THE BIGGER PICTURE

THE IMPACT OF AUTOMATION, AI, SHARED ECONOMY… ON OIL DEMAND

2° Investing Initiative

TABLE OF CONTENTS

2 DEGREES INVESTING INITIATIVE
WORKING PAPER NO. 2018/2

SUMMARY

This report seeks to quantify the potential impact of breakthrough technologies on oil demand.

It finds that breakthrough technologies like artificial intelligence, bio-plastics, 3D printing, holograms, nanotechnology, hyperloops, artificial intelligence, and autonomous driving, as well as trends like the 'sharing economy', can reduce oil demand by 34% relative to the baseline New Policy Scenario (NPS) of the International Energy Agency in the next 22 years.

This impact is the equivalent of the expected difference between the New Policy Scenario (NPS, ~4°C) and the Sustainable Development Scenario (SDS, ~2°C) of the International Energy Agency.

Adding the equivalent percentage adjustment of the difference of the IEA NPS to SDS to the alternative baseline implies a potential reduction of oil demand by 54% in the next 22 years.

These estimates rely almost exclusively on peer-reviewed or industry-expert assumptions about the trends for each technology and sector.

While admittedly highly uncertain, they suggest a potential volatility for the oil sector that is significantly more pronounced than that implied in current '2°C scenarios'.

Crucially, these estimates while optimistic may even understate the technology revolution.

Should technology adoption outperform or the IEA understate related climate policy trends, the effects may even be more pronounced, especially since they don't necessarily capture technology breakthrough in the buildings and petrochemical sector.

Figure 1: Impact of disruptive technologies on oil demand in 2040
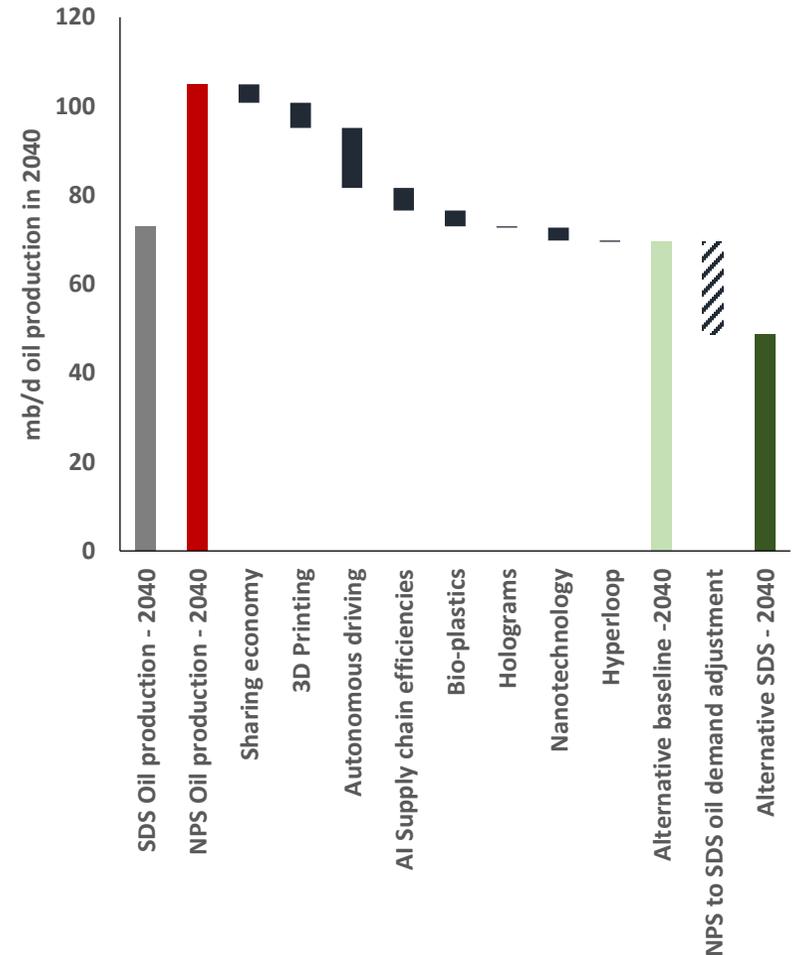
1. INTRODUCTION

The recommendations of the Financial Stability Board Task Force on Climate-Related Financial Disclosures (TCFD) have put scenario analysis on the agenda of both companies and financial institutions.

Specifically, the TCFD recommends that *"all organizations exposed to climate-related risks should consider: (1) using scenario analysis to help inform their strategic and financial planning processes and (2) disclosing the potential impacts and related organizational responses."*

In addition, the Paris Agreement in Art. 2.1c calls for aligning financial flows with climate goals. The translation of this policy objective in both mandatory (France) and voluntary disclosure initiatives (Switzerland) has made scenario analysis a core element of the policy and market toolbox for helping to achieve both the 2°C climate goal, as well as financial markets and economies that are resilient to the associated transition to a low-carbon economy.

These trends have put the question of the sources and assumptions of 2°C scenarios under increased scrutiny.

Arguably the most prominent scenarios in the oil & gas industry are those developed by the International Energy Agency (IEA). They are the primary scenario reference report in the annual reports and published scenario analyses of major oil and gas companies.[1] Specifically, the International Energy Agency has developed three scenarios: a Current Policy Scenario (CPS), roughly consistent with 6°C warming, a New Policy Scenario (NPS), roughly consistent with 4°C warming, and a Sustainable Development Scenario (SDS), roughly consistent with 2°C warming.

Traditionally, critiques of the IEA have focused on their assumptions around electrification of transport and speed of penetration of renewables.

Notable examples to that effect include research by Greenpeace developing an alternative decarbonization scenario.[2] These scenario also tend to increase the level of ambition with regard to the probability of limiting global warming to well below 2°C. Research from the Carbon Tracker Initiative has also challenged some of the macro assumptions of the IEA.[3]

This report takes a different approach, highlighting that disruptive trends like artificial intelligence, autonomous driving, and 3D printing can potentially by themselves bridge the gap between a 4°C and 2°C oil demand scenario.

Coupled with broader transition trends, this could create a 50% reduction in oil demand within just 22 years, significantly accelerating the transition and improving the likelihood of limiting global warming to well below 2°C above pre-industrial levels. Crucially, these achievements are possible relying exclusively on existing technology forecasts. More dramatic assumptions around robotics may lead to more pronounced shifts. Driven to a large degree by software, they circumvent some of the capital lock-in challenges traditionally associated with changes in the energy sector.

The report marks the first comprehensive analysis of a range of disruptive trends on oil demand in the context of the transition to a low-carbon economy. It thus fills a critical gap in the research space. It also shows how disruptive trends may require the use of more disruptive scenarios in the context of stress-testing and scenario analysis that take into account the current technology revolutions under way.

---

[1] See for example Carbon Tracker Initiative (2018)

[2] Greenpeace (2015)
[3] Carbon Tracker Initiative (2017)

2. Disruptive trends

Global oil production can be linked to a range of different uses, of which the most well-known, passenger vehicles, only makes up around a quarter.

Road transport represents roughly 40% of oil consumption, with aviation and shipping making up another 15%, and all other uses making up the rest (e.g. plastics, power generation, petrochemicals, buildings, steam and process heat, other). The figure below summarizes the different use cases for oil demand today. Crucially, the analysis does not look at carbon impacts of changes to different oil demands, but purely the underlying oil demand assumption

The range of different use cases also imply a significant exposure to disruptive trends across a range of industries. By extension, the range of disruptive technologies that might affect oil demand is also broad. The figure across shows the key types of disruptive technology trends potentially at play, with a more detailed discussion on the next page.

Figure 2: Oil demand by type in 2040 (Source: Authors, based on IEA estimates)
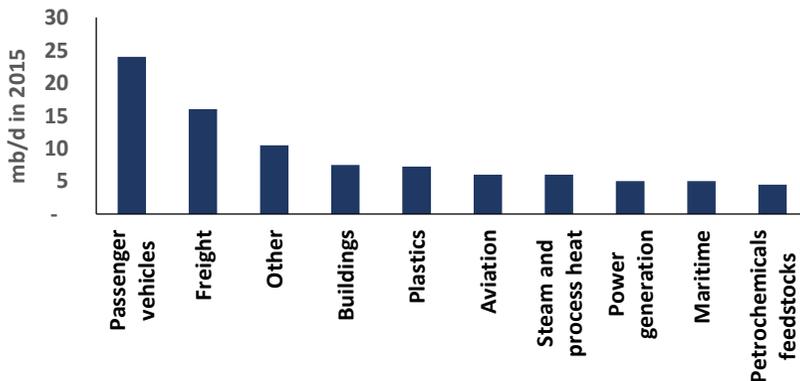
Sharing economy
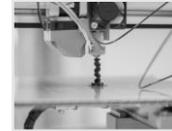
3D Printing

Autonomous vehicles
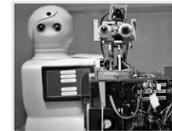
AI in supply chains

Bio-plastics

Holograms

Hyperloop
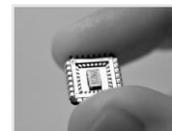
Nanotechnology

Sharing economy. Car- and bike-sharing programs, as well as the revolution in the nature of taxi services is set to reduce the purchase of private vehicles and by extension likely the consumption of oil related to passenger vehicles. Estimates by McKinsey suggest that the sharing economy is likely to reduce car sales by around 10% over the next 25 years. The effect on oil demand in 2040 of this trend is somewhat uncertain, related to both the speed of adoption of the sharing economy and the actual replacement of oil-fuelled vehicles with alternatives.

3D printing. 3D printing is set to have potentially significant impacts on the logistics sector, driving more local production of goods and potentially reducing the transportation of intermediate goods across long distances. [4] According to Integracore, around 25% of the freight, 41% of the air cargo sector, and 37% of the shipping sector may be at risk in the context of 3D printing. In estimating the implications for oil demand, there are data challenges related to the share that cargo makes up in the aviation and shipping sector respectively.

AI Supply chain efficiencies. Artificial intelligence will help significantly improve the efficiencies of supply chains, reducing waste both in the logistics chain itself, as well as in the nature of goods and services transported. Estimates suggest AI can help increase supply chain efficiencies by around 20-30%,[7] with commensurate effects in particular on the freight, air cargo, and shipping cargo sector.

Bio-plastics. Primarily driven by non-climate related environmental concerns, notably plastic trash in the ocean, biodegradable plastic is likely to make inroads as the technology develops, with potentially upward of 50% of plastics replaced by non-oil based alternatives by 2040, [8] including potentially with nanotechnology solutions.

Autonomous driving. Autonomous driving is another area of significant disruption. Autonomous vehicles are already tested on the road, with a significant degree of automation built into the Tesla software. Autonomous driving could thus be associated with limited lock-in effect as vehicles simply receive 'software updates' as the technology matures. The range of estimates on the impact of autonomous vehicles is wide, from rebound effects actually increasing oil demand to positive estimates suggesting up to a 40% efficiency gain across all road transport. [9]

Holograms. Holograms can help revolutionize business travel and by extension the consumption of oil. This is likely to – should it scale – impact business travel in particular. Given some travel constraints and the fact that the majority of air travel is either cargo or 'private', holograms are only expected to have a low single digit effect on air travel consumption, with no robust estimates to date on scale.

Hyperloop. The Hyperloop is designed to be an alternative technology to air travel, creating super high-speed on-ground travel connections, powered by electricity, across major industrial or population centers. Here too, estimates are missing, but high capital lock-in and long construction phases suggest limited penetration by 2040, even under an optimistic scenario, although hyperloops may come to play a more prominent role in the long-term.

Nanotechnology. Beyond its role in plastics, nanotechnology can also help accelerate fuel efficiency trends, through a combination of lowering the weight of vehicles and thus increasing efficiency, improving tire efficiency, and nanocatalysts that make fuel consumption more efficient.[10]

[5] IntegraCore (2016)
[6] Aviation Stack Exchange (2016)
[7] visualfabriq (2017)
[8] World Economic Forum (2016)
[9] Wadud, Z. et al. (2016)
[10] Nano Magazine (2017)

3. Impact on oil

The figure below summarizes the collective impact of the disruptive effects on potential oil demand in 2040. It suggests that these disruptive trends can account for the entire difference between the IEA New Policy Scenario (NPS – 4°C scenario) and the IEA Sustianable Development Scenario (SDS – 2°C with a 50% probability).

Thus, disruptive trends could in theory by themselves generate the oil demand reduction consistent with a 2°C scenario. This analysis of course does not reflect uncertainty as to the extent that these factors are already considered in the New Policy Scenario, for which the IEA does not provide specific information. However, given that the NPS is a 'baseline' scenario, it is unlikely that disruptive trends factor materially in this case. A detailed calculation methodology can be found in Annex 1, p. 13-15.

Crucially, the results control for 'double counting' such that for example efficiency gains from artificial intelligence materialize to an already more efficient transport fleet due to autonomous driving.

Applying the SDS trend proportionally to the alternative NPS baseline assuming disruptive trends shaves another 20 million barrels / day off of expected demand.

This implies that the aggregate impact of an economic disruption caused by artificial intelligence and other technologies (autonomous driving, 3D printing) as well as decarbonization envisioned under a SD scenario could halve global oil production in the next 22 years relative to a baseline 4°C scenario (-54%), and reduce oil demand by about 34% relative to a non-disruptive SDS.

*Figure 3: Impact of disruptive technologies on oil demand in 2040*
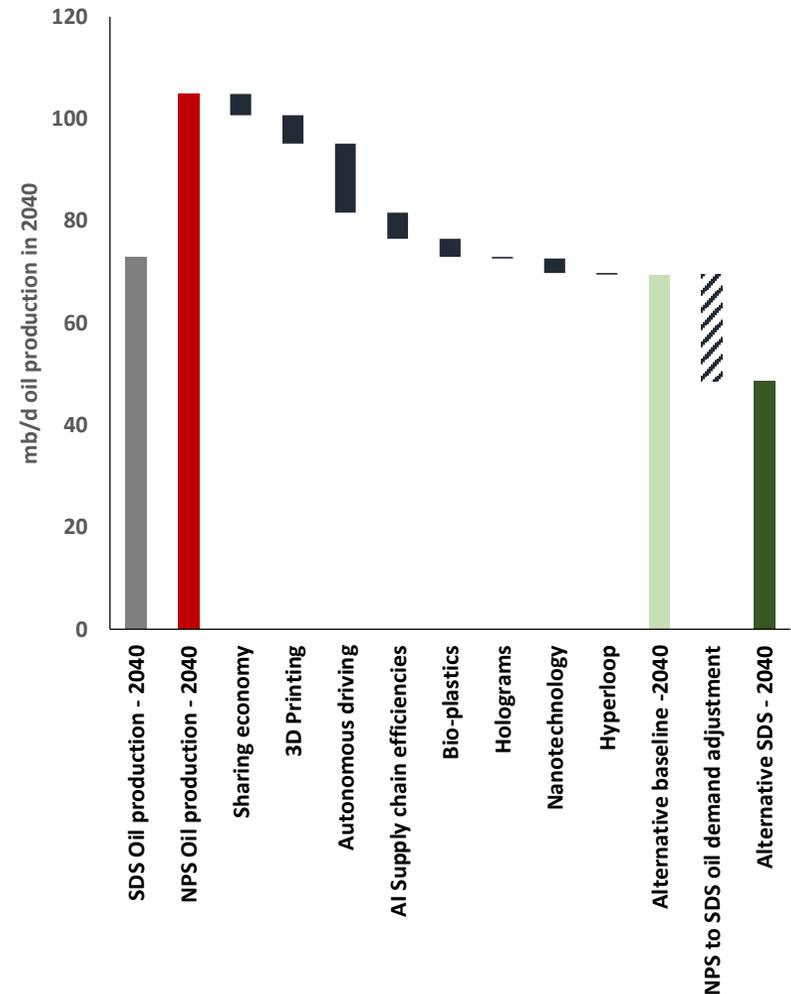
Autonomous driving is by far the largest potential impact with up to 13 million barrels per day, given its potential cross-cutting effect on both private and cargo transport across light- and heavy duty vehicles.

Other major potential impacts come from supply chain efficiencies and 3D printing. The results suggest that technologies addressing all transport modes and linked to low capital-intensity (e.g. software-powered) have the highest short-term potential.

In terms of sectors, it is passenger vehicles and freight that accounts for the most significant effects, with around 50-66% of oil demand cut out of the sectors by 2040 under the alternative baseline relative to the New Policy Scenario.

Figure 4: The relative estimated impact of technology trends on oil demand reduction by use
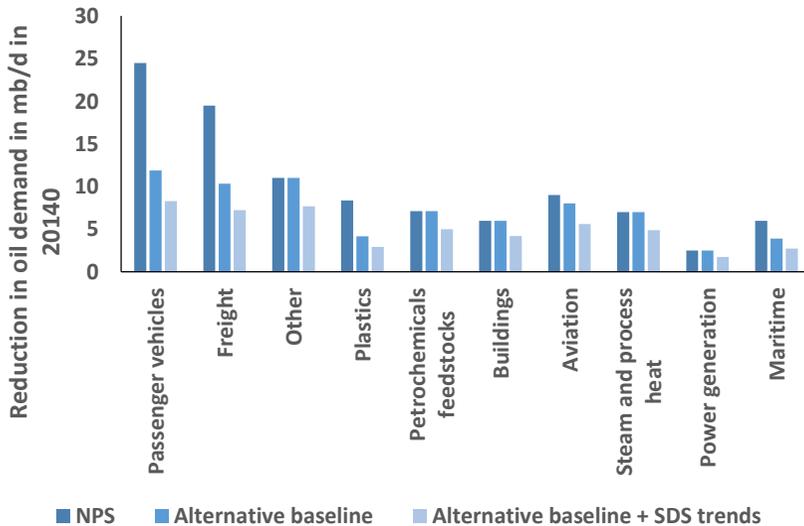
Figure 5: The relative estimated impact of different technology trends on oil demand reduction

- Sharing economy
- 3D Printing
- Autonomous driving
- AI Supply chain efficiencies
- Bio-plastics
- Holograms
- Nanotechnology
- Hyperloop
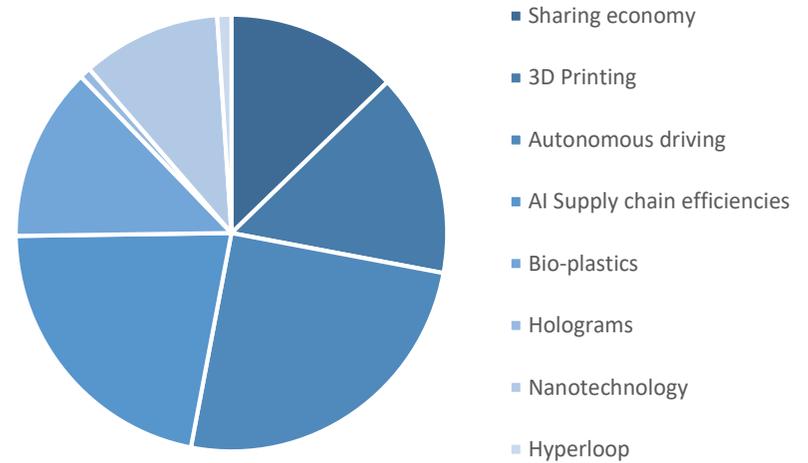
Unclear of course in the assessment is to what extent the additional effect from the IEA shift to a SD scenario can be counted proportionally or whether there are 'double counting' effects.

Should these additional effects materialize however – driven by climate policy and other market trends – oil demand may halve in the next 22 years. These results are striking, suggesting that the sector may face potentially a significantly more disruptive future than even a 2°C scenario imagines.

These results may suggest both companies fortunes and the financial asset prices underpinning them may be more exposed to financial risks than currently anticipated.

4. Conclusion

This paper sought to present the first comprehensive analysis of the potential aggregate impact of breakthrough technologies on oil demand.

The results are striking, with up to 50% of oil demand set to disappear in the next 22 years under optimistic technology assumptions – coupled with the implementation of the Paris Agreement 2°C climate goal policy agenda. Even without such an agenda, oil demand is set to drop by around one-third if these technology trends materialize. The results are dramatic and stand in stark contrast to a baseline scenario of increasing oil demand of around 10-15%, and even higher under the so-called 'Current Policy Scenario' of the International Energy Agency.

The results presented here are 'optimistic', but ground in credible third-party estimates.

This optimism relates to the potential adoption of the technology and its specific effects on oil demand, which is of course incredibly difficult to model and can be interpreted in very different ways, especially when considering different potential rebound effects. It represents what may be – depending on the eye of the beholder – a best case or worst case scenario for oil demand under a disruptive trend.

In this, it is critical to point out that the paper focused exclusively on one question – oil demand – and did not take into account other environmental or climatic factors. Thus, the breakthrough technologies described above may increase electricity demand that may give rise to increased demand for coal-fired or gas-fired electricity. Equally, the technologies involved in these trends may rely on other natural resources with negative environmental implications. While important, these effects were not in scope of the analysis.

The results should not be seen as a forecast, but an alternative scenario should technology disruption materialize and oil demand respond commensurately.

Crucially, this scenario is not science fiction, but an aggregated perspective based on credible, third-party estimates on potential effects, that are at least in-part grounded in peer-reviewed academic processes and / or in-depth industry research.

A scenario is just that, a scenario. However, it speaks to a potentially credible future that may – unlike a 2°C scenario constrained by assumptions around current technologies and capital lock-in – truly disrupt the oil sector in a very short period of time.

While the scenario may seem like 'science fiction', it may even understate the technology revolution underway.

Nanotechnology, 3D printing, artificial intelligence, and related technologies may fundamentally rupture a range of markets that shift our transport, energy, and materials needs. A science fiction narrative might lead to a complete replacement of oil-based plastics, lab-based biofuels that replace oil in the aviation and shipping sector and related trends. The sky is the proverbial limit.

References

Aviation Stack Exchange (2016) "What percentage of airliner flights globally are freight flights?" <https://aviation.stackexchange.com/questions/30542/what-percentage-of-airliner-flights-globally-are-freight-flights>

Biron, M. (2017) "Industrial Applications of Renewable Plastics – Environmental, Technological and Economic Advances"

Carbon Tracker Initiative (2017) "The Unexpected Power of Low-Carbon Technology"

Carbon Tracker Initiative (2018) "Under the Microscope: Are companies' scenario analyses meeting investors' requirements"

Chen, Z. (2017) "The Influence of 3D Printing on Global Container Multimodal Transport System" Complexity, Volume 2017, 19 pp.

DHL Trend Research (2016) "3D Printing And The Future Of Supply Chains" < http://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/dhl_trendreport_3dprinting.pdf > [20.04.2018]

Endresen, Ø.; Sørgård. E.; Behrens, H. L; Brett, P. O. and Isaksen, I. (2007) "A historical reconstruction of ships' fuel consumption and emissions" Journal of Geophysical Research: Athmospheres, 112, D12.

Exxon Mobil Corporation (2018) "The Outlook for Energy" <http://corporate.exxonmobil.com/en/energy/energy-outlook> [12.04.2018]

FreightWaves (2018) "The sharing economy: Six disruptions on the transportation ecosystem" <https://www.freightwaves.com/news/2018/1/2/the-sharing-economy-disruption-on-transportation> [20.04.2018]

Greenpeace (2015) "Energy Revolution 2015" <https://www.greenpeace.org/archive-international/en/publications/Campaign-reports/Climate-Reports/Energy-Revolution-2015/> [12.04.2018]

IntegraCore (2016) "The Future Impact of 3D Printing on the Transportation Industry" <https://blog.integracore.com/freight/the-future-impact-of-3d-printing-on-the-transportation-industry/> [20.04.2018]

LoupVentures (2017) "Auto Outlook 2040: The Rise of Fully Autonomous Vehicles" < http://loupventures.com/auto-outlook-2040-the-rise-of-fully-autonomous-vehicles/> [20.04.2018]

McKinsey (2017) "How shared mobility will change the automotive industry" <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-shared-mobility-will-change-the-automotive-industry> [20.04.2018]

Nano Magazine (2017) "7 Ways Nanotechnology Could Combat Climate Change" <https://nano-magazine.com/news/2017/6/29/7-ways-nanotechnology-could-combat-climate-change> [12.04.2018]

Nordic Council of Ministers (2017) "Environmental impacts and potential of the sharing economy" TemaNord 2017:554, <https://norden.diva-portal.org/smash/get/diva2:1145502/FULLTEXT01.pdf> [20.04.2018]

Progressive Markets (2017) "Bioplastics Market - Size, Trend, Share, Opportunity Analysis, and Forecast, 2017-2025" <https://www.progressivemarkets.com/industry-research/bioplastics-market> [20.04.2018]

References

PwC (2015) "2015 Commercial Transportation Trends"
<https://www.strategyand.pwc.com/trends/2015-commercial-transportation-trends> [20.04.2018]

The Drive (2018) "Forecast: Autonomous-Vehicle Sales to Top 33 Million in 2040" < http://www.thedrive.com/sheetmetal/17298/forecast-autonomous-vehicle-sales-to-top-33-million-in-2040> [20.04.2018]

The Telegraph (2017) "What does AI mean for the future of manufacturing?", 15.08.2017 < https://www.telegraph.co.uk/business/social-innovation/artificial-intelligence-future-of-manufacture/>

UNCTAD (2016) "Review of Maritime Transport"
<http://unctad.org/en/PublicationsLibrary/rmt2016_en.pdf >

Visualfabriq (2017) "The role of machine learning to significantly improve forecast accuracy", presentation held at POI European Promotion Optimization Summit 2017 <https://visualfabriq.com/wp-content/uploads/2017/09/POI-Amsterdam-2017-Visualfabriq-Optimizing-Forecast-Accuracy.compressed.pdf>
[12.04.2018]

Wadud, Z. et al. (2016) "Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles" Transportation Research Part A, 86: 1-18.

World Economic Forum (2016) "The New Plastic Economy: Rethinking the future of plastics"

The following describes the methodology underpinning the estimates on changes in oil demand by 2040. The baseline oil production figures are derived from the International Energy Agency.

Shared economy. The shared economy effect was exclusively applied to passenger duty vehicles, although it also may impact other sectors like freight.[11] Effects in terms of energy consumption for example in buildings however are expected to be muted and may even be offset by higher disposal income effects.[12] Estimates with regard to penetration range from 10% (McKinsey)[13] to 68% (LoupVentures)[14] by 2040 in terms of fleet penetration. In a meta-study focusing on the impact of shared vehicles on car use, most estimates suggest around 25% lower net oil consumption, although estimates will go as high as 48% in one case study.[15] For the purpose of this paper, the optimistic penetration estimate was applied (68%), albeit with the average savings (25%). This implies a net reduction of 17% in oil demand in the passenger vehicle sector.

3D Printing. The effects of 3D Printing were applied exclusively to the freight, aviation and maritime sector, using the cargo share estimates for aviation (10%) and shipping (52%) highlighted earlier. Here, the analysis relies on estimates from PWC.[16] More specific estimates also suggest impacts on oil tanker demand in terms of a reduction of 10%.[17] Applying this additional factor only reduces oil demand by about 100,000 barrels a day however and is thus – in relative terms – negligible in the overall analysis. Of course, logistics companies in their scenario analysis paint a much more conservative future of single-digit reductions in freight volume, claiming it will primarily impact 'last-mile' logistics.[18]

Artificial intelligence supply chain. The reduction in transport needs in the freight, air cargo, and shipping sector due to efficiencies in supply chain is highly uncertain and not extensively modelled. However, estimates for efficiency gains in manufacturing for example are around 10%[19] and some industry actors assume gains of 20-30%.[20] The estimates in this paper apply an optimistic 30% estimate to the freight sector and a similar oil demand reduction for air cargo (~10% of air travel)[21] and maritime. For maritime, estimates for the share of cargo in total maritime shipping could not be identified, but are expected to be quite high, given the relative prominence of cargo shipping. Estimates suggest fishing vessel bunker demand (not considered in the supply chain discussion) represent around 10% of maritime bunker demand. It is unclear to what extent artificial intelligence can be expected to increase the efficiency of oil tankers, which is thus also excluded from the analysis. Data on the relative share here too is scarce in terms of maritime bunker demand,[22] but based on tonnages represents around 35% of commercial cargo shipping.[23] While obviously differences in fuel efficiency, use, etc. may imply that the actual oil demand underlying the cargo tonnage differs significantly from its share in tonnage – generally receiving a lower EVDI score (implying higher fuel efficiency), but perhaps differing in use case. Without further data, the 30% efficiency gain was thus applied to 52% of maritime oil demand. It is perhaps relevant to note that more or less conservative assumptions do not significantly change the estimates (less than 1 mb/d based on a basic sensitivity analysis).

[11] FreightWaves (2018)
[12] Nordic Council of Ministers (2017)
[13] McKinsey (2017)
[14] LoupVentures (2017)
[15] Nordic Council of Ministers (2017)
[16] PwC (2015)
[17] Chen, Z. (2017)
[18] DHL Trend Research (2016)
[19] The Telegraph (2017)
[20] Visualfabriq (2017)
[21] Aviation Stack Exchange (2016)
[22] Endresen et al. (2007)
[23] UNCTAD (2016)

METHODOLOGY

Autonomous vehicles. The expected penetration of autonomous vehicles by 2040 varies widely. Crucially, with software update capabilities in future cars, technology lock-in should be minimal, thus implying that any technology improvement in the late 2030s will be scalable across the global car fleet. Estimates of penetration vary from around 25%[24] to 90%.[25] A study by Wadud et al. in Transportation Research Part A[26] models different 'efficiency futures' with optimistic and less optimistic outcomes ranging from an increase in total road transport energy demand of 110% to a decrease of 40%. The optimistic outcome was chosen here, where total energy demand for passenger vehicles drops by around 55% and increases slightly by around 3% for freight (largely driven by an increase in travel demand not offset by a reduction in energy intensity). Assuming that these effects apply to 90% of autonomous vehicles in a world where around 80% of vehicles are not electrified, the overall effect is a 41% reduction in oil demand for passenger vehicles and a 2% increase in oil demand for the freight sector.

Bio-plastics. While bioplastics currently represent about 1-2% of the plastics market, this figure is set to grow to perhaps 15-20% by 2025, according to Progressive Markets.[27] More long-term estimates suggest the moment where bioplastics achieve 50% penetration may be 2040.[28] This estimate was applied to oil demand.

Holograms. No meaningful third-party estimate exist to their effect. In order to illustrate the effect, a 30% reduction in business travel (and commensurate reduction in oil demand) was assumed. Given the very limited impact of this estimate, a higher or lower estimate would be unlikely to shift the broader picture. Business travel is estimated to represent 12% of the passenger air travel, which in turn represents 90%.

Nanotechnology. Nanotechnology can impact oil demand through a range of different drivers, notably through the use of lightweight nano-composite materials increasing fuel efficiency, nano-coatings reducing drags of aircraft, nanocatalysts improving fuel efficiency, nano-structured materials to improve the energy ratings of tires, as well as improved renewables and batteries. Together, these applications can transform the climate challenge, assuming their technological potential will materialize. For the estimates in this paper, a 15% efficiency gain was applied to passenger vehicles and freight, based on the potential for nano-structured material sin tyres to drive category A tires consuming 7.5% less fuel and 8-10% fuel savings of nanocatalysts identified by Energenics.[29] These savings may of course be higher when factoring the additional potential of nano-coatings and nano-composite materials, as well for aviation and maritime shipping.

Hyperloop. Similar to the hologram, hyperloop estimates are poorly defined. A generic 1% saving across passenger vehicles, freight, aviation, and maritime shipping was applied, with similar low impacts suggesting that higher or lower estimates would be unlikely to change significantly the overall picture.

[24] The Drive (2018)
[25] LoupVentures (2017)
[26] Wadud, Z. et al. (2016)
[27] Progressive Markets (2017)
[28] Biron (2017)
[29] Nano Magazine (2017)

METHODOLOGY

Methodology note on sequencing and cumulative trends. The relative impact of each trend is applied in sequence. Thus, the 15% potential reduction in oil demand for passenger vehicles is applied on the adjusted baseline demand after factoring in autonomous vehicles, shared economy, etc. The relative effects of each technology breakthrough are thus lower or higher in part depending on which place they take in the sequence.