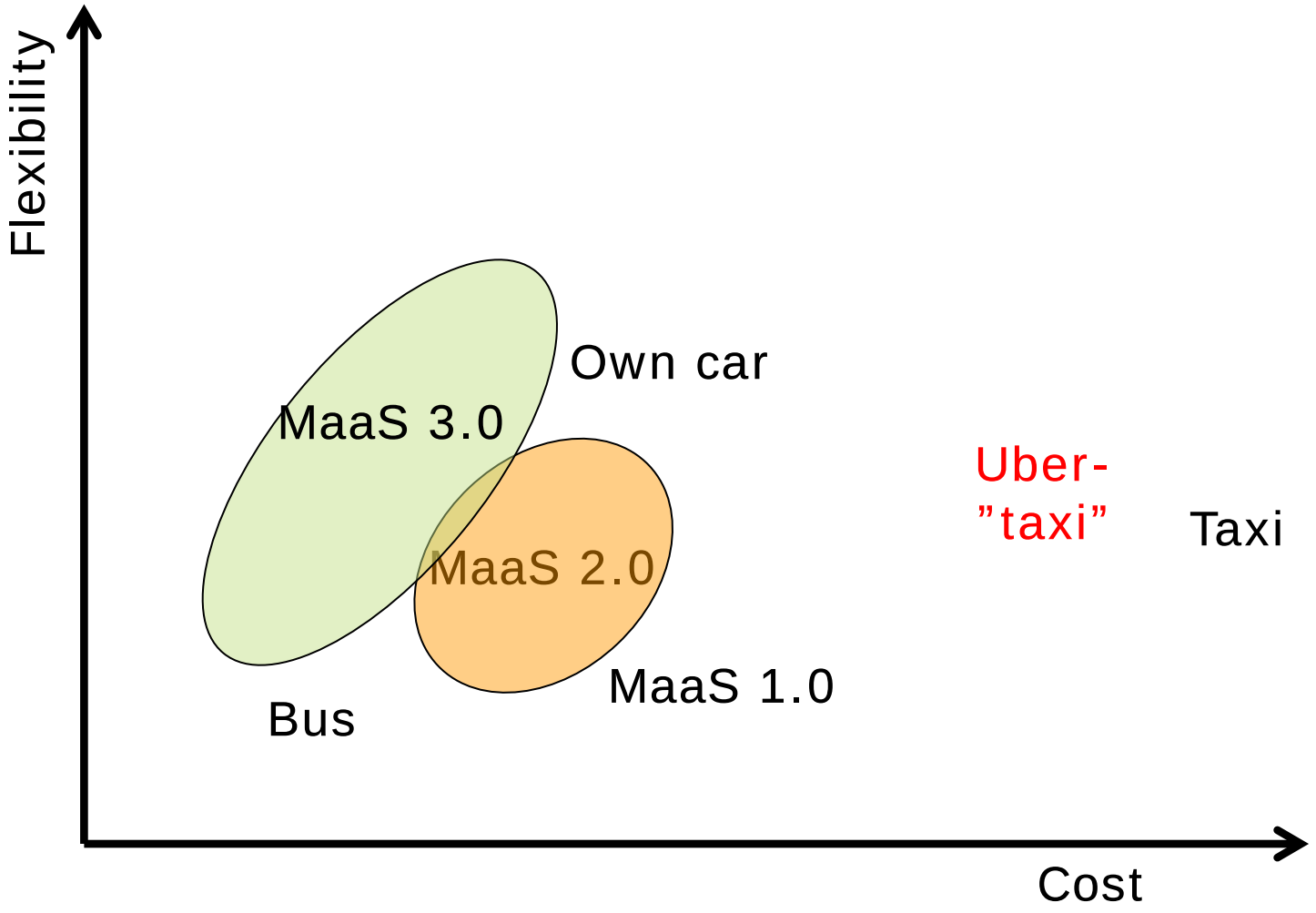
40% of Brits don't offer lifts due to dirty interiors

Forty per cent of British drivers do not offer friends or colleagues a lift due to the mess in their car.

PA

Last updated: 12 October 2015, 13:10 BST

Shared economy and ”Mobility as a Service”, MaaS, as concept



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New transport sollutions

- Passenger cars
- Public flex traffic with driver
- Busses
- Trams/Light rails
- Trains

- Passenger cars
- Individual shared cars
- Shared cars (+1 per car)
- Flexible mini busses
- Busses
- Self driving BRTs
- Trams/Light rails
- Trains

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3 Autonomous vehicles

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Five levels of automation

SAE J3016 (Jan-14) Driving Automation Definitions

Self driving features – seen from the user:

- **Self driving**: Driving – under certain conditions – does not require attention from the drive.
  - The driver can therefore better utilise the travel time
  - BUT must be ready to take over driving
- **Driverless**: The vehicle can completely drive itself from door-to-door
  - New users without driving license
  - Empty repositioning

The self driving features can be limited to certain parts of the road network, and by weather speed, traffic conditions, etc.

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Different degrees on assisted driving

- More safe – maybe!
- More comfortable - probably
- Better use of time – but how much does this matter?
  - Value of Time for passengers?
- Better use of capacity (on motorways), however, dependent on critical mass
- Improved traffic control?
  - Dependent on level of connectivity
  - Traffic signal control, etc.
  - Public versus private marked

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Three paths for automating passenger transport
- three business concepts

Development path

1. Graduately automating private cars → Self driving private cars

2. Fully self driving "taxis" → Driverless taxi concepts
   - 'Taxis'
   - 'Shared taxisr'
   - 'Taxi busses'

3. Driverless public transport systems → Automated public transport

Mobility-as-a-Service


Volvo vision


VW Sedric


Daimler City Pilot

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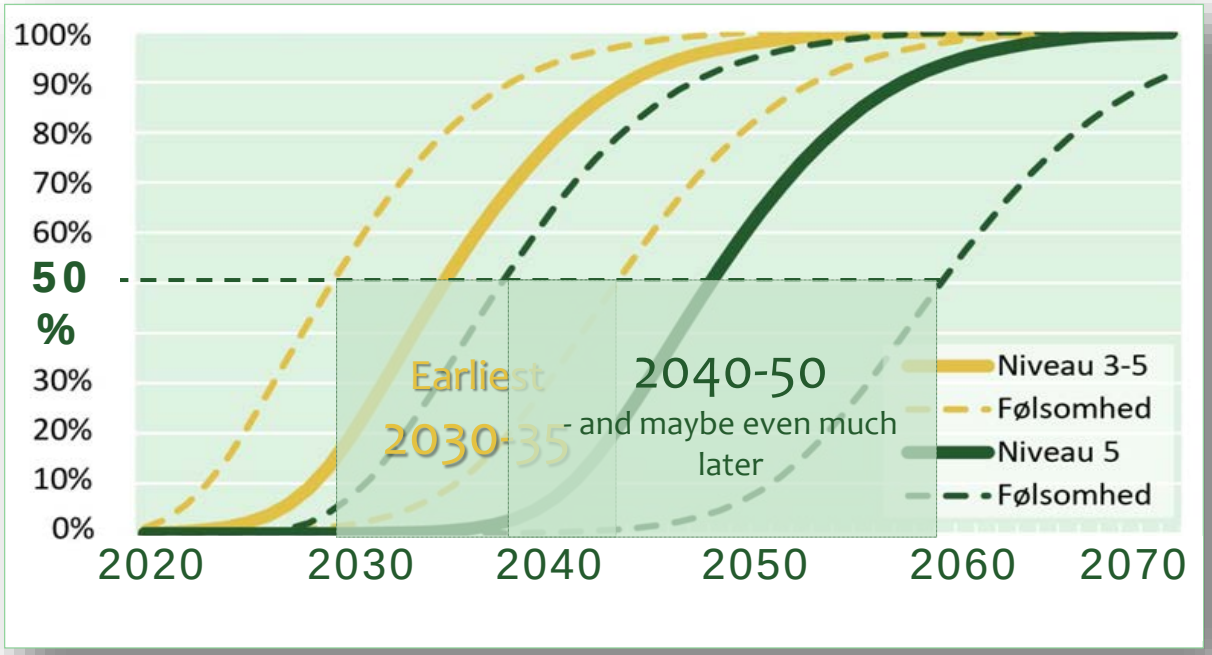
Large share of driverless private cars are possible long out into the future

- but there is large uncertainty and lack of consensus about the time perspective



1. **Introduction** to the market
2. New technologies penetrates slowly into the **market for new cars**
3. Share of the **car stock** increase slowly due to the long life of cars

The Danish value-based car taxation even slow down this transition as compared to other countries…

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Disruption potential, driver costs

Mode	Share (%)
Passenger car	0
Taxi	73-77
Bus	67
Truck	33-40
Passenger train	25-27
Passenger airplane	10
Ship/ferry	3-70

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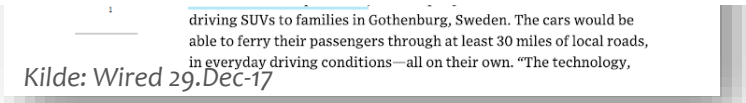
Driverless taxi concepts

Kilde: Reuters 30. Nov-17

- Driverless taxies may be introduced much earlier than driverless cars
  - Automation of taxies develops as driverless from start to save the salary

Is this difference in expected time of market introduction between private cars and taxies realistic?


driving SUVs to families in Gothenburg, Sweden. The cars would be able to ferry their passengers through at least 30 miles of local roads, in everyday driving conditions—all on their own. "The technology,

Kilde: Wired 29.Dec-17

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Driverless busses

- Today: Mini busses for niche markets
  Later: Normal busses

- Driverless busses will probably also appear before private cars
  - Salary costs strong driver
  - Fixed route makes it possible to adapt the infrastructure, establish support systems and interact easier with the other traffic

Stockholm får Skandinaviens første førerløse bus

Den førerløse bus har plads til 12 passagerer og vil følge en programmeret rute på 1,5 kilometer.

ONSDAG D. 24. JANUAR 2018 KL. 10:57

ARKIVFOTO: DGI Landsstævne 2017. En nyudviklet førerløs bus kørte dagen lang på en 300 m. lang oregik. Det er Aalborg fredag d. 30. juni 2017.

dk 24.Jan-18

THE STRAITS TIMES

NTU and Volvo Buses to develop electric, driverless buses by 2019

Signing of MOU between Volvo, SMRT and NTU

11TH JANUARY 2018

ABB

ELECTRIC

Through a partnership inked on Thursday (Jan 11), Volvo will provide two 12m, 40-seater battery-powered buses, which will be fitted with autonomous driving technologies. ST PHOTO: TIMOTHY DAVID

www.straitstimes.com 11.Jan-18

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Self driving trucks are already driving in closed areas

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When we get completely autonomous cars!

- New use of cars
- New user groups
- Self-parking
- Easier Mobility as a Service
- Delivery transport by passenger cars

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New use of cars

- Moving office
- Moving hotel room
- Assumingly this will lead to (much) more transport

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New user groups

- Children
- Handicapped
- Elderly
- Drunk

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Parking

- Empty drive waiting
  - No dis-benefit for the owner
  - Value of Time = zero
- Self driving to parking
  - Or empty return run

Average number of persons per car can be less than 1 !

- Result
  - Urban centres can be relieved for parked cars
  - BUT the road network will be loaded with more congestion due to empty cars driving around
  - And more car driving in general

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Mobility as a service, empty driving

- Self driving cars solves the imbalance between flows of persons and goods in space and time
- Empty return run
- Repositioning of cars to expected demand
  - Swarm of cars driving arround

- How Uber Uses Psychological Tricks to Push Its Drivers' Buttons
  - https://www.nytimes.com/interactive/2017/04/02/technology/uber-drivers-psychological-tricks.html?_r=0

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Will autonomous MaaS cars replace private cars in the long run?

- MaaS becomes
  - Cheaper
  - Easier to use and more reliable
  - But still some transaction costs
- Private cars may become
  - Cheaper (relatively to income)
  - More flexible when autonomous
  - Still convenience of owning
  - And we become richer!

Some policy implications

- Possible more car traffic and pressure on roads
- Even more conflicts on use of urban space
  - Shared mobility concepts will change parking needs, but will also increase car use
- Rail has a speed/comfort benefit on long distances, maybe with new type of feeder transport
  - But may also be challenged by new mobility concepts
- Rail has a role in the big cities due to the efficient land use
- Shared economy concepts and driverless vehicles may help public service in rural areas

Road pricing, dependent on time and location

- Benefits increases
- Costs decreases
- But still challenging to implement
- Does benefits justify the costs and risks?

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And what happened with the expert group conclusion

Ole Birk: Sådan gør vi noget ved trængslen - Transportministeriet Page 1 of 2

Ole Birk; This is how we can do something about congestion

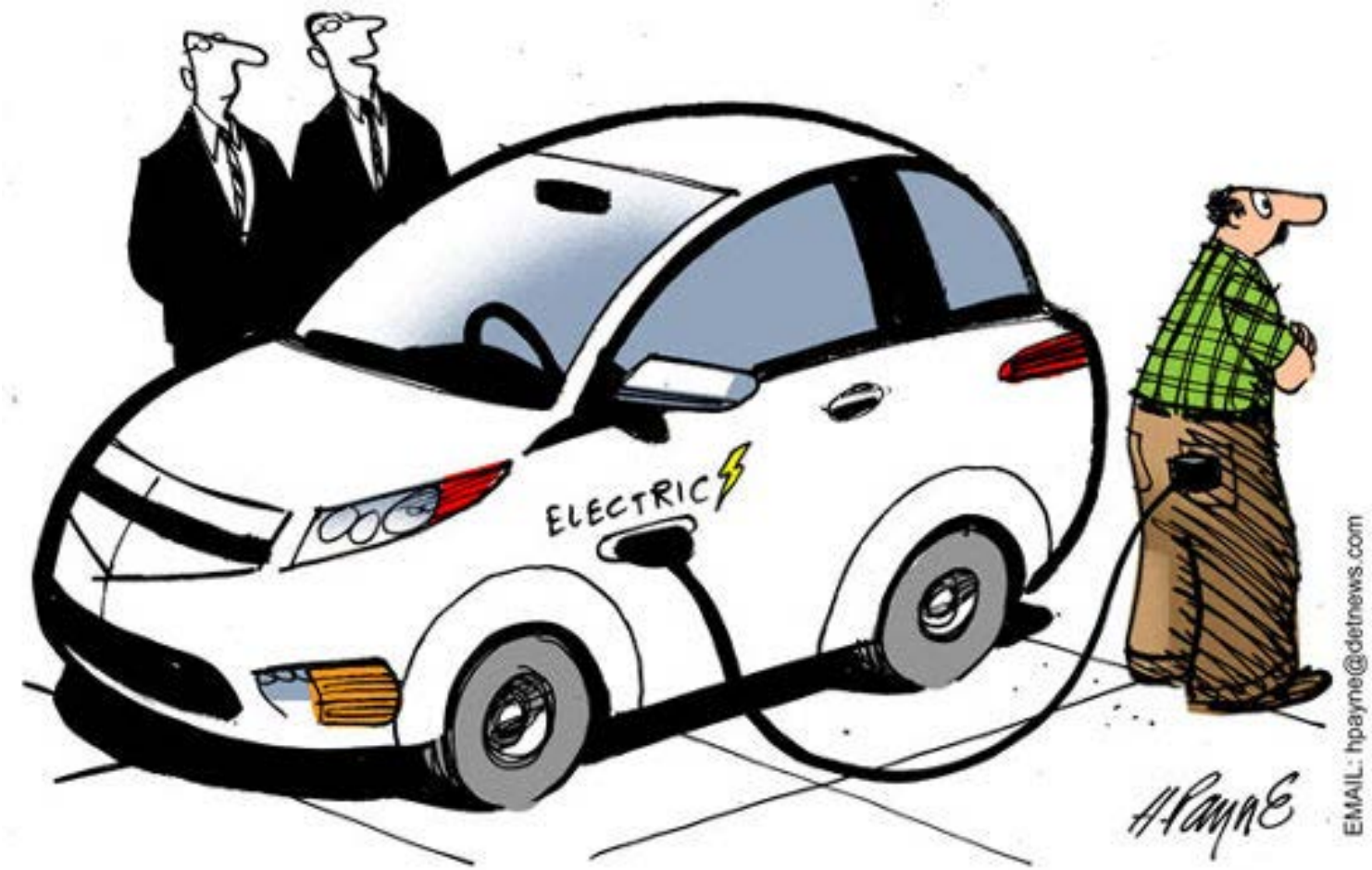
More investments in roads, new technology and intelligent road pricing can in the long term keep congestion at a reasonable level

Transport-, Bygnings- og Boligministeriet

Forside / Ministeren / Taler og artikler / 2018 / Ole Birk: Sådan gør vi noget ved trængsler

The technology is still not good and robust enough to introduce time and space dependent road pricing, but it is only a matter of time before it will be a sufficient cheap and precise solution, which can replace the present car-related taxes, which are both too high and imprecise. If one instead of a high registration tax and high fuel taxes pay after how much on drive and contribute to congestion, then it will distribute the traffic both temporal and geographical. This will also increase the incentive to drive together in the rush hour and hereby utilise the car-fleet better

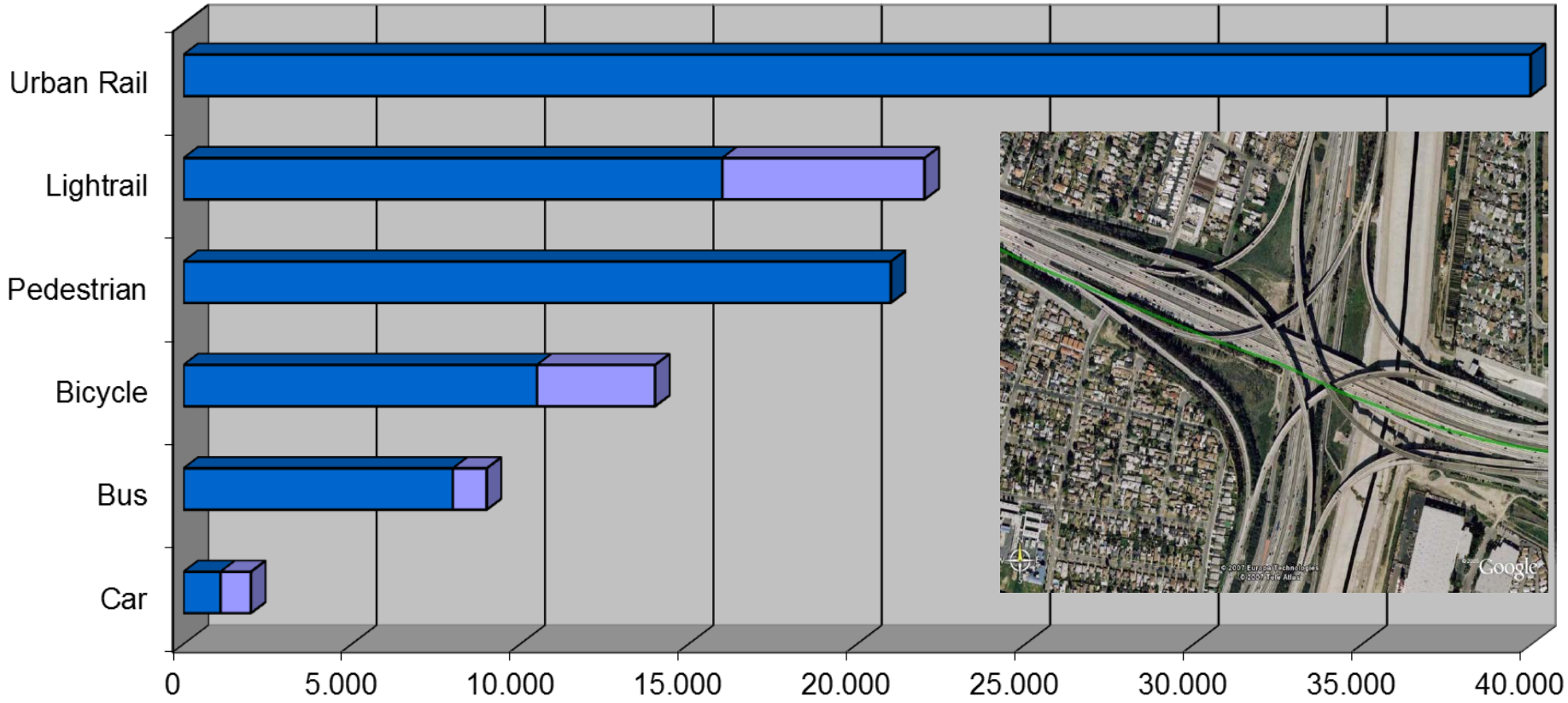
Thank you for your attention!



"Plug in to nearby taxpayer's wallet and she's ready to go!"

Otto Anker Nielsen
Transport DTU, DTU Management Engineering, Technical University of Denmark

Capacity for different modes of transport (Passengers per hour per lane)



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