FRAMING STRANDED ASSET RISKS IN AN AGE OF DISRUPTION

MATERIAL ECONOMICS

SEI STOCKHOLM ENVIRONMENT INSTITUTE

With contributions from

SEB

Svenska kyrkan

RATOS

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REFLECTIONS FROM THE CONTRIBUTORS

"As a long-term asset owner, we recognize that the rising temperature of our planet together with up-coming disruptive technologies and business models will cause stranded assets along many value chains. Whether we mitigate climate change or just try to adapt to the effects, we will see severe effects on the economy. Investors therefore need a practical tool how to assess the values at risk in their investment portfolios. This report is hoped to be such a tool. Based on three case studies, it provides guidance on how asset managers can integrate stranded assets risks into their investment analyses. We do believe this piece of work will be highly useful for investors, to protect and enhance value, also to the benefit for society at large."

Gunnela Hahn, Head of Sustainable and Responsible Investment at the Church of Sweden

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"All facets of economy are being disrupted at an increasing pace. Identifying stranded asset risks facing different industries should be valuable for bank and non-bank capital market participants as well as other economic actors. Going through the process of building non-linear future scenarios for industry sectors and considering key success factors for individual companies offers new insights and improves basis for decision making. The framework and methodology presented in this report offers a usefull toolkit for analysts, investors and bankers."

Jukka Honkaniemi, Senior banker, Chairman of Large Corporate Sustainability Committee SEB

"The private equity community is not immune to stranded asset risks. Although awareness about sustainability is growing, the financial analysis, investment processes and decisions seldom integrate these kinds of risks and disruptive developments. Given the signinficant ownership and longer term investment horizon of 5-10 years, where the next owner also might have at least a similar holding period in mind, we need to better incorporate integrated, disruptive scenarios 15-20 years out in time. The framework developed during this project provides a practical approach for the financial community at large, and is in my mind very applicable and helpful when assessing private equity investments."

Jenny Askfelt Ruud, Advisor Responsible Ownership and Sustainable Investments, previously Head of Sustainability at Ratos

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"This study explores the powerful mix that can arise when sustainability trends and business disruptions reinforce each other, potentially leading to entire sectors and business models to be turned on their head. There are plausible, large and material impacts in the near future for businesses and investors and a scenario thinking approach can help identify them. The methodology developed here is a wonderful starting point. Change might not be as far into the future as we might think."

Luca De Lorenzo, Head of Unit, Climate, Energy and Society at Stockholm Environment Institute

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PREFACE

The sustainability transition is gaining momentum. New sustainable practices are developing fast, policy makers are establishing regulation promoting more sustainable outcomes, and many companies are developing strategies to become more sustainable and to capture sustainability-related market opportunities. This is good news for all who believe a transition is necessary, and it also means many new markets and industries will grow, such as wind power, solar power, electric vehicles and many others.

This transition has attracted significant attention within the financial community, for good reasons: the asset base of entire industries will shift, and many of the most concerned industries are capital intense. But it is striking how much of the financial community's attention is directed towards financing the 'new'. There are numerous reports and industry initiatives on 'green finance', i.e. how to most effectively scale the financing of new green technologies and markets. While this is certainly needed, it is also striking how much fewer research and industry initiatives there are on the 'old' industries and assets, and what will happen to them. This is a big problem: if there is one lesson to learn from economic history, not least Joseph Schumpeter's work on 'creative destruction', it is that this type of massive transition will also mean massive stranded assets. Managing the stranded asset issue well will mean less unnecessary investment, fewer write-offs, less risk and fewer negative social consequences.

This is what our initiative starts addressing. Under the umbrella name of 'stranded assets', it looks at which assets are at risk of becoming economically unusable due to the sustainability transition and broader disruption risks, and it develops a practical framework for the financial community to identify and quantify stranded asset risk. We hope that the methodology will prove a useful decision-making tool for the financial industry. The report starts with a case study of the European electricity industry between 2010 and 2017 (which has already suffered major stranded assets), and then goes on to look at automotive, apparel, and a forward-looking perspective of the electricity sector – to see what the assets at risk are in those industries and how they can be quantified.

The project was financed by Vinnova and delivered by Material Economics and the Stockholm Environment Institute – with support and expert input from SEB, Ratos and the Church of Sweden Asset Management. While all project participants contributed considerably, each participant might not agree with every conclusion in this report, and Material Economics carries the responsibility for any errors.

We also want to thank all the many external experts who provided advice along the way.

Luca De Lorenzo, SEI

Per-Anders Enkvist, Material Economics

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ABBREVIATIONS

B2B	Business-to-business
BCI	Better Cotton Initiative
BEV	Battery electric vehicle
bn	Billion
CAPEX	Capital expenditure
CCGT	Combined cycle gas turbine
CHP	Combined heat and power
EBIT	Earnings before interest and taxes
ESG	Environmental, social and governance
ETS	Emissions Trading Scheme
EV	Electric vehicle
FSB	Financial Stability Board
GDP	Gross domestic product
GRI	Global Reporting Initiative
ICE	Internal combustion engine
IEA	International Energy Agency
IRR	Internal rate of return
KPI	Key performance indicator
LCOE	Levelized cost of electricity
MW	Megawatt
MWh	Megawatt hours
OEM	Original equipment manufacturer
OPEX	Operational expenditure
P/E	Price-to-earnings
PE	Private equity
PPE	Property, plant and equipment
PRI	Principles for responsible investment
PV	Photovoltaic
R&D	Research and development
SASB	Sustainability Accounting Standards Board
t	Tonne
TCFD	Task Force on Climate-related Financial Disclosures
TWh	Terawatt hours
WEO	World Economic Outlook
Wp	Watt peak

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EXECUTIVE SUMMARY

This project aims to understand which assets could become economically stranded as a result of the transition to a more sustainable economy and related disruptions. It also aims to develop a pragmatic framework for the financial industry to use when assessing stranded asset risks.

The key conclusions of the work are as follows:

1. Stranded assets are a major economic issue that deserves more attention. In the transition to a greener and more sustainable economy, the 'new' products, business models and markets get significant attention. While this is good, understanding what will happen to the 'old' industries and assets is also crucially important, as major economic values and employment opportunities are at stake. Economic history shows that such transitions often happen in waves of creative destruction, and in many cases it will not be incumbents adjusting to new market circumstances, but new entrants outcompeting incumbents. For some incumbent industries, the negative effects are obvious (e.g. in the coal and oil industries). But there are many other, less obvious industries that will also be hit: for example, electric vehicles do not have gearboxes and do not need fuel pumps, sustainable food production requires much less packaging and fertilizer, and so on.

2. The timeline of the sustainability transition makes it highly relevant for the financial industry to look carefully at stranded asset risk now. A key question in the project was whether the stranded asset risk is relevant to financial industry decisions today, or whether it lies further into the future. Our conclusion is that assessing these risks is already highly relevant. Credit decisions are routinely taken with a timeline of 5-10 years. Equity analysts typically consider the market at least 3-5 years into the future. And when private equity firms make an acquisition, they are often looking to hold the company for 6-9 years, and then sell to someone valuing cash-flows another 7-10 years into the future. In all of the industries assessed during this project, significant asset stranding might well happen within such timelines.

3. The European electricity industry has suffered impairments of €130 billion in the last 6 years alone, and has many insights to offer on how fast and non-linear the change can be also in capital-intensive process industries. The dramatic developments of the electricity industry since 2010 was used as a historic case study of asset stranding as a result of disruptive sustainability-related change. Mirroring the impairments, during the same time period, 7 out of the top 10 power utilities in Europe lost on average 65% of their share price 2010-2016. This is very surprising in an industry that 'on paper' should be very predictable: electricity demand is very stable and quite inelastic to price fluctuations, power plants have a 25-60 year lifetime, and electricity generation is an engineering-based B2B industry. So what explains such a dramatic turn of events, with massive stranded assets? The full explanation is given in chapter 2, but in a nutshell, what happened is that the growth of renewable technology and energy efficiency resulted in electricity demand growth for the incumbent technologies (gas, coal, nuclear) turning negative. This, in turn, led to a toxic mix of effects: run-hours decreased in the incumbent power plants, and in parallel, the contribution margin per run-hour also decreased as average and peak prices dropped. Perhaps most importantly, it became clear to financial analysts that wind and solar power were not merely marginal phenomena but could really eat into 'base load' production. Consequently, it became clear what was the 'old' and the 'new' of the industry, and analysts dramatically lowered growth expectations for the 'old'. In many ways this was a textbook example of disruption and creative destruction. It also caught many financial actors off guard, and the equity and credit rating reports from the last 5-7 years are not a pretty read. While hindsight is of course a major advantage, one cannot escape the impression that both the industry itself and the financial community could have seen the disruption coming a few years earlier – there was plenty of writing on the wall – which would have put an early stop to many investment projects that are now written down.

One important insight is that what happened in electricity could also happen in many other fixed asset industries, not least those located in mature slow-growing economies such as Europe. The change dynamic is generic: a low underlying demand growth turns negative for incumbents due to a new technology or business model. This in turn reduces utilization, contribution margins, and growth expectations. A new consensus view is formed, and investors quickly want out of the old and into the new, with major implications for valuations and asset stranding.

4. The project has identified up to ~€750 billion of assets in Europe exposed to significant risk of becoming stranded over the coming 10 years, in three industries: automotive, apparel, and further electricity write-offs.

4A. Up to ~€240 billion, or 40% of the total Enterprise Value, at risk in the European automotive industry. The automotive industry is being rapidly reshaped by three simultaneous trends, each one impactful enough to be called a disruption: electric vehicles ('EVs'), driverless vehicles, and car sharing services:

- **EVs.** Driven by very rapid improvements in battery technology (cost decrease of 77% during the last 5 years, with the improvement pace actually picking up), EVs are already cost competitive on a total-cost-of-ownership basis in many segments and are quickly approaching cost competitiveness even on a pure sticker price basis. This raises a whole range of difficult questions for incumbents, who have focused heavily on the combustion engine and drivetrain over recent decades, while outsourcing many other components of the car. An electric engine is much simpler than a combustion engine (20 moving parts compared to 2 000), and EVs do not even have gearboxes, so the risk of physical and intellectual assets getting stranded is obvious.
- **Driverless vehicles** are also closer than many think. Google's Waymo self-driving cars have by now clocked more than 3 million miles with virtually no incidents, and Uber is already testing self-driving taxis in both Singapore and Pittsburgh. This is a massive technology shift, and driverless functionality might be one of the most important selection criteria over the next years and has the potential to completely revamp mobility as we know it.
- **Car sharing.** European cars have a capital utilization of only 2% (they are parked 92% of the time and when driven, only 1.5 out of 5 seats are occupied)[1] and the value of the car capital stock is enormous (in Sweden alone, it is about 500 billion SEK or approximately 12% of GDP – 5 million cars with an average value of 100 000 SEK). Car sharing is an excellent way to better utilize this massive capital stock, and hence it is growing fast across the world. Since every shared car replaces 4 to 7 privately owned cars, sharing has the potential of driving a wedge into total car sales. Also, it will mean a different type of customer for car companies: fleet customers with higher demands and better negotiation abilities.

An assessment of which assets of the car manufacturers could become economically stranded as a result of these disruptions is presented in chapter 4. The overall conclusion is that property, plant and equipment ('PPE'), R&D capitalized into combustion technology and leased products are all at varying risk of stranding and have a combined worth of €134 billion for the European industry (22% of the enterprise value). But in addition to the asset-by-asset exposure, these combined trends also raise deep questions about the brand value and overall growth expectations of these companies. A test was made as to whether the same type of negative growth scenario that played out in the electricity industry could happen also in automotive, and the conclusion is that it is not at all difficult to create a similar scenario, with even much larger asset values at risk of stranding.

4B. Apparel. The European apparel industry's major ESG issues lie in its supply chain: water use, chemicals release, labor conditions and

[1] Stuchtey, Enkvist, and Zumwinkel.

compensation, and CO_2 emissions. Also, a particularity of the apparel industry compared to the other industries analyzed during this project is that balance sheet assets only make up for approximately 20% of the total enterprise value, while other capital market expectations (presumably growth and profit expectations from brand, design capabilities, customer loyalty) make up for the remaining 80%. The key question related to sustainability becomes: in the transparent age of pervasive social media, how big is the risk that the ESG issues highlighted above spill over to the apparel companies, and taint consumers' image of a specific company, and perhaps of the entire industry? What would this do to consumer spending? While some of the big apparel brands have high ambitions on sustainability in this supply chain, the research reviewed for this project also shows that they have a lot of work ahead of them on sustainability. The report analyzes this question together with the other megatrend for apparel companies – the ongoing, fast shift towards online sales – and asks what these two trends in combination can do to the brands and growth of apparel companies. We have not put a number to the stranded asset risk in apparel, but it is clear that it could be a substantial share of the total €351 billion enterprise value of the top-10 European apparel companies.

4C. Electricity sector – up to another €500 billion at risk? As explained above, the European electricity sector has already suffered impairments of €130 billion 2010-2015. But the technology shift in electricity is far from over, and more assets are at risk of getting stranded. Wind and solar power are enjoying very fast growth globally (solar growing at a dramatic pace of 39% per year globally), and prices for these new technologies decrease fast. New solar and wind power projects internationally have a *total cost* of generating electricity (including capital payments) for new installations that are already below the *running cost* of incumbent coal and gas power plants. This means it is already economically rational in some situations to shut down existing assets with remaining technical lifetime and replace them with new-built renewable power plants, a very dramatic tipping point. The stock market seems to have accounted for such a development much more than company financial reports: the enterprise value of the top-12 listed European utilities are at only 65% of their book value, a discrepancy of €239 billion in absolute terms. In total, the book value of PPE (property, plant and equipment) and goodwill sum to €496 billion for the 12 largest utilities in Europe, and it is no exaggeration to say that €300-500 billion of these assets are exposed to the risk of getting economically stranded. So it looks like the European utility sector is far from through its transition.

5. To frame and understand these risks, the financial industry needs to move well beyond current ESG approaches. A new methodology has been developed that we believe better captures the risks in the example industries studied. Methods of reflecting ESG impacts in investment analysis have developed fast over the last 10 years, and include methods such as norms-based exclusion, decarbonizing strategies, qualitative ESG ratings analyses, as well as other principles-based investment strategies (e.g. the approach and recommendations set by the Principles for Responsible Investment, PRI). Much current attention goes towards identifying 'material' sustainability issues and assessing those. While all this is certainly valuable, a key message from this study is the deep interlinkages between sustainability and other major technology and business model changes (e.g. driverless vehicles, sharing, e-commerce), and the spiraling negative growth dynamic that the combination of these can imply for the incumbent industry. Such risks are not systematically addressed in most legacy ESG analysis approaches, and therefore a major conclusion is that analysts who wish to understand the value implications of the sustainability transition need to integrate ESG analyses with traditional financial value assessments. The methodology created in this report consists of developing a quantitative understanding of the key disruptions hitting the industry (both sustainability-related and not), combining them to scenarios, testing whether there is a real risk that the growth of the incumbent industry could turn negative in any of these scenarios, and then quantifying the impact on the major asset types in the industry.

2

CASE EXAMPLE OF STRANDED ASSETS IN THE UTILITY SECTOR 2010-2015

The development of the European utility industry since 2010 offers valuable lessons about how quickly and dramatically seemingly stable industries can change as a result of sustainability, and what implications this can have for investors. For the large utility players, a combination of renewable power technologies, energy efficiency and a weak economy created a toxic mix of negative growth, low utilization, and substantial margin pressure. The result? Impairments of €129 billion over just 6 years, and market capitalization losses of 200 billion across just the 10 largest public utilities (figures 2.1 and 2.2). If the industry and the financial community had seen the risks just a few years earlier, this would have meant massive savings and a more orderly transition.

This chapter reviews what happened in the utility industry, and what the financial community said and did during the crisis, and discusses what lessons can be learned now that other industries are heading into the same rapid transition.

2.1 What happened in the utility sector?

Let's use 2005 as the starting point for the analysis. That was a good year for most European electricity producers: electricity prices were high in most of Europe's core geographical markets, driven by a healthy demand growth, by high coal and gas prices, and by the newly established European cap-and-trade system for greenhouse gas emissions which created large 'windfall' profits for many generation companies. In most integrated utilities, the generation business represented a majority of earnings and the power plants were seen as the core assets of the company. A wave of mergers and acquisitions ensued, perhaps encouraged by the industry's high profitability, and many geographic markets were consolidated as large players battled for positions.

Building new generation assets was a big part of the growth plans of many utilities. In many countries, the rule of thumb was that if GDP grew by 1%, electricity demand grew 0.5-0.8%. The IEA, one commonly used source for demand forecasts, projected that European electricity demand in 2014 would be about 280 TWh higher than in 2005, and similar estimates were a common starting point for the industry's capacity planning.

Total impairments for the 10 largest public power companies in Europe was €129 billion 2010-2015, and accelerated at a rate of 24% per annum

Impairments for the electric power sector in Europe 2010-2015

Accumulated, Bn EUR

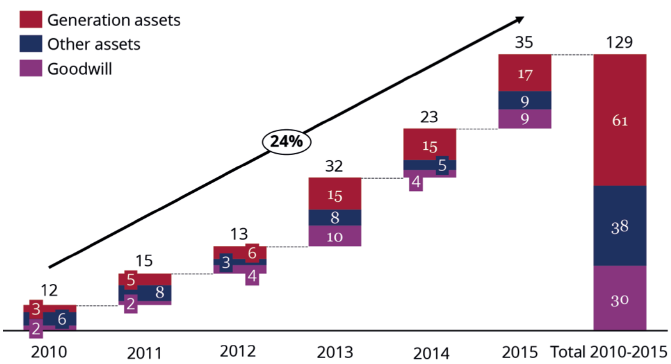
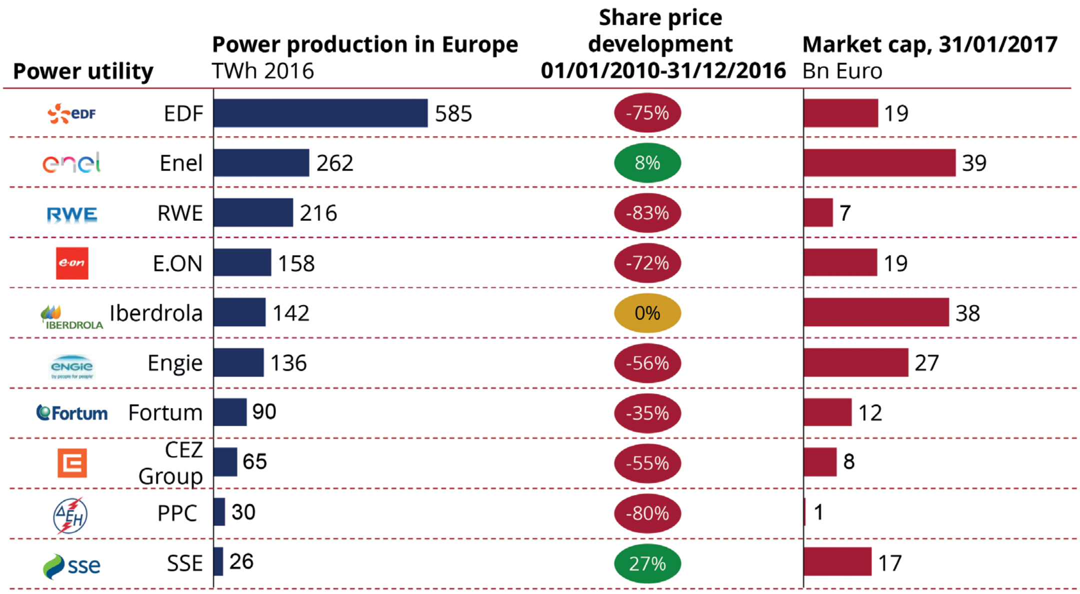


Figure 2.1 Impairments for the electric power sector in Europe[2,3]

[2] Impairments per region: Continental Western Europe and Nordics (47%), UK (12%), Southern Europe (14%), Eastern Europe (9%), Non-specific (19%) (when region has not been possible to determine).

[3] "Benchmarking European Power and Utility Asset Impairments."

Of the 10 largest public electric power utilities, 6 of them have seen share prices drop by more than 55%, 2010-2016
Development for the 10 largest public power utilities in Europe 2010-2016



E.ON divested the fossil fuel part of the company into Uniper 2016, which is included in market cap figure (€4.7 bn). Share development for E.ON is taken during the period from 1 January 2010 to 1 January 2016 given the divestment
Source: Company IR websites

Figure 2.2 Share price development of public power utilities in Europe[4]

As figure 2.3 shows, the reality turned out to be very different: first, the financial crisis hit in 2008 and 2009, and caused a major dent in European GDP growth, and until 2014 it destroyed 140 TWh of the projected growth. Second, the ratio of electricity demand growth to GDP growth turned out to be lower than forecasted, as energy efficiency improvements were faster than forecasted, wiping out another 419 TWh of 2014 demand. Finally, renewable electricity technologies – which have a very low marginal cost and hence always run once built and once the weather permits – grew and wiped out another 98 TWh of demand. All in all, the projected growth went from a positive 280 TWh to a negative 400 TWh for conventional technologies, or put differently, demand for electricity from conventional technologies dropped approximately 20%.

This development created a toxic triple-hit effect for conventional power generation technologies, and hence for incumbent players:

First, for the reasons laid out above, it lowered utilization in the large-scale power plants whose economic viability is built on high utilization.

Second, prices decreased, and so utilities reaped less revenue for each of the (lower) number of GWh they were able to sell. There were three major reasons for this in addition to the supply glut:

1) Solar had a disproportionate effect on margin generation. In Germany, for instance, solar PVs reduced peak prices by between 40% and 60%, see figures 2.4 and 2.5. The explanation is easy: solar PVs have low marginal production cost and peak in their production during afternoons when the demand is at its highest (and when traditional utilities achieve the highest margin). In total, the average daily price in Germany fell 30-40%[5] from 2007-2016.

[4] 1) E.ON divested the fossil fuel part of the company into Uniper 2016, which is included in market cap figure (€4.7 bn). Share development for E.ON is taken during the period from 1/1 2010 to 1/1 2016 given the divestment. Source: Company Investor Relations websites. 2) Includes Innogy which was split from RWE.
[5] EEX, IEA WEO, Eurostat.

2) The global price of hard coal fell, not least because the US shale gas revolution made gas outcompete coal in US power production, leaving US coal producers with few options but to flood global markets with cheap coal.
3) CO_2 prices fell, as the cap-and-trade system proved to be oversupplied with emission rights. That these two last factors made electricity prices decrease is perhaps surprising to non-specialist readers. This is due to the fact that coal- and gas-fired power plants typically have the highest marginal cost and thus set the price in many geographies. If their marginal production cost decreases, this will decrease the electricity price for the entire market.

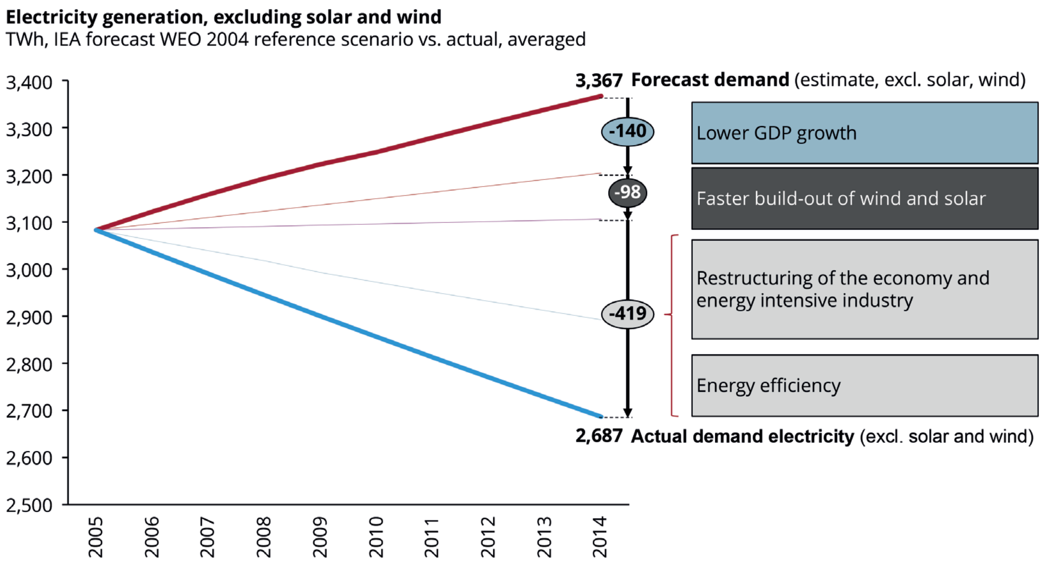
Third, growth expectations for conventional technologies plummeted during these years, most visibly for publicly traded companies. As utilization and profitability of coal- and gas-fired power plants decreased drastically, closures and mothballing became commonplace. In parallel, climate change concerns increased, and solar PV, wind, and battery technology improved dramatically. All this created a paradigm shift among companies and investors: it became obvious what was the 'old' and what was the 'new' in the power system, and it became clear the industry was in a fast transition. As soon as this became clear, companies and investors quickly wanted out of the 'old' and into the 'new'. In Germany, this was further accentuated by the government's decision to phase out nuclear power rapidly following the Fukushima disaster. Today, very few investors in Europe see a future in which new coal- or gas-fired power plants are built.

Combined, these three effects led to the massive impairments and market capitalization decreases as described in figures 2.1 and 2.2. Importantly, a comparatively small addition of renewable power technologies (the growth of 428 TWh 2005-2014 only represents ~14% of the total market) led to a *tipping point* in the industry and to a *disproportional impact* on the profitability and valuation of the entire asset base. A feeble positive demand growth was turned to a negative growth, which very often has this type of disruptive impact in fixed asset industries.

The business environment can change dramatically in just a few years – example electricity

Electricity generation, excluding solar and wind

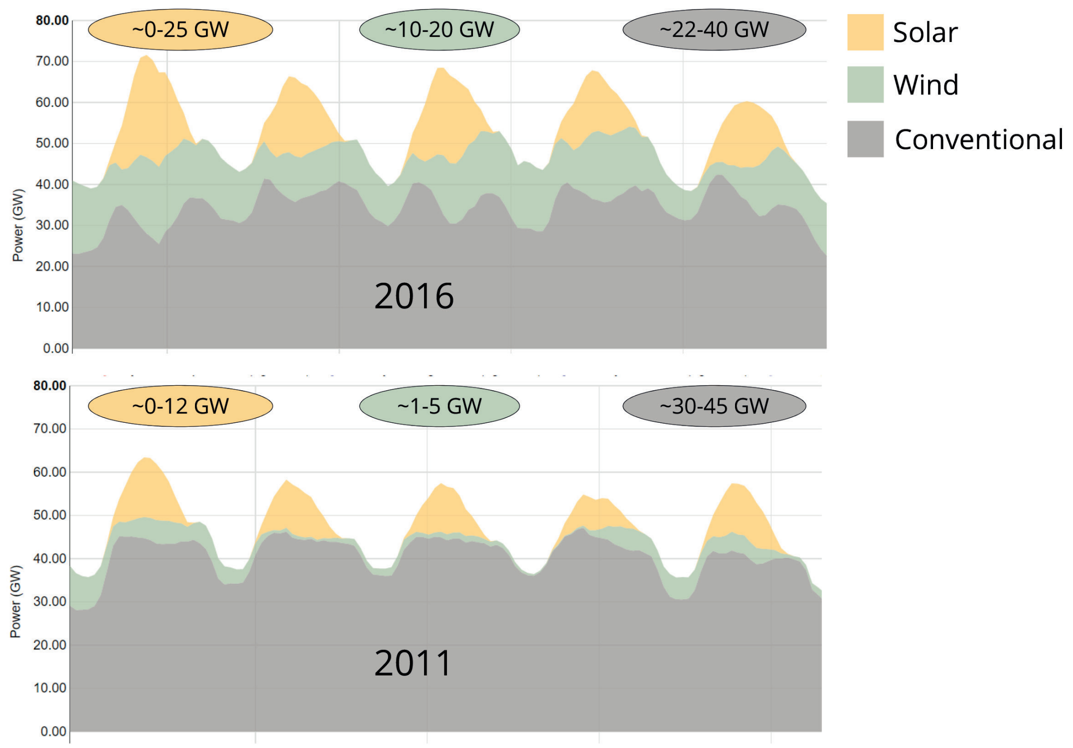
TWh, IEA forecast WEO 2004 reference scenario vs. actual, averaged



Implied demand in 2014 based on growth forecast until 2020 by IEA in 2004 World Energy Outlook reference Scenario
Source: IEA WEO2004 reference scenario, Eurostat statistics

Figure 2.3 Forecasted demand of conventional electricity compared to actual

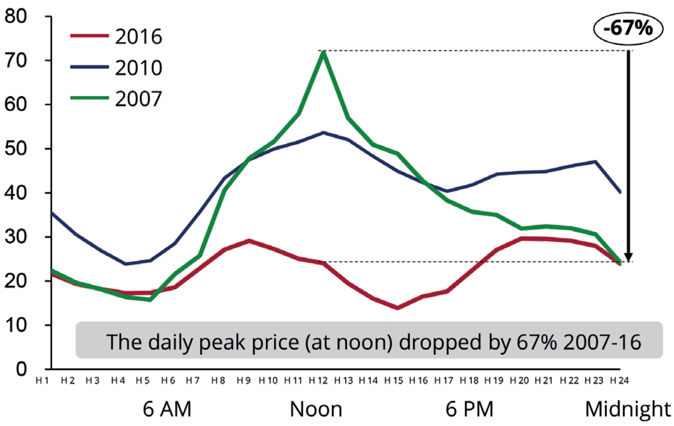
Renewable load increased from a maximum of 17 GW daily to 45 GW in only 5 years
Power production per source, Week 19 2016 and 2011



Source: Fraunhofer

Figure 2.4 Peak production of renewable energy in Germany[6]

Daily peak-prices and volatility was dramatically reduced by renewables
Wholesale electricity hourly spot-prices in Germany
EUR/MWh, average hourly prices during May



Source: EEX

Figure 2.5 Changes in daily peak prices and volatility due to renewables

2.2 Could the developments have been predicted?

If parts of this development had been acknowledged just a few years earlier, enormous values would have been saved: construction of new fossil plants would have been stopped earlier, reducing impairments. And with more foresight, investors and lenders could have reduced exposure earlier.

Hindsight is always a great advantage, and of course all of what happened was impossible to foresee, but a fair and important question to ask is *whether more of the development could or should have been foreseen?*

Our top-line answer is that a large part of what happened actually was predictable, and that this was not a black swan event (an extremely unlikely and unforeseen event with very large impact).

[6] Burger, "Electricity Production from Solar and Wind in Germany in 2013."

In more detail:

- The policy makers' push towards decarbonization and renewable power was largely predictable. There were many targets, subsidies, and statements indicating this, both at the national level and at the European level. Already the 2001 European directive contained renewable energy targets and there was full commitment behind the '20/20/20' targets that were established in 2009, and which stipulated 20% renewable electricity by 2020. Beyond adding up current targets and legislation, the political momentum should have been clear. It would not have been unreasonable for a utility to put in a 'base case' assumption of new policies and targets supporting the renewable transition.
- The changing electricity/GDP growth ratio should also not have been impossible to foresee. It was the result of measures taken by companies to lower energy consumption and thereby costs but also the result of companies moving their production facilities.
- The financial crisis and ensuing low GDP growth was hard to predict, but should have been one out of several scenarios in companies' strategy planning. The total European GDP growth 2009 to 2014 was 6.1% – not an improbably low number.
- The decrease in coal and CO_2 prices in our minds was difficult to foresee – the coal price decline was driven by the US shale gas revolution and the CO_2 system was brand new, multi-sector, and highly complex.

All in all, this makes about half of the demand decrease predictable, and a big share of the other half a realistic scenario. Also, the fact that these trends could turn a weak underlying demand growth negative, with the negative spiraling effect described above, was not impossible to predict.

Interestingly, many companies went ahead with major construction projects well after the 2008 financial crisis and the 2009 20/20/20 targets. One result was that Uniper, RWE and Engie collectively had to make impairments of half the original construction cost of coal power plants brought online in 2015. RWE alone, made write-downs of €2.3 billion[7] in 2013 on their Dutch gas and coal portfolio, including one 1.6 GW coal plant that was finalized in 2015. In 2012, Vattenfall opened a gas power plant in the Netherlands[8] which only 2 years later was taken out of service, with impairments amounting to 30 billion SEK[9].

2.3 How did the financial industry understand these developments?

The interviews and analyses we have done suggest that the financial sector lagged behind the power industry in understanding these developments. Instead of pulling the break, equity analysts kept predicting a bright future and increasing market valuations for the large utilities. To illustrate, figure 2.6 shows how the average of individual price target estimates submitted by covering sell-side analysts (forward-looking, 6-12 months) was continuously predicted to be higher than the actual price, despite the stock being on a consistent downward trajectory.

The credit side reacted in a similar way and in 2013 some of Europe's biggest power companies had all lost positions on Moody's credited rating, as described in figure 2.7 – a clear sign of the magnitude of the crisis for the sector during this time.

2.4 What can other sectors learn from the utility sector?

We suggest three lessons for other sectors from what happened – and continues to happen – in the power sector:

1) There is a clear '*snowball*' effect when many sustainability trends combine, making the combined effect much bigger and more dramatic than just the sum of the individual effects. This in turn can easily escalate to a tipping point when expectations change quickly, and observers can distinguish the 'old' from the 'new'.
2) It is important for both companies and investors to assess policy *intent* as much as actual policies *implemented*.

[7] Wynn, "The Dutch Coal Mistake."
[8] Kerpner, "Staten Tjänar Gigantiska Pengar På Föroreningar."
[9] "Kolkraften Ökar Vattenfalls Utsläpp."

The target price was continuously predicted to be higher than the actual price despite the difficulties the industry went through

Evolution of target price and actual price of the E.ON stock (E.ON SE)

EUR

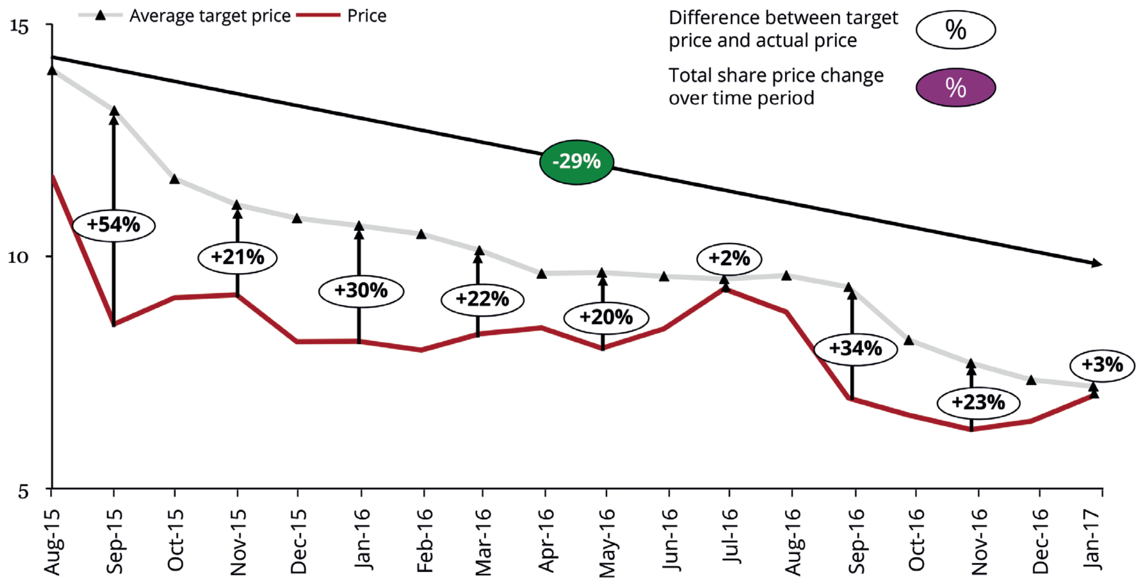


Figure 2.6 Predicted stock price for E.ON compared to actual price

Moody's kept downrating some of Europe's biggest utility companies. In retrospect, a sign of the magnitude of the crisis

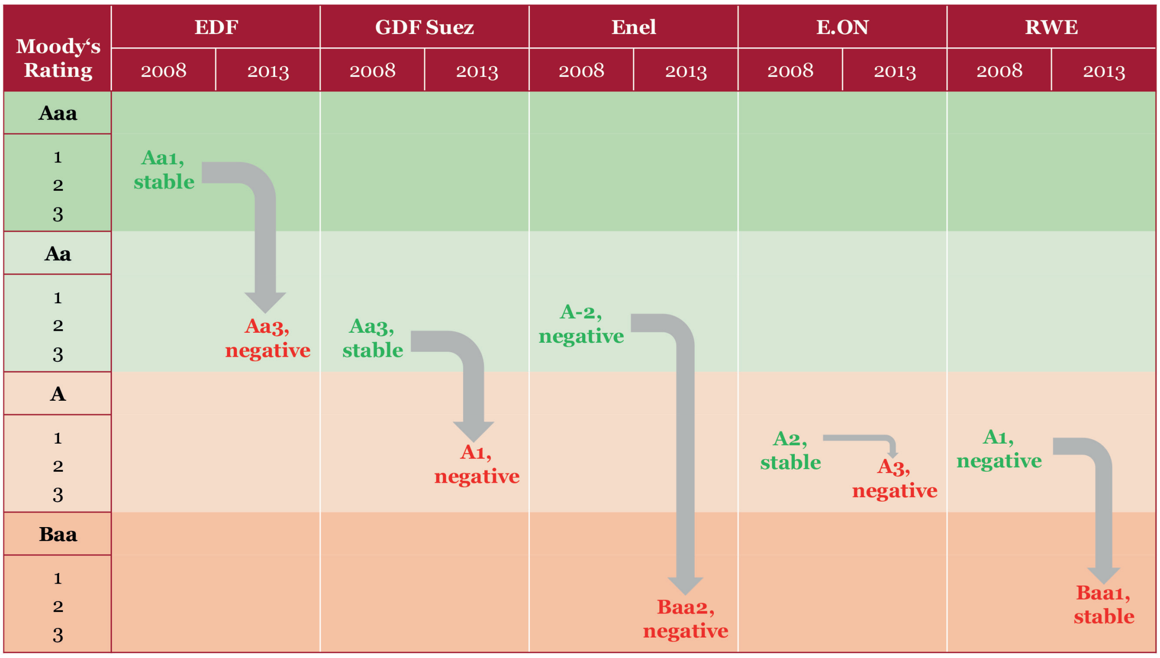


Figure 2.7 European power companies downrated by Moody's during the financial crisis[10]

[10] "Moody's Downgrades EDF to Aa3; British Energy Upgraded to Baa3, Still on Review for Upgrade"; "Moody's Downgrades GDF SUEZ to A1; Outlook Stable"; "Moody's Downgrades Enel's Ratings to Baa2; Outlook Negative"; "Moody's Downgrades E.ON's Ratings to A3/P-2; Stable Outlook"; "Moody's Downgrades RWE's Ratings to Baa1; Outlook Stable."

3) Industries with a high share of fixed assets and low demand growth are specifically vulnerable to the sort of dynamics described above. This includes many energy-intensive and manufacturing industries.

We see a huge importance in trying to predict such developments.

3

METHODOLOGY: FRAMING STRANDED ASSET RISK IN AN AGE OF DISRUPTIONS

This chapter presents a pragmatic methodology for framing the stranded asset risk in different industries. It consists of three steps, which are described in detail in this chapter:

Step 1: Assess potential disruptions and combine them to scenarios

Step 2: Test for spiralling negative dynamics

Step 3: Translate to asset-type implications

Step 1: Identify possible disruptions, develop an approximate quantification of how fast they are developing, and combine them to scenarios.
Step 2: Assess what impact the scenarios can have on the growth of the incumbent industry or incumbent technology. Specifically test for the type of negative spiraling dynamic that was so hurtful to the electricity industry.
Step 3: Quantitatively map the main asset types of the industry in question and assess what impact the scenarios can have on each asset type.

This chapter outlines the methodology that was developed during the project to frame stranded asset risk in an age of disruption. The aim was to develop a methodology that practitioners in the financial industry find relevant, and that yields both qualitative lessons into what could cause asset stranding, and also some degree of quantification (while acknowledging that exact quantification in an age of disruption is a near impossibility). The methodology was gradually refined during the project, based on discussions with practitioners in the financial industry, and what they found most value-adding and practically doable.

The chapter first puts the methodology in the context of current practices in the financial industry and discusses what is new and different. It then describes the methodology step by step, in the hope that this can act as a guide for interested members of the financial industry. Finally, it discusses the relevance and applicability of the methodology to different groups of users within the financial industry.

3.1 Context to understand current financial industry approaches

One of the key conclusions from this project is that the financial impact of ESG-related developments should not be assessed in isolation. In electricity, as chapter 2 showed, it was the combination of environmentally motivated technology shifts (wind power, solar power) and broader developments (lower-than-foreseen GDP growth, closures of energy-intensive process industries in Europe) that created the negative spiraling effect. In automotive, as chapter 4 will show, the total impact can only be understood if the electrification trend (which is largely environmentally driven) is assessed together with the trend towards driverless technology (which is not). Therefore, to understand how the financial industry looks at these same topics today, and how our methodology can add value, let us first separately look at how ESG-related issues are analyzed and reported, and then how disruptions are analyzed.

3.1.1. Current financial industry approaches to analyzing and reporting ESG

ESG (environmental, social and governance) topics have received much more attention among companies and the financial industry over the last 20 years. Figure 3.1 illustrates the different types of reporting and how they have evolved. Hazardous materials have been reported since the 1960s in many advanced economies and standards for environmental management and reporting were introduced in the 1990s with the introduction of ISO 14000 being the most well known. ESG reporting only really got onto the reporting map with GRI, which was launched in 1997 and got broad attention in 2005-2010. GRI helps businesses and governments worldwide understand and communicate their impact on critical sustainability issues such as climate change, human and labor rights, governance and social well-being. The issue many users see with GRI, however, is the wide range of KPIs its standards suggest companies should report. This drives hours, and sometimes makes it hard to see the wood for all the trees. GRI, in its new GRI Standard, has therefore tried to improve the focus on what is essential for the specific company.

As a reaction to these issues, a sophisticated 'materiality' approach has been developed by the Sustainability Accounting Standards Board ('SASB'), encouraging companies to focus their analysis on the handful of ESG factors that really matter to overall company performance. Materiality is a quite new development which has only gained real traction since 2015, and many companies are still working out what factors are material to them and how to analyze and report those factors. But already now, it is clear that materiality resonates with the financial community, as it focuses on the core performance drivers of companies.

Finally, the Task Force for Climate-Related Financial Disclosures ('TCFD') is an effort under the umbrella of the Financial Stability Board ('FSB'). TCFD is aimed at the financial sector and those sectors that have a major impact on the climate or are strongly affected by it. TCFD reported its findings in June 2017, and its key recommendations are that climate-related risks and upsides should be connected much more clearly to company value and financial measures, that both physical and transitional impacts should be reported, and that this climate reporting should be *integrated with financial reporting*. TCFD suggests that companies should set themselves a five-year time horizon for achieving this much more

Investors now start to require environmental reporting to be linked to actual business value

	Environmental management systems and regulation	Resource metrics	'Materiality' reporting	Value-relevant reporting
Key organizations (examples)	• National and local environmental regulators, ISO	• GRI, CDP	• SASB, UN Global Compact	• TCFD
What	• Processes and systems for reporting • Mandatory reporting of specified substances	• Reporting list of resource-related metrics	• Focus on a number of resource- and other sustainability metrics that matter	• Sets objective of relating climate to value • Transition + physical
Why	• Measure & manage operations, influence supply chains	• Transparency of natural resource use and CO_2 emissions	• More pragmatic, leaves time to analyze the issues that matter	• FSB / investor need to manage climate value risks

Focus on reporting past and current performance. Covering the whole ESG agenda.

Focus on current performance and future value risk. Covering climate and technology with a strategic approach.

Figure 3.1 Development of environmental reporting focus over time

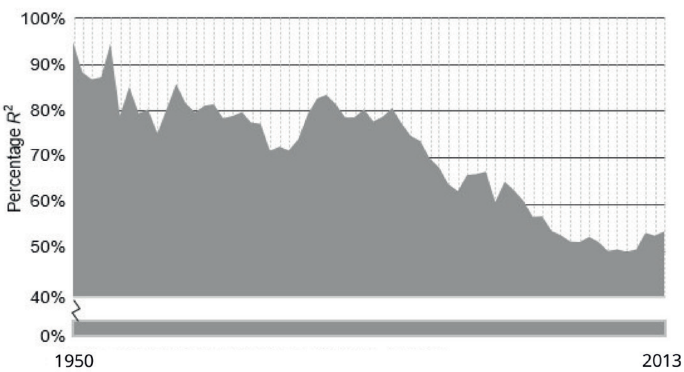
advanced and financially relevant reporting. TCFD's recommendations are not legally binding, but many in the financial community believe they will set a de facto standard for how well-run companies report on climate and other major ESG developments. It is worth noting that GRI and SASB are covering the whole ESG agenda while TCFD focuses on climate. GRI also has focus on conduct while the TCFD has a more strategic approach.

3.1.2 Current financial industry approaches to analyzing disruptions

Financial analysis in itself is developing in parallel with the ESG developments described above. One key trend is that financial analysis has become much more difficult over recent decades, since the value of companies has become more disconnected from their financial reporting. In their much-cited book *The End of Accounting and the Path Forward for Investors and Managers* from 2016, authors Baruch Lev and Feng Gu show that while financial accounts could explain 85-95% of the market capitalization of the S&P 500 in the 1950s, that figure was down to just over 50% in 2013 (see figure 3.2).

'End of accounting' and the increasing importance of non-financial data

Correlation between market capitalization and accounts (specifically earnings and equity book value)



Source: End of Accounting and the Path Forward for Investors and Managers, Lev & Gu, 2016

Figure 3.2 Development of how much financial accounts can explain market capitalization[11]

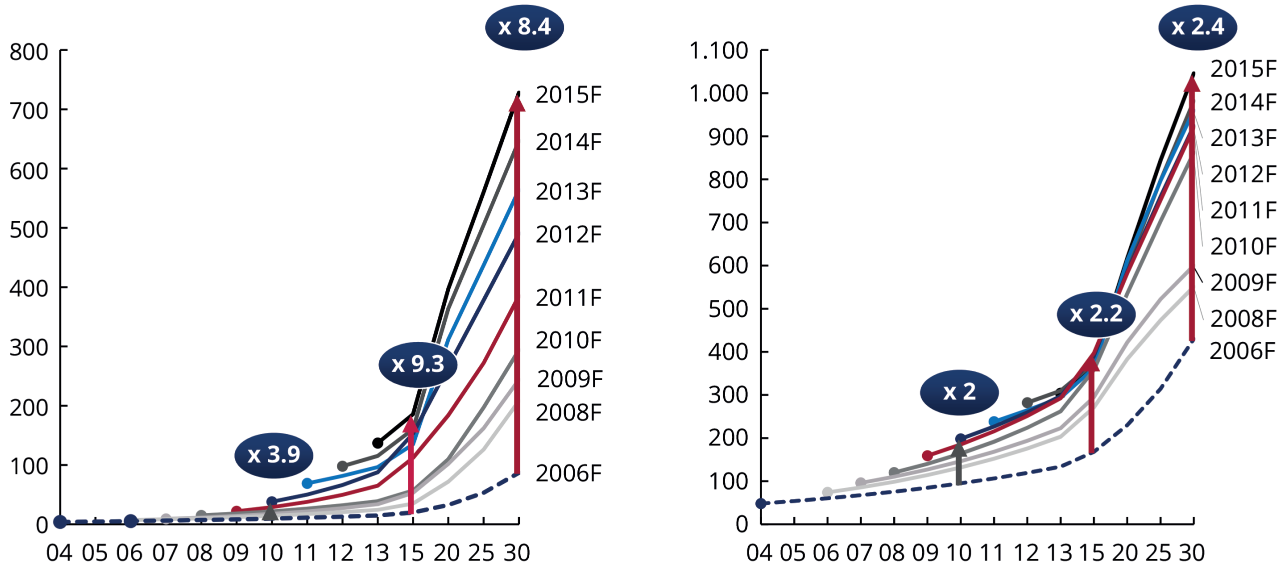
The main explanation that Lev and Gu identify is that in the 1950s, the 'strategic resources' of a company (the assets and resources crucial to its value creation) were largely physical assets, which could be well reflected in financial accounts. Today, instead, the most strategic resources are often intangible, such as brands, capabilities, or customer networks. These, in turn, are much more difficult to adequately value in financial accounts.

In this context, disruptive developments are particularly difficult to assess and value. A full mapping of how different actors within the financial industry today assess disruptive developments goes beyond the scope of this report, but a few tentative conclusions can be drawn from the experience of the project group and the interviews conducted during the project:

1) *Disruptive developments are often modeled based on historic extrapolations.* Financial analysts often use extrapolations of historic trends when forecasting the future. And for good reason – it is obviously a very good starting point. The problem, of course, is that disruptive developments, by definition, do not follow historic trends, and therefore it becomes a problem if too much weight is given to historic extrapolations. Figure 3.3 illustrates this latter phenomenon. It shows the forecasts for solar PV and wind growth from consecutive versions of the International Energy Agency's ('IEA') *World Energy Outlook* between 2006 and 2015. During these 9 years, the IEAs 2030 forecast for these two technologies increased by factors of 8.4 and 2.4, respectively. Analysts' linear extrapolations of historical growth of these renewable technologies consistently underestimated future growth, with dire consequences for financial and operational decisions in this industry, as the previous chapter showed.
2) *Few institutions look at disruptions systematically, across industries.* Few institutions we know of gather analysts from different sectors to look at disruptions from an economy-wide perspective. But there are several ongoing disruptions, not least related to digitization and sustainability,

[11] Lev and Gu, *The End of Accounting and the Path Forward for Investors and Managers*.

Effects of non-linear change routinely underestimated
International Energy Agency's forecasts for global cumulative capacity for renewables (GW)



Source: IEA World Energy Outlook (2006, 2008-15)

Figure 3.3 Renewable energy forecasts compared to linear extrapolation of historic change[12]

which will have major impacts across the economy: driverless automotive technology will of course impact the automotive sector, but will also have major implications for many types of distribution businesses, retail businesses and logistics. If the solar PV disruption continues, it will mean very cheap clean energy in many parts of the world, with massive implications not only for the energy sector and all its sub-suppliers and customers, but also for processing industries around the world. There are many other examples.

In summary, we see the financial industry's needs from an ESG and a 'generalist' point of view coming together: from both points of view, the next level of financial analysis is about understanding how a set of disruptions, some ESG-related and others not, can impact company value. The methodology presented below presents our best attempt at what such an approach could look like. The final steps of the methodology focus on stranded assets, but the first steps are generic and should be relevant also to a broader financial analysis.

3.2 Methodology for framing stranded asset risks

The methodology starts by identifying the disruptions at work in the industry under analysis and describes quantitatively how each might play out. It combines the disruptions to a set of scenarios that illustrate the total effect of all the main forces at work. Secondly, since this methodology is focused on stranded assets, it asks whether a similar 'spiraling negative growth' dynamic as we saw in the electricity industry could happen in any of the scenarios, where a new paradigm quickly takes hold of an industry, and radically changes expectations. Thirdly and finally, it looks at the key asset types (plants, leased products, capitalized R&D, etc.) within the industry, and analyzes how each asset type could fare in each of the scenarios, and specifically what the risk of stranding is.

Some of these steps are 'traditional' and are part of most financial analysis. But there are also a few things we believe are quite novel compared to how most analysis is done today: 1) This is a much more valuation-oriented approach than most ESG analysis conducted today, 2) The methodology marries

[12] "World Energy Outlook 2006."

together ESG analysis with general financial analysis in a way that will be novel to many organizations. As the chapters on electricity and automotive show, this is crucial to reaching a realistic understanding of how these sectors might develop, 3). The specific focus on the 'old' technology and business model and the analysis of negative growth dynamics is an important aspect that we think is new to most organizations. Finally, we also believe there is a value to putting together all the steps into one coherent methodology.

3.2.1 Step 1: Assess potential disruptions and combine them to scenarios

The first step aims to build a better understanding of the potential disruptions that may impact the industry, and then to combine these to dynamic scenarios.

The methodology steps are as follows:

Step 1.A: Identify and prioritize disruptions that may hit the industry. These will sometimes be sustainability related, but may also be related to digitization or other megatrends. The stranded asset risk is a result of the combined impact of all of these disruptions, so it is important not to pre-emptively limit the assessment to a certain type of disruption. Having said this, it is also important to prioritize heavily once all potential disruptions have surfaced: in all the sectors assessed during this project, 3-4 disruptions came out as significantly more important than the others. The potential disruption identification and the prioritization was done using expert interviews, articles and reports.

Step 1.B: Explore and quantify future development paths of the prioritized disruptions. Again, we suggest doing this through expert interviews and literature review. For most of these trends, there are plenty of reports and other research available. Much of the work tends to be compiling a quantitative view of each of the disruptions, e.g. reports on possible electric vehicle penetration in different time frames. Beware that these reports will also often underestimate rather than overestimate the change. Further, one must explore what qualitative implications each disruption would have on the sector in a value chain perspective (as an example, electric vehicles require much less maintenance, reducing the size and attractiveness of the aftermarket substantially).

Overall methodology

Step 1: Assess potential disruptions and combine them to scenarios

- **A** Identify and prioritize disruptions that may hit the industry
- **B** Explore and quantify future development paths of the prioritized disruptions
- **C** Form scenarios of the disruptions to explore their combined effects

Step 2: Test for spiraling negative dynamics

- **A** Ask whether a scenario could become the new norm and what negative spiraling dynamics this could lead to
- **B** Ask whether a scenario could create negative business growth for the incumbent as the "new" solutions would be superior to the incumbent

Step 3: Translate to asset-type implications

- **A** Identify and quantify main asset types
- **B** Expose each asset type to the scenarios developed
- **C** Conclude on stranding risk in each asset type and in total

Figure 3.4 Overall methodology for framing stranded asset risks

Step 1.C: Form scenarios of the disruptions to explore their combined effects. Specifically explore how the disruptions impact each other. In automotive, for instance, both the mobile internet disruption and the electrification disruption dramatically facilitate the sharing disruption, since they make booking, key delivery and 'fueling' so much easier. And often, technological disruptions also change customer behaviors and policy. Creating such scenarios is an art as much as a science, and we will not go into details here, since there is already a broad range of literature on how to best develop and use scenarios in many different fields. The well-known 'Shell scenarios' have been prominent in the energy sector since the 1970s and can serve as a good source of inspiration.

3.2.2. Step 2: Test for spiraling negative dynamics

As chapter 2 described, what happened in the European electricity sector was a negative spiraling dynamic, where several trends and disruptions reinforced each other to create a nightmare for the conventional industry, with major asset stranding as a consequence. The turning point was when the paradigm of the industry shifted, or put differently, when a new consensus view was formed. When it became clear to everyone what was the 'new' (renewable technologies) and the 'old' (fossil fuels) in the industry, expectations and valuations changed quickly. When applying this methodology to the automotive and apparel sectors, it became clear that such negative spirals are not difficult to construct for those sectors either. And what is happening to these sectors today has of course already happened to many other sectors in the past (the typewriter, the analogue camera, the fixed-line phone…), often with fast and dire consequences.

Step 2.A: Ask whether a scenario could become the new norm and the base case in the industry. To start the testing for spiraling negative dynamics, we found it helpful to ask ourselves whether the new disruptive technology or business model could become the new norm and 'base case' in the industry.

Step 2.B: Ask whether a scenario could create negative business growth for the incumbent. Are there disruptive technologies, business models or scenarios where the 'new' is just a better choice for the customer on every dimension, and where the customers' question will very quickly turn from 'why choose the new technology', to 'why on earth not'? Let us look at a few examples:

- In electricity, solar PV is now already the cheapest source of new power in countries close to the equator, and its competitiveness frontier is quickly moving to colder climates, as it continues its dramatic cost decrease. If solar is cheaper than fossil and nuclear alternatives, does not emit greenhouse gases, is modular so it does not require investment in the billions, and has a much lower political risk than incumbent alternatives, then why should any customer in a few years choose anything else? If the new solar value chain cannot scale fast enough to meet customer demand, will customers even prefer to wait a year or two instead of investing in long-lived alternatives seen as technologies of the past? Could sales of the old technologies not gradually decrease but completely collapse in a similar time frame?
- In automotive, imagine that you as a private individual go to buy a car in 2022 or 2024. Then many forecasts say EVs will beat gasoline and diesel cars on total cost of ownership and in many segments also on sticker price, and that most of today's range issues will have been resolved. With better acceleration, lower maintenance costs, less noise, less pollution, no need to go to the gas station, why would any consumer choose anything else? Could sales of gasoline and diesel cars not gradually decrease, but completely collapse in a similar time frame?
- In apparel, e-commerce is already 27% of global sales and growing at 20% a year compared to ~0% a year for offline sales. In 5 or 10 years, when the online offering has continued to improve with more products, better logistics, lower prices, and more internet-savvy customers, and physical stores simultaneously have continued to lose customers and have had to limit their range, will we reach a tipping point where for broad categories of apparel, physical stores are simply not competitive? Their product range might be an order of magnitude thinner, and their prices higher? Could sales through physical apparel

stores more or less collapse for many categories in a similar timeframe? Will the default question for most apparel consumers quickly become one of 'why should I go to a store?' rather than 'could I get this online'?

These questions are deliberately formulated in black and white terms, to challenge conventional industry thinking. But then, of course, one also needs to put numbers to the developments. The growth framework in figure 3.5 below turned out to be useful. It starts by identifying the underlying demand growth in a 'business-as-usual' scenario, and then looks at what negative 'growth wedges' different new technologies and business models could create in one of the alternative scenarios developed in Step 1. The key question is how extreme are the assumptions one needs to put into the model to make growth go negative or substantially negative in the next 5-10 years. If it is easy to put together a permanent negative growth scenario without stretching assumptions very far, this should be a reason for major concern about asset stranding in the incumbent industry. For the electricity sector in figure 3.5, the changes on an individual basis were not all that dramatic but put together they resulted in a dramatic reduction in demand of conventional power and a resulting negative development for the industry.

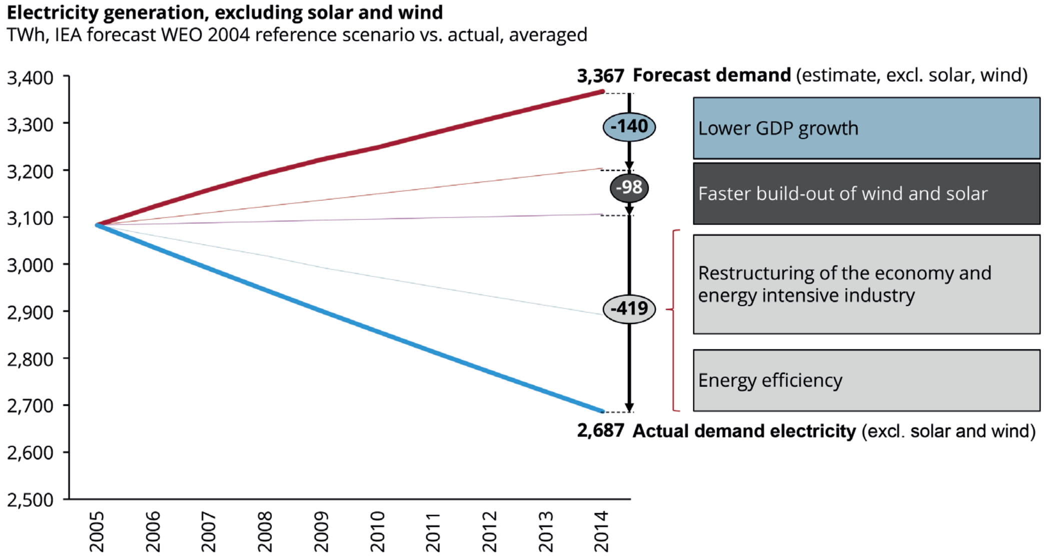
The framework focuses on growth because growth is easy to model but yet captures the type of spiraling dynamic we wish to capture. It also tends to be very strongly correlated to cash-flow.

3.2.3 Step 3: Translate to asset-type implications

Different asset types have very different resilience to the disruptions and scenarios described above. In general, assets that are long-lived, inflexible, and that require a high utilization to be profitable are the most vulnerable to asset stranding.

Step 3.A: Identify and quantify main asset types. The end product of the first step is to develop a breakdown of the company or sector enterprise value into groups of assets that will react similarly to

The business environment can change dramatically in just a few years – example electricity
Electricity generation, excluding solar and wind
TWh, IEA forecast WEO 2004 reference scenario vs. actual, averaged



Implied demand in 2014 based on growth forecast until 2020 by IEA in 2004 World Energy Outlook reference Scenario
Source: IEA WEO2004 reference scenario, Eurostat statistics

Figure 3.5 Example of how to test for negative spiraling dynamics and negative growth[13]

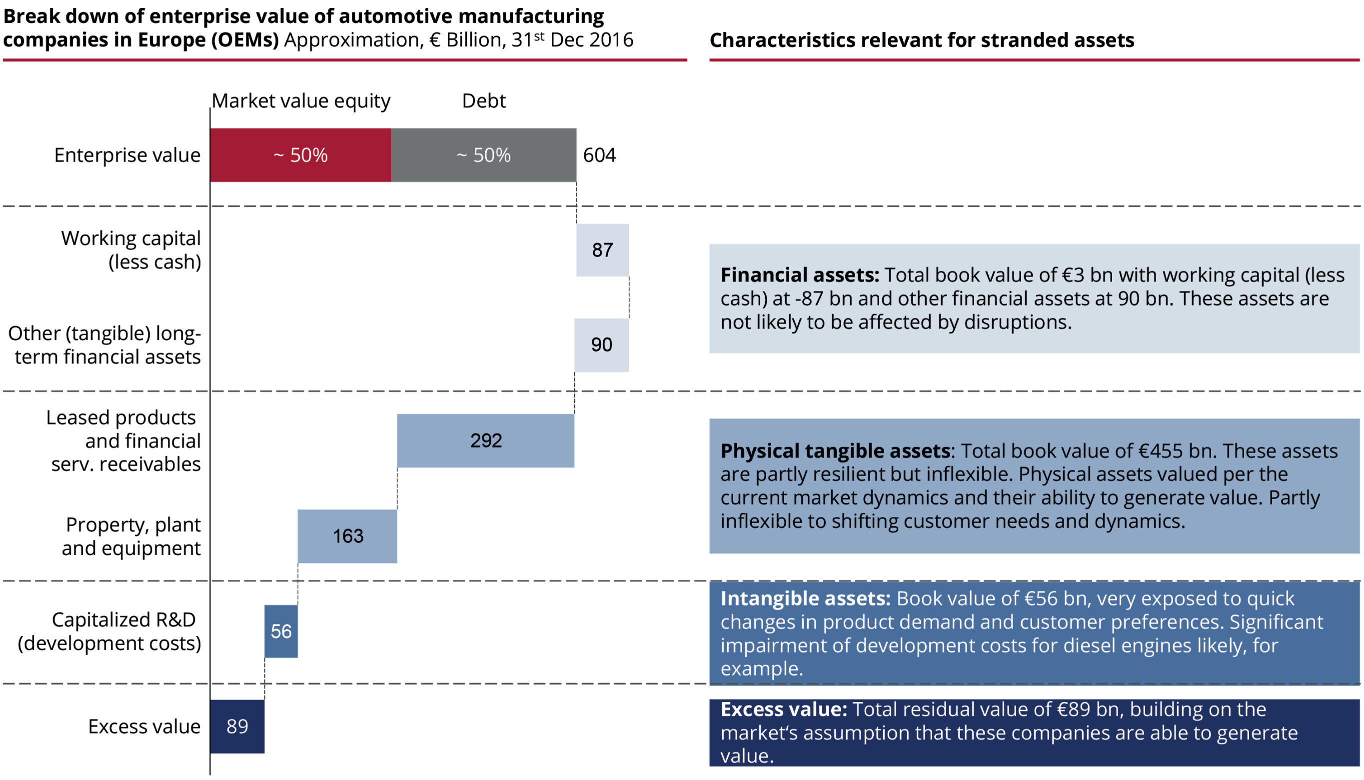
[13] "World Energy Outlook 2004."

disruption, see figure 3.6 for an example from the car industry. For an experienced analyst with access to standard financial workbench tools, this step should be a matter of hours rather than days.

In more detail, the analytical steps are as follows:

- Decide on which companies to include in the scope. In the case of the European car industry, seven groups make up for >95% of all car sales, so they were taken as proxies for the entire European industry.
- Break down the balance sheet of each company into homogenous asset types (for instance plants, capitalized R&D) and value these from the balance sheets of the companies. This step requires a bit of experience, but is certainly within the grasp of most analysts. For the type of industries this project is mostly concerned with ('heavy' industries with major environmental footprints) physical assets often make up a large share of the enterprise value.
- Obtain the combined enterprise value for these companies. This is easily available from standard financial analysis tools, or just from the internet. 'Explain' as much as possible of the enterprise value, bottom up, from the balance sheets. There will be a residual gap to get to the total enterprise value. This gap is the capital market's total assessment of all the other less easily valued parts of the companies, for instance growth expectations or brand value. Extrapolate to the total sector as needed.

The enterprise value of automotive manufacturers at ~€604 billion, represented by ~75% physical assets and ~24% intangible assets



Note: Market cap for the 8 largest automotive manufacturers in Europe (including subsidiaries): VW, FCA, BMW, Daimler, Renault, PSA, Volvo Group, Volvo Cars. Asset values latest available numbers, from 31 December 2016.

Figure 3.6 Example of how to break down the enterprise value in asset types

The steps outlined above present the methodology as a very mechanistic one, but of course applying qualitative knowledge into what is really worth something in the sector studied is also of crucial importance and will add to the insight. Continuing to use the car industry as an example, this industry has long seen the engine and drivetrain as their core capabilities and has outsourced many other parts and assembly processes. Now that engine technology might shift from combustion to electric in many segments, this raises fundamental questions as to how valuable the core capabilities of some of the car manufacturers will be in the future.

Step 3.B: Expose each asset type to the scenarios developed. The second step consists of analyzing how resilient each asset type is, and how it will fare in each of the scenarios developed. In our experience, it is useful to first do this analysis qualitatively, before doing it quantitatively.

- Characterize the asset types according to their resilience. Cash and other short-term working capital is typically not at any major risk of stranding, whereas long-lived physical assets (e.g. a tanker ship) or assets specific to a certain threatened technology or customer group (e.g. capitalized R&D on the diesel engine) are much more vulnerable. Assets that require a high utilization to be economically viable are especially exposed.
- Systematically apply both the disruptions individually and the combined scenarios to the asset types of the industry in a qualitative way. Let us again use the electrification of cars as an example to illustrate this. The implication of the trend is that the powertrain of the car transforms completely; therefore, assets tied to the production of these components will be exposed to the risk of being stranded, especially if the assets are inflexible and the transition fast. Based on the qualitative understanding, quantitatively estimate the assets at risk of getting stranded from each scenario. This is of course not an exact science, but our experience from the industries assessed is that the asset group breakdown, in combination with the assessment of how flexible each asset type is, gives a higher precision than one might expect.

Step 3.C: Conclude on stranding risk in each asset type and in total. Combine the numbers from the previous step to derive the total assets at risk of stranding. Here, different financial actors will take different approaches: credit analysts, focused on the default risk, might pick the worst scenarios and spend extra time assigning probabilities to those, and comparing to the debt/equity position of the relevant companies. Equity analysts might rather look across all scenarios and average them or pick a 'central scenario' that they consider most likely.

3.3 Relevance to different actors within the financial industry

Different actors within the financial industry have very different needs and opportunities when it comes to assessing stranded asset risks. Here, we briefly discuss the relevance for three different types of actors: fundamentals-driven actors in public markets, actors in private bi-lateral markets, and broad asset owners.

3.3.1 Fundamentals-driven actors in public markets

We believe the methodology described above should be a very relevant complement to the way many actors in public markets (e.g. asset managers, and the equity analysts who advise them) work today. In many sectors, disruptive developments are so important that in many ways, applying this or a similar methodology is almost compulsory for an ambitious asset manager or equity analyst. Also, the additional time required to apply the methodology should be within reach for many such organizations. Or to turn it around, if thinking through disruptive developments in a structured way is not within reach, then perhaps that is a sign that the organization is sub-scale.

Asset managers and equity analysts often think 3-4 years into the future. Developments further into the future are only relevant if they can be translated back to possible market movements in approximately this time horizon. Often, a key question when it comes to disruptive developments becomes 'when will the consensus view change', i.e. when will the rest of the market change its expectations on different technologies and business models – hence impacting valuations. Judging from the case studies we have looked into during this project, *the moment when underlying growth for incumbents goes to zero might be a very important warning sign* to look at. This might be a trigger point to sell, as zero growth might mean that a tipping point in consensus view is upcoming. When incumbent growth has gone to zero, then the new technology or business model has already scaled, so performance of the new technology will likely continue to develop fast for scale reasons if nothing else. Financial analysts will only require another year or two of track record before putting negative growth expectations for the incumbent technology into their models.

3.3.2 Actors in private, bi-lateral markets

Actors in private, bi-lateral markets include, for instance, private equity investors and banks giving corporate credits. These actors work in much less liquid markets, and make deeper commitments to a single company, than actors in public markets do. Typically, actors in private and bi-lateral markets have to think 10-15 years ahead and can afford to spend even more time analyzing individual sectors and companies.

Most capable private equity investors and lenders are already using scenario approaches to assess future risks, but we believe this methodology will anyway be a useful complement in many situations through forcing a discussion about non-linear developments and adding structure, timelines, and case examples. Compared to the generic methodology described above, we believe private equity (PE) investors and lenders will also spend much more time assessing whether the specific company they are looking at will be able to adapt to the disruptive trends, how capable its management is, and so on.

In terms of early warning signs, it is not enough for PE investors and lenders to understand when incumbent growth is going to zero – then it might in many cases already be too late to take the right decision. One useful 'earlier' warning sign might be to find if there is any new technology or business model that is unequivocally better (such as the electric vehicle) and specifically if a new entrant has already scaled and proved the commercial viability of this new technology (e.g. Tesla). If this is the case, then one could expect zero growth for incumbents a few years later, and the shift in consensus view following a few years later yet.

While this report looks at major companies in different sectors, private equity firms often invest in small and medium-sized companies in the supply chain of larger internationals. These companies are even more at risk for stranded assets in an age of disruption, since they generally depend on one or fewer products, and have fewer financial capabilities to change course if needed (e.g. a company focusing on injection pumps in the car). It is therefore even more critical for private equity companies to understand the risks related to stranded assets.

3.3.3 Asset owners

Finally, we believe that the types of value shifts that this methodology helps identify are relevant and investable for many asset owners. The work would be similar to the work described above for asset managers, but with one big difference: asset owners' mandates are typically broader, so asset owners would have to apply the methodology to more sectors and compare them, to understand what sectors and asset classes should be over- and under-weighted. This is entirely doable, but is still a challenge for many smaller asset owners, who might not have the personnel resources to conduct this type of effort. Since many of the smaller asset owners lack the internal resources to conduct much analyses themselves, they are often clients to larger asset managers and can ask them or even require them to do the stranded assets analyses, using their purchasing power.

4

STRANDED ASSET RISK IN THE EUROPEAN AUTOMOTIVE SECTOR

The automotive sector is undergoing an unprecedented transformation that over the next decade will expose up to €243 billion in asset value to a risk of becoming economically stranded.

Summary of findings in the automotive sector

Step 1: Assess potential disruptions and combine them to scenarios

A Three major disruptions include electric vehicles (EVs), self-driving cars, and car sharing services.

B EVs/hybrids are expected to represent up to 21% of the global fleet by 2030. Many car makers have also publicly stated that they aim to have fully self-driving vehicles by 2020-2021. Finally, car sharing is growing fast, with European membership rates increasing at 50-70% per year.

C Four scenarios were formed combining (1) individual car ownership versus sharing, and (2) speed of EV breakthrough with self-driving technology. The disruptions are also mutually reinforcing, with e.g. self-driving technology speeding up sharing.

Step 2: Test for spiraling negative dynamics

A EVs, self-driving, and car sharing services could all become the new norm in the industry, since these trends hit an inefficient system with huge improvement potential (e.g. car utilization is about 1.5% since cars are driven productively 5% of the time, and then only 1.5 out of 5 seats are occupied).

B Negative growth dynamic is highly possible. The underlying demand growth for cars in Europe is already slow and the three disruptions could all take out a substantial 'wedge' from the growth of petrol and diesel cars. The negative spiral then accelerates with less-utilized plants, intensified price competition, and investors starting to see clearly what is the 'old' and the 'new'.

Step 3: Translate to asset-type implications

A Main asset groups include leased products and financial service receivables (€292 bn), property, plant, and equipment (€163 bn), and capitalized R&D (€56 bn).

B Capitalized R&D is at risk of getting stranded since a majority is tied to the combustion engine powertrain. Also property, plant and equipment is at risk because much of the production line investments are tied to a specific car platform or model, with a life-length of 7-10 years.

C The scenario with shared electric self-driving cars growing fast has up to €247 bn at risk of being stranded. Here the car is almost completely transformed with a new drivetrain and also a new business model logic, affecting heavily both physical assets and capitalized R&D.

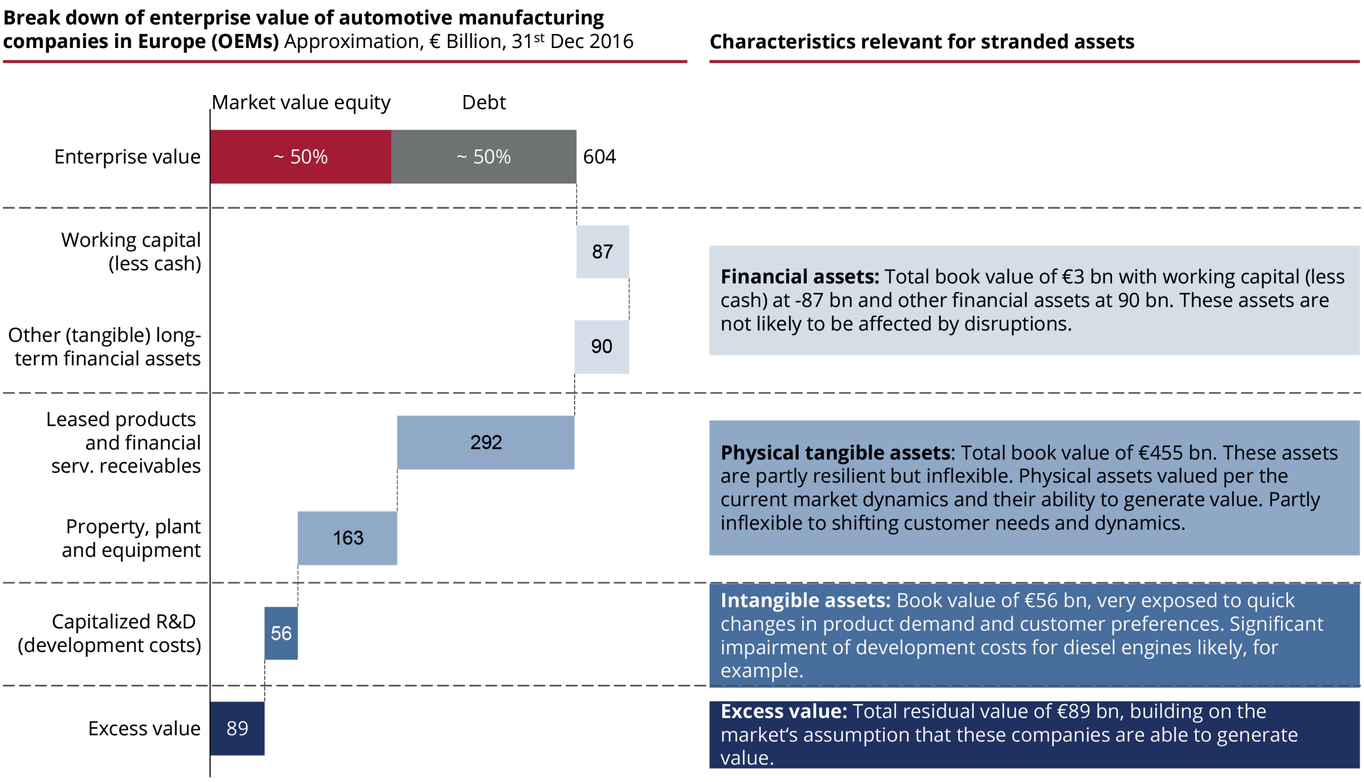
4.1 Introduction: the automotive sector and its assets

The total enterprise value of the European car industry was €604 billion on 31 December 2016[14]. Figure 4.1 breaks down this total enterprise value into different types of assets.

When analyzing automotive assets, it is also important to understand the major outsourcing trend that has happened in automotive manufacturing over recent decades. Most car companies have defined the engine and powertrain, the final assembly (including just-in-time delivery from a complex supply chain), design and marketing as their core competencies. Most components have been outsourced to the supply chain. As figure 4.2 shows, the car manufacturer itself adds less than €6 000 value-add, out of a total of almost €18 000. Of the ~€6 000, the engine and powertrain is by far the largest individual item.

This specialization has helped car companies achieve ever greater efficiencies, but it also leaves them more vulnerable to disruption: their suppliers are most often happy to sell components also to other car manufacturers. Deutsche Post DHL's 'Streetscooter' is a good example. In 2016, Deutsche Post DHL announced it had earlier decided the automotive industry was too slow in developing the

The enterprise value of automotive manufacturers at ~€604 billion, represented by ~75% physical assets and ~24% intangible assets



Note: Market cap for the 8 largest automotive manufacturers in Europe (including subsidiaries): VW, FCA, BMW, Daimler, Renault, PSA, Volvo Group, Volvo Cars. Asset values latest available numbers, from 31 December 2016.

Figure 4.1 Enterprise value breakdown of European automotive manufacturers

[14] European car industry here represented by the 8 largest automotive manufacturers: BMW, Daimler, FiatChrysler, PSA, RenaultNissan, Volkswagen, Volvo Cars, Volvo Group.

fully electric delivery vans that Deutsche Post DHL wanted[15]. Hence, Deutsche Post DHL developed its own van, called the Streetscooter, stating that it only needed 50 skilled engineers since the supply chain was so developed. Between 10 000 and 15 000 Streetscooters per year will be developed, covering all of Deutsche Post DHLs own needs, and in spring 2017 the company announced it will start selling the Streetscooter also to others. In a year, Deutsche Post DHL had gone from being one of Volkswagens largest customers to instead becoming a competitor.

4.2 Three major disruptions in the automotive sector

Three transformative trends have been identified for the automotive sector: electric powertrains, autonomy (self-driving), and sharing (i.e. non-personal ownership models – also highly related to multi-modal mobility).

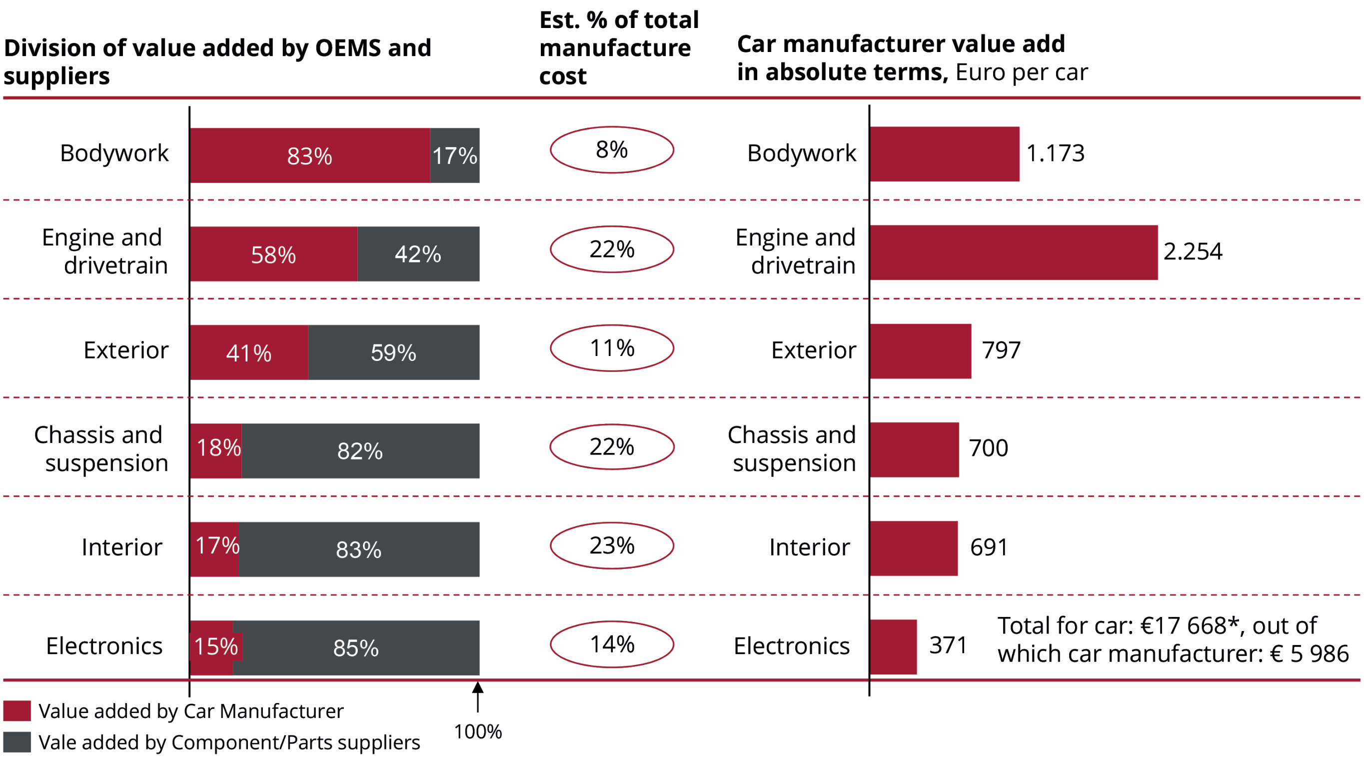
Each of these trends will have a very strong impact on the future of the automotive industry, and one can quite easily argue that each one of them individually has the power to 'disrupt' the industry. Together, their impact spells a revolution in how cars are made, used, and owned, with revolutionary implications for the car manufacturing industry.

This section will first review each one of these trends, and then use scenarios to describe what their total impact might be.

4.2.1 The electric vehicle avalanche

On paper, the advantages of electric vehicles (EVs) compared to gasoline and diesel cars have been

Today, the majority of the value in a car is developed and added by the supply chain



Source: PWC ~ how to be number 1 facing future challenges in the automotive industry
* Cost breakdown converted to euros: McKinsey (2012), The future of the North American Automotive Supplier industry: Evolution of Component Costs, Penetration, and Value Creation Potential Through 2020

Figure 4.2 Value added by car manufacturers and suppliers[16]

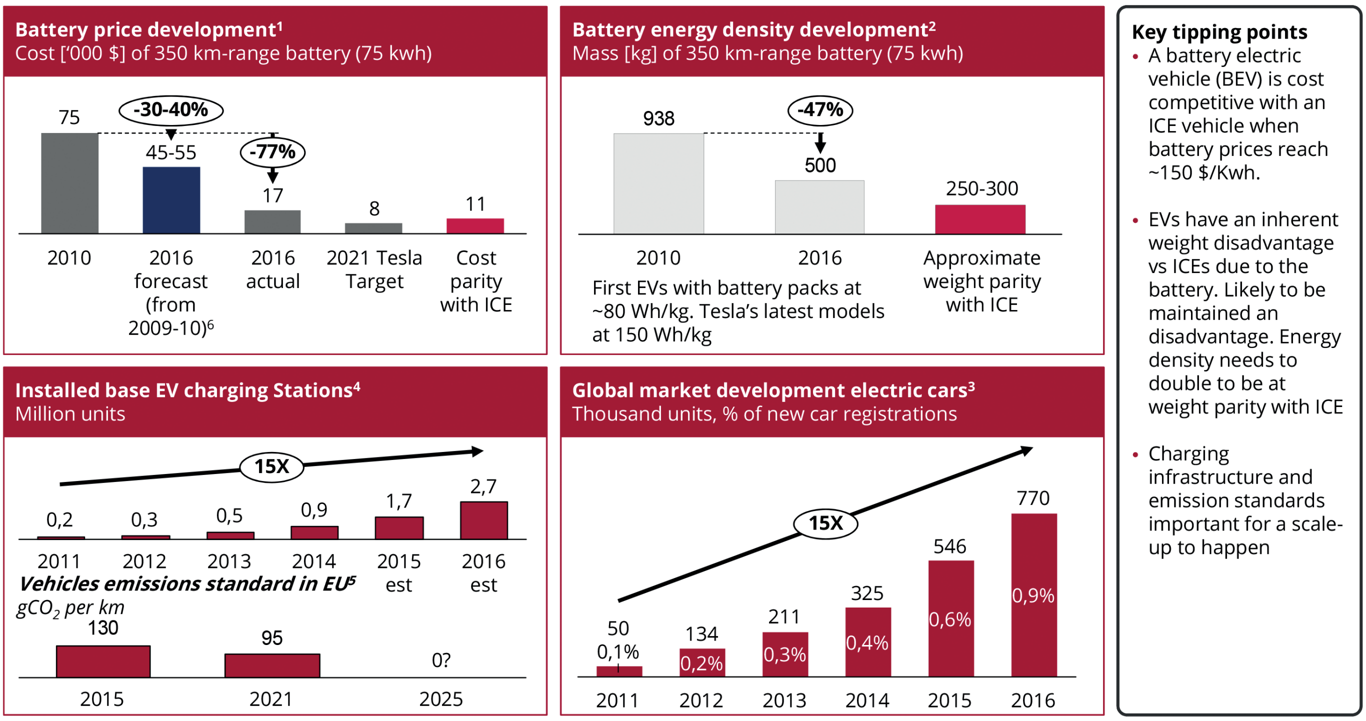
[15] Taylor, "Deutsche Post Van Signals New Entrant Threat to Auto Industry."
[16] "How to Be No. 1 Facing Future Challenges in the Automotive Industry."

known for decades: they are virtually CO_2-free (if run on renewable electricity), do not cause any other local air pollution, reduce oil dependence, are silent, have better acceleration, more interior space, and much fewer moving parts, therefore requiring much less maintenance, and finally have a lower center of gravity and hence better road grip. This is a long list of advantages.

The disadvantages have also been obvious for decades: price and range, stemming from insufficient battery technology. As a result, EVs have always been limited to very specialized applications (e.g. indoor transportation and golf carts).

But over the last 5 years matters have changed dramatically, and over the coming 5 years, we believe the *base case assumption should be an electric revolution*. Figure 4.3 summarizes some of the key battery technology developments: costs have decreased by 77% since 2010, and energy density doubled. Costs are already now on par with combustion cars on a total-cost-of-ownership basis (i.e. if one off-sets the higher sticker price against much lower fuel costs during the cars' lifetime) in some long-miles segments (e.g. taxis). Also, Tesla, BMW and others have dramatically changed the image of EVs. Whereas the previous generation of hybrids and EVs (e.g. Toyota Prius, Nissan Leaf) were

Electric vehicles have developed rapidly given battery improvements, but still account for only 0.9% of sales



Source: 1) McKinsey 2016, 2) Janek et al. Nature Energy Sep 2016, 3) http://www.ev-volumes.com/country/total-world-plug-in-vehicle-volumes 4) IHS May 28 2015, 5) The ICCT, Policy Update January 2014, 6) IEA, McKinsey, BCG 2010, batteries for electric cars, 7) assumes ICE weight drive-train of 280-340 kg, engine 170-200 kg, tank 60-80 kg, gear box, exhaust system, oil pumps etc. 50-60 kg, EV-engine and inverter 30-40 kg

Figure 4.3 Improvements in battery prices and energy densities[17,18,19,20]

[17] "Global Plug-in Vehicle Sales for 2017 H1 + July, August Update."
[18] Janek and Zeier, "A Solid Future for Battery Development."
[19] "Global EV Charging Stations to Skyrocket by 2020."
[20] "EU CO_2 Emission Standards for Passenger Cars and Light-Commercial Vehicles."

primarily marketed as green and efficient ways to reach the same performance, the Tesla and BMW i8 have shown that EVs can achieve a much better performance.

Looking forward, Tesla has set the target of reducing cost by another factor of two by 2021, which would make the total EV cost on a par with combustion cars also on a pure sticker price basis. This would mean maintaining the long list of advantages, while turning also the two disadvantages into advantages. As one expert interviewed put it, "Even for car lovers, there will be no reason not to go electric".

Policy makers are also increasingly targeting gasoline and diesel cars. Many large car markets now have policies targeting the transport sector, which accounts for 14% of global greenhouse gas emissions[21], see figure 4.4. Simultaneously, local air pollution has made individual cities such as London, Paris and Oslo ban diesel cars in city centers due to nitrogen oxide emissions. The competition between combustion and electric vehicles is not taking place on a level playing field – the judges are actively trying to make EVs win as fast as possible.

So there seems to be little doubt that the vehicle fleet will be substantially more electric in the future. But how fast will it go? In 2016, 95.8% of the cars sold in Europe were still driven by gasoline or diesel – the remaining 4.2% were a mix of alternative fuels out of which only 1.5% were battery electric[22]. There are 2030 scenarios ranging from below one percentage point of the 2030 global vehicle fleet, to 21% of the global fleet.

Lack of global CO_2 policies creates a more volatile and fast-moving policy environment for many sectors – example vehicles

Announced policies for electric vehicles / against diesel/petrol vehicles

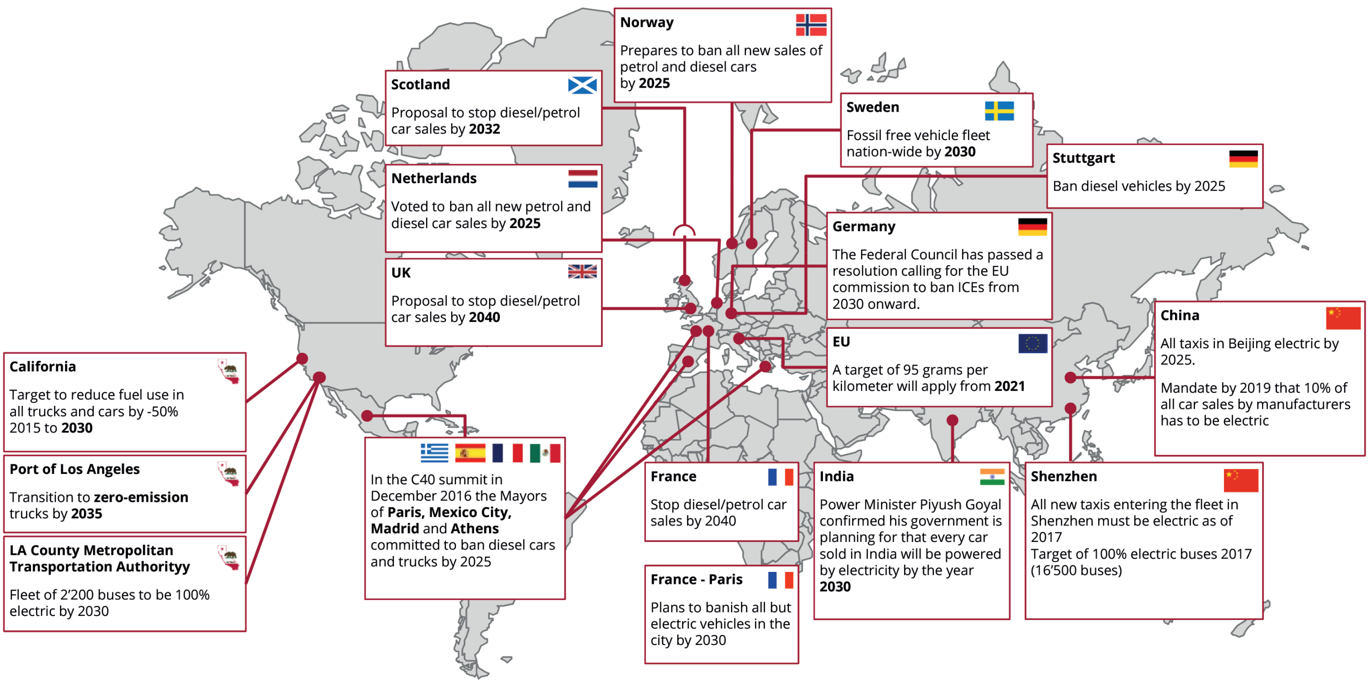


Figure 4.4 Countries and regions taking stricter measures on internal combustion engines[23,24,25,26,27,28]

[21] Edenhofer et al., "Summary for Policymakers."
[22] "Passenger Cars EU."
[23] Hanley, "China Will Replace All 67,000 Fossil-Fueled Taxis In Beijing With Electric Cars."
[24] "Reduction in CO_2 Emissions of New Passenger Cars."
[25] Deign, "Which Country Will Become the First to Ban Internal Combustion Cars?"
[26] "On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulation."
[27] Agerholm, "India to Make Every Single Car Electric by 2030 in Bid to Tackle Pollution That Kills Millions."
[28] Allen, Lopez, and Ransom, "Zero-Emission Vehicles and Infrastructure."

For 2040, the most aggressive scenario is that 64% of the global fleet could be electric, see figure 4.5.

This project has not developed its own scenario for EVs, but there are two lessons from the electricity sector assessment that are worth keeping in mind: 1) There is a tendency of modelers to underestimate the pace of change in breakthrough technology situations such as this. We saw a pattern in the electricity sector where the forecasts for solar and wind were substantially increased year after year. 2) Incumbent *growth* matters as much as absolute numbers – one of the tipping points in electricity was when incumbent growth turned negative.

4.2.2 Driverless cars – closer and more disruptive than one might think

Automation of driving is the next disruption identified. It has not yet started to scale as EVs have, but it could be even more dramatic in its implications.

Let us quickly review where driving automation is today, and what targets companies are setting for themselves. A significant degree of automation is already built into premium brand cars today as figure 4.6 indicates. Parking assistance, self-parking, adaptive cruise control systems, and automatic lane-keeping are among common features. These functions already require the cars to have a fairly sophisticated sensor system that is aware of its surroundings and emerging 'intelligence' to act on the information received. This is often referred to as 'level 2' automation.

There are also cars acting at level 3. Google's experimental car has by now (13 November 2017) driven 3 million miles independently, without causing any major accident[29]. Tesla's models S and X have all

There is no agreement on the future penetration of electric vehicles in the global LDV fleet

Scenarios for electrification of the global light-duty-vehicle fleet

% of the fleet of light-duty-vehicles globally that are plug-in-hybrid or battery-electric

Scenario	2030	2040
Imperial College / CTI Strong policy-scenario (2017)	21%	54%
Imperial College / CTI Weak policy-scenario (2017)	19%	55%
Statoil Renewal Scenario (2ºC) (2016)	14%	64%
IEA 2ºC-scenario ETP (2016)	10%	20%**
Statoil Reform Scenario (2016)	10%	45%
Bloomberg New Energy Finance (2016)	8%	23%
Paris Declaration (100 mn EVs by 2030) (2015)	7%	NA
Shell Mountain Scenario (2013)	6%	20%
Statoil Rivalry Scenario (2016)	6%	28%
BP BAU Energy Outlook (2017)	2-3%*	12-15%
IEA 4ºC-scenario ETP (2016)	1.6%	NA
Exxon Reference Scenario (2016)	1.5%	4%
OPEC Ref Scenario. World Oil Outlook (2015)	0.4%	2%

* BP Scenario applies only for 2035 at 6% of global fleet

** IEA-Scenario gives only 10% in 2030 and 40% in 2050. 2040-number interpolated

Figure 4.5 Scenarios of electric vehicle development for the global light-duty vehicle fleet

[29] "Waymo."

the hardware built into them to act at level 3, and the software is at a level where in most situations the car can drive itself, but the (human) driver is still for safety and regulatory reasons required to closely monitor the vehicle. Many other car makers have stated publicly that they aim to have fully self-driving vehicles (level 4) ready to launch by 2020-2021. Volvo, for example, plans to have level 4 self-driving cars by 2021[30]. So far, pilot tests have been done in urban and highway settings in areas with few nature-caused obstacles like snow or heavy rains. Cities and highways are preferred since maps are up to date and accurate, a prerequisite for self-driving cars. Rural areas place higher requirements on these: to withstand weather events and to have accurate maps over bigger areas.

Also, on the truck side there are exciting developments. Uber has successfully road-tested self-driving trucks[31] and Tesla unveiled an electric self-driving truck in November 2017. Swedish start-up Einride has developed a semi-autonomous electric truck that was launched in July 2017[32]. Here, a remote human driver steers the truck onto the highway from a control room, in the simpler traffic on the highway the truck is fully autonomous, and when the truck leaves the highway the control-room driver again takes over.

It is hard at present to imagine all the changes full automation will bring, but several deep changes can already be foreseen that can have both dramatically positive, but also negative effects to urban mobility:

- The time spent inside can be used for things other than driving. This may reduce the hurdle for commuting long distances, especially if the autonomous vehicle is electric and hence cheap

There is still a long way to level five automation

Level of automation	Description: vehicles equipped with...	Current status
0	...no automated features. Driver in full control of the vehicle.	Older cars such as Volvo V70, 945 and similar
1	...one or more primary automated features as cruise control.	Most low end cars on the market today
2	...two or more primary features, such as adaptive cruise control and lane-keeping, that work together to relieve the driver from controlling those functions.	Most high end cars today
3	...features that allow the driver to relinquish control of the vehicle's safety-critical functions depending on traffic and environmental conditions. The driver is expected to take over control of the vehicle If needed.	Google's experimental Lexus RX450h and Tesla
4	Fully autonomous vehicles that monitor roadway conditions and perform safety-critical tasks throughout the duration of the trip with or without a driver present.	Not yet in the market, pilots are running

Note: Autonomous vehicles, 2016, University of Michigan, center for sustainable systems.

Figure 4.6 Different levels of automation and current state of automation[33]

[30] "Volvo Cars and Autoliv Team up with NVIDIA to Develop Advanced Systems for Self-Driving Cars."
[31] "Uber Advanced Technologies Group – Truck."
[32] "Einride – Future of Transport."
[33] "Autonomous Vehicles."

per mile driven – improving interconnectivity, but also increasing the total amount of transportation.

- Taxis, buses, and trucks will be dramatically less expensive without the driver, and will likely get additionally cheaper with electric powertrains. This can lead to more traffic, individualized solutions and more freight transportation, with implications for city congestion (see above).
- If desirable, the owner could make the car available for other riders during the day and by that make money on it instead of just spending money on it.
- Drastically fewer accidents: Google's incident rate is already down to only a few percent of the human incident rate, and its automated driver will soon be several orders of magnitude more experienced than even the most experienced human driver.
- The ride can be made more efficient through the car calculating the best route based on the latest data, avoiding congestion and optimizing fuel consumption[34]. It then drops its rider off at the destination and finds a parking spot in a quiet area.
- The self-driving car also opens up for people who do not have access to cars, cannot drive or cannot afford a taxi. The driverless car will be a cheaper option, in terms of cost per km, and can make personalized mobility accessible for larger groups.

For car manufacturers, and their assets, autonomous driving raises an additional set of questions:

1) Will the incumbents be successful at building these self-driving systems in time? The skill set is clearly different and much more oriented towards advanced software and artificial intelligence than gears and varnish. If they have to buy these systems – which look to be so critical for competitiveness – won't the software company capture a large share of the value and perhaps be seen as the most important link to the customer?
2) What will autonomy do to branding, specifically for premium brands? Who will pay for the fun of driving if a computer is anyway doing the driving? And if many more trips are done using a car that someone else owns, will this not also mean a major risk of commoditization, in much the same way that few people today care particularly about the car brand of the taxi they step into?

4.2.3 Car sharing and multi-modal transport

The third disruption is car sharing. Car sharing allows customers to utilize company owned fleet cars through pay-as-you-go business models. These business models have in principle been available for decades (rental cars, leased cars, car pools, etc.) but in practice, they have become radically more viable and attractive with the advent of mobile internet. Previously, renting a car meant going to the rental company's local office, picking up the key and filling in paperwork, and then again returning the car to the local office after use. With mobile internet, you pick up the car at any of hundreds of parking stations, and you unlock with a code delivered to your smart phone rather than a physical key. Convenience is more comparable to a taxi or a privately-owned car than to the traditional rental car experience. Car sharing is growing fast, with European membership rates increasing at 50-70% per year. Key benefits include lower cost than private ownership (especially for customers driving few miles per year) and less hassle (insurance, maintenance, fueling up, etc.). One eye-catching example is that the average cost of owning a car for a year translates to the cost of driving a Zipcar for 1 122 hours, or more than 3 hours a day. Some cities, e.g. Paris, have also created reserved parking space for shared cars, freeing drivers from the pain of searching for parking and creating an additional important benefit.

From a consumer point of view, the economic benefit is huge: a privately owned European car is on average only driven productively about 5% of the time (it is parked 92% of the time and another 3% is lost looking for parking or in congestion), and when driven only 1.5 out of the 5 seats are occupied. The capital utilization is thereby only about 1.5% for this huge capital stock – a tremendous improvement opportunity now made available by the mobile internet. See figure 4.7 for an overview of some of the key market and growth numbers for car sharing.

For car manufacturers the picture is decidedly more mixed: a shared car replaces 4-7 privately owned

[34] Litman, "Autonomous Vehicle Implementation Predictions – Implications for Transport Planning."

cars, which could have a clear impact on the sales of new cars. Countering this, there may be an effect where car sharing creates additional demand for travel (e.g. people without a privately-owned car starting to use shared cars) and a shift from public to private transport (as private gets cheaper and more convenient) that could lead to increasing demand. The expected overall result is a slightly lower total demand of cars in the long term.

The implications on brands and aftermarkets are also interesting. When the car becomes a part of a fleet system it is unlikely that the brand will continue to be as important in the purchase decision. Other factors such as availability, condition of the car and how easy the service is to use are probably factors that will instead grow in importance. To make the cars suitable for a fleet service, their durability preferably needs to increase, and downtime decrease. This in turn could affect the aftermarket, which would work as a supplier to the car fleet service. Car fleet companies could also put pressure on the aftermarket to lower prices in a way the individual consumer cannot, and by that decrease the profitability of the sector.

The trend towards more shared cars should be seen against the general context of urban mobility. In most larger cities, road traffic is a problem, causing congestion, noise, lack of parking, pollution, and frustration. The private car is the main culprit, and as a result, most cities actively try to decrease the number of cars.

Car sharing schemes can help in all of these respects: they are more parking efficient as the cars are driven a larger share of the time, they typically make cars a 'last-mile solution' and so decrease congestion, and

Car sharing is growing rapidly and expected to be a major part of the new car sales market

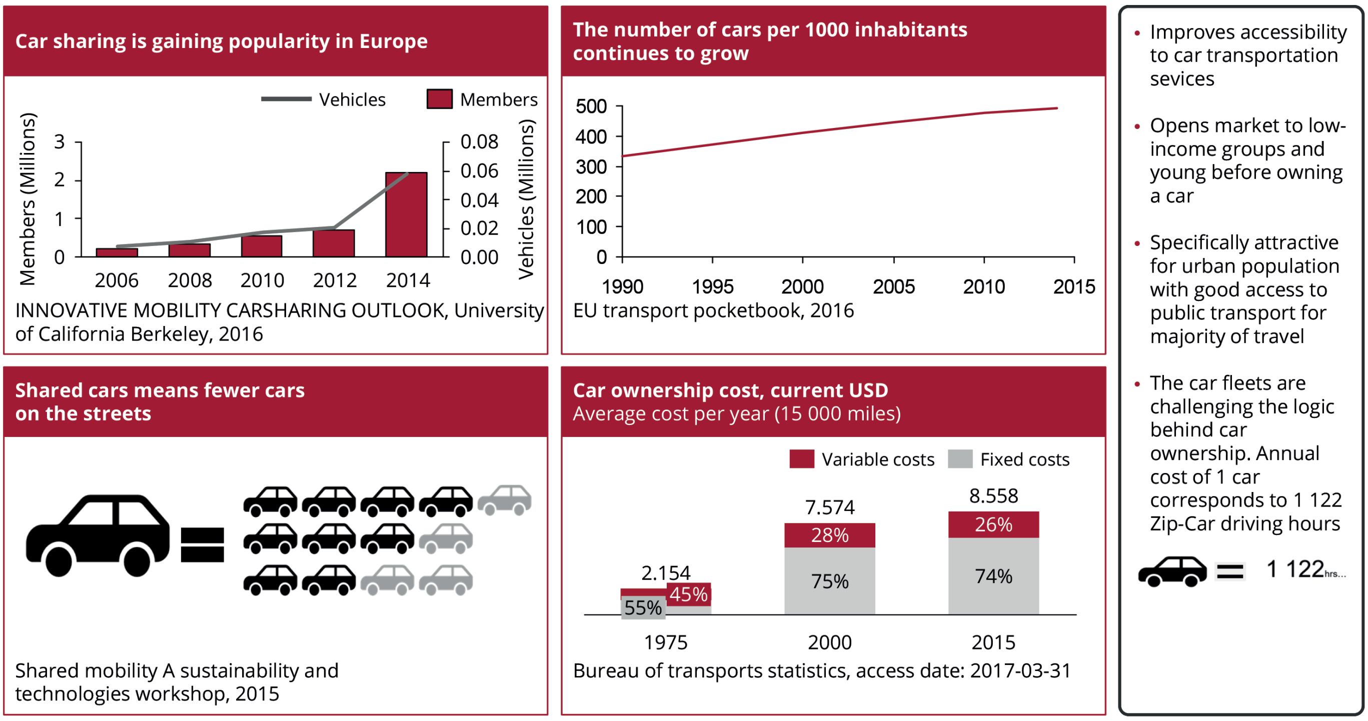


Figure 4.7 Development and statistics on car sharing[35,36,37,38]

[35] "EU Transport in Figures – Statistical Pocketbook."
[36] Shaheen and Cohen, "Innovative Mobility Carsharing Outlook – Carsharing Market Overview, Analysis, And Trends."
[37] Shaheen et al., "Shared Mobility: A Sustainability and Technologies Workshop: Definitions, Industry Developments, and Early Understanding."
[38] "Average Cost of Owning and Operating an Automobile."

they can more easily be made electric as cities have many more pressure points on car fleet companies than on consumers. And electric cars of course are less noisy and less polluting.

So over time, we expect significant city support to car sharing, as the advantages are so clear. Some cities, e.g. Paris, have already come very far in this, reserving parking for electric shared vehicles all over the city. Others are more hesitant – often because taxi drivers feel threatened by the new business models and are vociferous in their protests – but our expectation is that taxi drivers will only be able to delay this development by one or a few years. The underlying forces are simply far too strong.

4.3 Scenario analysis based on disruptions

As dramatic as the above trends are, the next step is to think through how they could combine to different scenarios and what the total effect of those scenarios could be.

The first observation to make is that the three megatrends described above are mutually reinforcing: EVs facilitate sharing (it is much easier to convince a shared car user to just plug in the car to a socket than to go and fuel up) and vice versa (EVs are suitable for the driving pattern of shared cars, i.e. many shorter trips with charging time in-between). Autonomy also helps sharing (as cars themselves can go and pick up customers). This is an important insight, and suggests a fast development.

The second observation is that these trends hit an inefficient system with huge economic and environmental improvement potential. Look at figure 4.8, which shows the efficiency of the car from a few different perspectives. It shows that the capital utilization is about 1.5% (the car is driven productively 5% of the time, and then only 1.5 out of 5 seats are occupied). The productive energy efficiency is similarly low: well-to-wheel ratios (measuring what share of the chemical oil energy in the ground is transferred to kinetic energy in the

Major structural waste in the mobility system

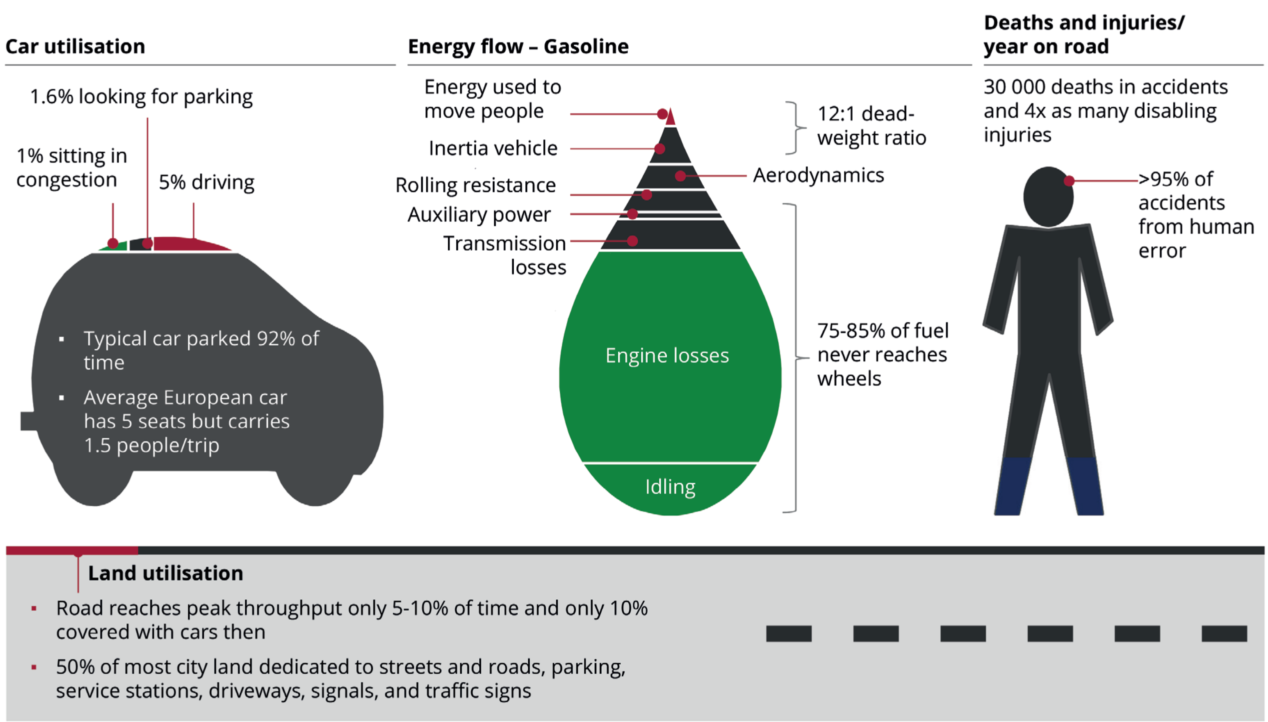


Figure 4.8 Inefficiencies in how a car is being used[39]

[39] "Growth Within: A Circular Economy Vision for a Competitive Europe."

car) are typically 20-25%. But divide this with the deadweight ratio of 12 (1.2 metric tonnes of steel to transport 100 kilograms of human) and you'll end up with a productive energy use of 1.5-2%. From a land perspective, 40-50% of expensive inner-city land is devoted to transport infrastructure (roads and parking space), which is used at maximum capacity only at rush hour (5-10% of the time) and then only 10% of the roads are covered with cars. Again, multiply these numbers and you'll find a 1-2% land efficiency. And transport is the second largest greenhouse gas emitting sector in many countries (after electricity production).

The trends and technologies described above can address these huge inefficiencies: EVs have a much higher energy efficiency, shared cars have a much higher capital utilization, and sharing and automation both help improve land efficiency. This has the potential to free up enormous economic values. Take Sweden's stock of cars as an example: Sweden has about 5 million registered cars. If one assumes each car is worth on average €10 000, this translates to a capital stock of €50 billion, and again it has a utilization of a paltry 2% today. Increasing this number to just 3 or 4% holds major economic opportunity.

All the analysis suggests we are moving towards an avalanche of new technology and change. But what are the uncertainties in the development, and what will it mean for incumbent car manufacturers? The project has identified two major branching points:

1) **Individual car ownership versus shared/semi-public.** While there are strong rational arguments for not privately owning a car, and the above trends are strengthening these arguments, it is a fact that most people today prefer owning their own car. Cars are also tied to many emotional values such as 'beating the neighbor' and signaling personal success, a sense of freedom, and a sense of identity. These emotional values vary considerably between different customer groups: Generation Y is less concerned about the status of car ownership, women are less concerned than men, city dwellers have more reasons to share cars and so on. It is difficult today to know how hard different consumer groups will cling to private ownership.

2) **Speed of EV breakthrough.** While the long-term answer clearly seems to be EVs, there is a question as to how quickly it will break through. This is partly about battery and other technology costs, but also about how quickly incumbents choose to shift over, how quickly global battery supply can scale up, how quickly charging infrastructure is built up, and so on. In addition, fuel-cell technology is still on the map but today most manufacturers seem to clearly prioritize battery electric vehicles in the near term. If batteries do not prove themselves, this could be an alternative technology to support the trend of electrification.

These two major uncertainties have been used to generate 2x2 scenarios, see figure 4.9. The least dramatic is of course the 'mobility as usual' scenario where both these trends move slower (but still quite fast), and the most disruptive is 'individual transport revolution' where shared electric cars grow very fast. The scenarios reflect a European mature market with developed public transport.

4.4 Testing for negative growth dynamic

Starting at a high level, economic history, and specifically the work of Joseph Schumpeter, tells us that incumbents typically do not do well in times of rapid change. Incumbents have major vested interests in the 'old' way of doing things, including physical assets, capabilities, business relationships, but also personal beliefs and power bases among executives and directors. It has proven very difficult for senior managers of incumbent businesses to shift resources aggressively to new technologies and business models (which may not even suit the company's capability set), at the same as time scaling down their existing businesses and reducing personnel. Most companies scale down when they absolutely have to, which is often too late. As a result, in wave after wave of 'creative destruction' in different businesses all the way back to the industrial revolution, the pattern is that new entrants are better at taking advantage of disruptions than incumbents. Examples include the typewriter, the analogue camera, and the fixed-line phone.

How big is the disruption ahead of the automotive industry? We would argue that electrification and

Based on the development paths of disruptions we propose 4 scenarios for the mobility sector by 2030

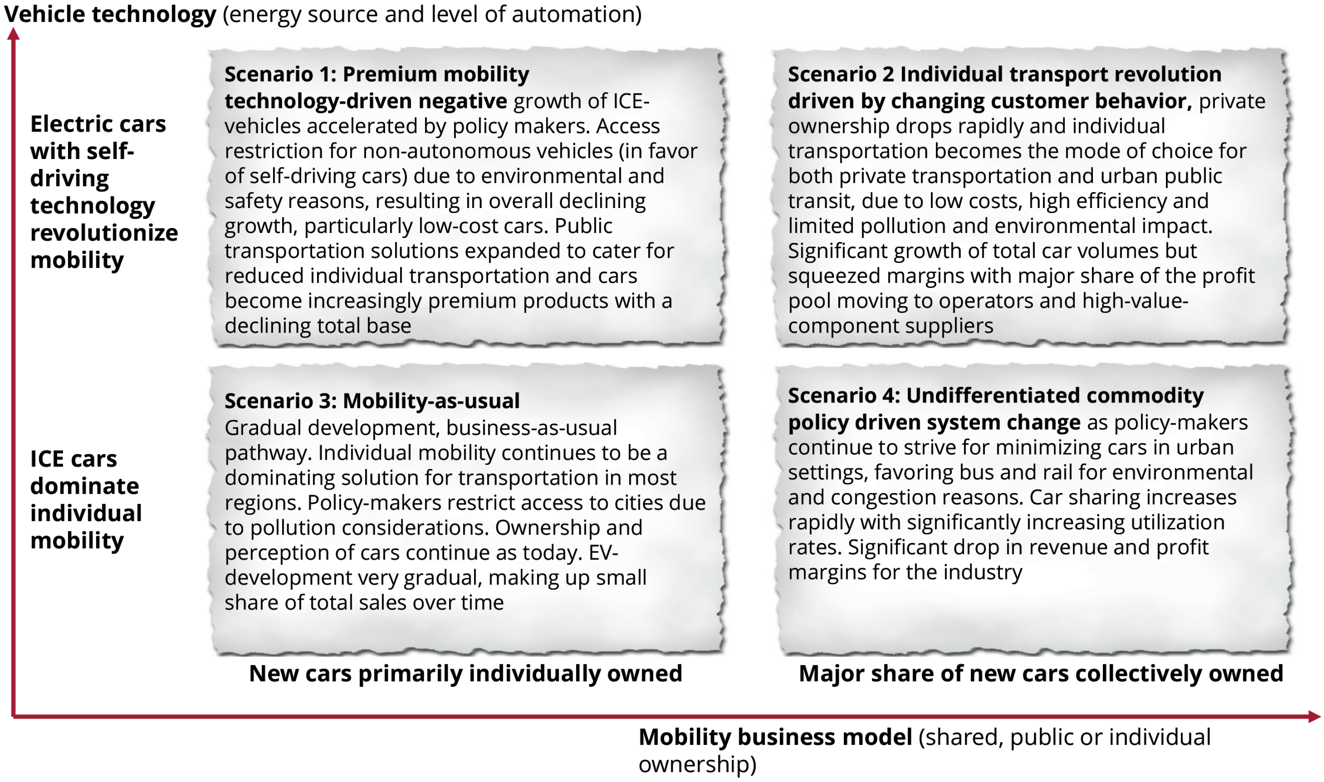


Figure 4.9 Scenarios for the automotive manufacturing sector

autonomy, and maybe also sharing, each individually are bigger shifts than anything that has happened in the automotive industry since Henry Ford created the modern mass-production car. When played out together, it is hard to call this anything but a massive disruption. Two other automotive trends one could compare to are *lean manufacturing and globalization*. *Lean* was just a new, more effective, production philosophy that carried little physical investment. But after Toyota introduced it in the 1950s and 1960s, it took then-incumbent car manufacturers decades to adjust and many went bankrupt. Toyota instead went on to become the world's largest car manufacturer, since incumbents did not in time adjust to the new production philosophy. *Globalization* similarly meant manufacturers such as Kia Motors and Hyundai took a major market share at the expense of Western manufacturers, as Western companies were slow to move production to new low-cost locations. In our view, in spite of the deep scars these trends caused then-incumbents, they are both smaller trends than the shifts we see now and that will reshape the industry in the next 15 years.

In the electricity sector disruption, negative incumbent technology demand growth turned out to be a tipping point, causing the toxic mix of effects described in chapter 2 above, and eventually leading to massive impairments and equity value losses. A highly relevant question is, therefore, could something similar happen in the automotive industry? Figure 4.11 models this, using the assumptions of scenarios 2 and 4 (those assumptions differ primarily when it comes to the speed of EV penetration). The conclusion is that indeed, one does not need very aggressive assumptions at all to come up with a similar dynamic as in the electricity industry. The underlying demand growth in Europe is already very slow, and EVs, car sharing, and a potential economic downturn are all material enough to take out a substantial 'wedge' from the growth. The negative spiral of less-utilized plants, intensified price competition, and investors starting to see clearly what is the 'old' and the 'new' and all running for the door simultaneously starts to feel familiar.

It is outside the scope of this assessment, but the consequences of the disruption are going to spread outside of the automotive sector. Oil and gas producers are likely to be affected by a slowing down in the demand of their products. Estimations show that if electric vehicles account for 27-37% of sales in 2030, this will correspond to a decrease of oil sales of 8-25%[40]. Many suppliers and aftermarket providers will see declining demand, see figure 4.12.

A paradigm shift for petrol and diesel cars?

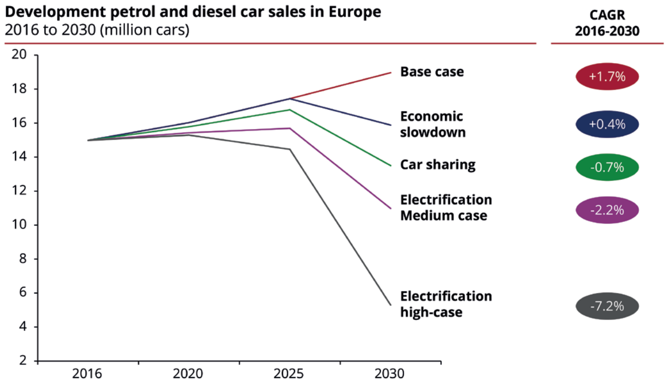


Figure 4.10 Negative growth scenario for the European automotive industry

Deep implications for many other sectors too

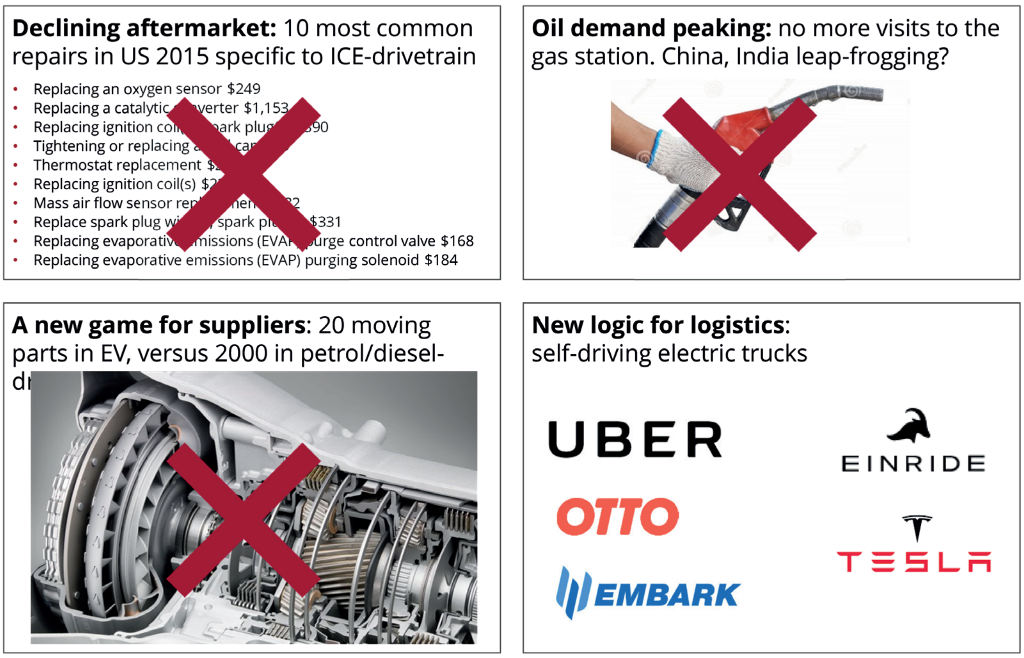


Figure 4.11 Disruptions in the automotive sector affecting other sectors

4.5 Implications and assets at risk of becoming stranded

These combined trends will impact the incumbent automotive industry massively. Let us first look asset by asset:

1) Net working capital (about €150 billion in total) is not at any significant risk, as it has a turnaround time that is counted in weeks or months rather than years.
2) Leased products are at some risk due to the intense recent discussions in some cities about forbidding diesel cars. The second-hand value of those diesel cars might simply be much lower than expected, if consumers – who often have a decade-long time horizon when buying a car and who also think about what the next buyer will be willing to pay – get worried about future regulation, or are simply worried that diesel engines will get considered as part of the past.
3) Some of the property, plant and equipment ('PPE') of €163 billion is clearly at risk. Much of the production line investments are tied to a specific car platform or model – with a life length of 7-10

[40] Patel, Seitz and Yanosek, "Three Game Changers for Energy." McKinsey and Company.

years – and is not of much use if that model starts to sell less. Over 95% of cars sold are fossil fuel based, and so virtually all production assets are optimized for internal combustion engine (ICE) car production. To shift these lines to production of a new type of car will require the same type of investment as does every new model launch. However, the difference this time is that the changing market landscape might force the car manufacturers to invest in a new asset base before the current is outdated, leaving equipment, tools and facilities stranded. Some car manufacturers have invested in production lines that are flexible enough to handle several platforms, but many have not.

4) There is also a broader production capability in automotive manufacturers that is not necessarily captured in the balance sheet valuations of PPE. These companies are used to manage a global supply chain where hundreds of thousands of parts find their way to the right assembly plant just in time, and are assembled with very few quality issues, at a scale of millions of cars per year. But no matter how impressive this is, one should also keep in mind that automotive manufacturers have systematically outsourced much of the production to suppliers over recent decades, and many of the car manufacturers have kept primarily the engine, powertrain, and the final assembly in-house. These suppliers are of course happy to supply also to newcomers, reducing the entry barriers considerably.
5) Capitalized R&D is at major risk of becoming partly stranded. A bottom-up summary of all the annual reports of the largest car manufacturers shows that a majority of the capitalized R&D is still tied to the combustion engine powertrain and those car models in use today. On the other hand, there is also capitalized R&D focused on the chassis or safety features, which will probably better withstand a disruption.
6) There is a broader question as to how well the brand and capability set of today's car manufacturers will travel to an electric, self-driving, connected car market. Many car manufacturers have defined the engine and power transmission as their 'core' capabilities, have big engineering departments of combustion engineers, and have outsourced many other parts to the supply chain. And a significant part of the customer appeal of many brands (e.g. BMW, Audi) is related to the engine and the power transmission, as manifested in corporate slogans ('Freude am fahren', 'Vorsprung durch Technik'). Will these companies be able to create the same technological advantage for their future cars, and will they be able to convince customers of it? How much will customers even care about brand if the car is shared, and maybe even drives itself? This is a much broader question than just write-offs of 'capitalized R&D' and a technology shift. This is in many ways a question of the corporate identities of these companies.
7) Finally, assets related to the aftermarket are not displayed separately in the asset breakdown of the automotive manufacturers, since few companies separate out these numbers in their annual reports. But the aftermarket is often the most profitable business of an automotive company, due to the inherent customer lock-in, and often represents a sizeable share of total EBIT. Unfortunately, also in this area the EV revolution should make analysts worried. An electric engine has about 20 moving parts, compared to about 2 000 for a combustion engine – a factor of 1 000 difference[41]. This means much fewer parts will need maintenance or replacements, and much lower aftermarket revenues. Further underlining this, a recent survey showed the top 10 highest spend items in the US aftermarket were all related to the combustion engine and powertrain.

Our quantitative assessment of these risks by asset class is shown in figure 4.10. Scenario two will have the biggest impact since it heavily affects both physical assets and capitalized R&D. The car is almost completely transformed with a new drivetrain and also a new business model logic. In this scenario, up to €243 billion is exposed to significant risk of stranding, and risks wiping out much of the equity value of the industry. Yes, this is a very drastic scenario, but is it more drastic than what happened in the electricity sector? See appendix 1

[41] "ReThinking Transportation: Summary."

for a description of the assumptions underlying the numbers across the scenarios. Given that it is based on an outside-in analysis, the numbers are of course estimates of the total magnitude of value exposed to significant risk across the scenarios, based on the different disruptions driving the scenarios.

4.6 Early signs to look out for

To understand which route the development is taking, a set of warning signals, as in figure 4.13, might be useful. The signals can guide the analysis as to what scenario is becoming more or less likely and thus what that means for the specific part of the industry that is scrutinized. Different financial actors also typically approach these risks and issues quite differently:

- Equity analysts and asset managers are normally early in the process looking for the first signs of the position of a company worsening, or when the market is starting to react to a potential worsening position. For these people, a system of early warning can help them be on top of industry development and analyze implications for their companies.
- Credit institutions do normally have a long-term relationship with their clients and a set of early warning signals would primarily be used as input to the assessments of risk premium and credit rating, especially when approaching the credit renewal stage for specific clients.
- Private equity firms are to a large extent tied in, given the majority ownership, which makes the exit timing more challenging to manage. Understanding risk and picking up early warning signs for a specific scenario before the market might enable early exits. Also, the warning signals can give significant value when assessing a new acquisition as part of the due diligence process, to test the competitiveness of the target in the different possible scenarios and to weigh in the likelihood of specific scenarios developing.

Economically stranded assets by 2025; risk of significant value-loss of up to €243 billion

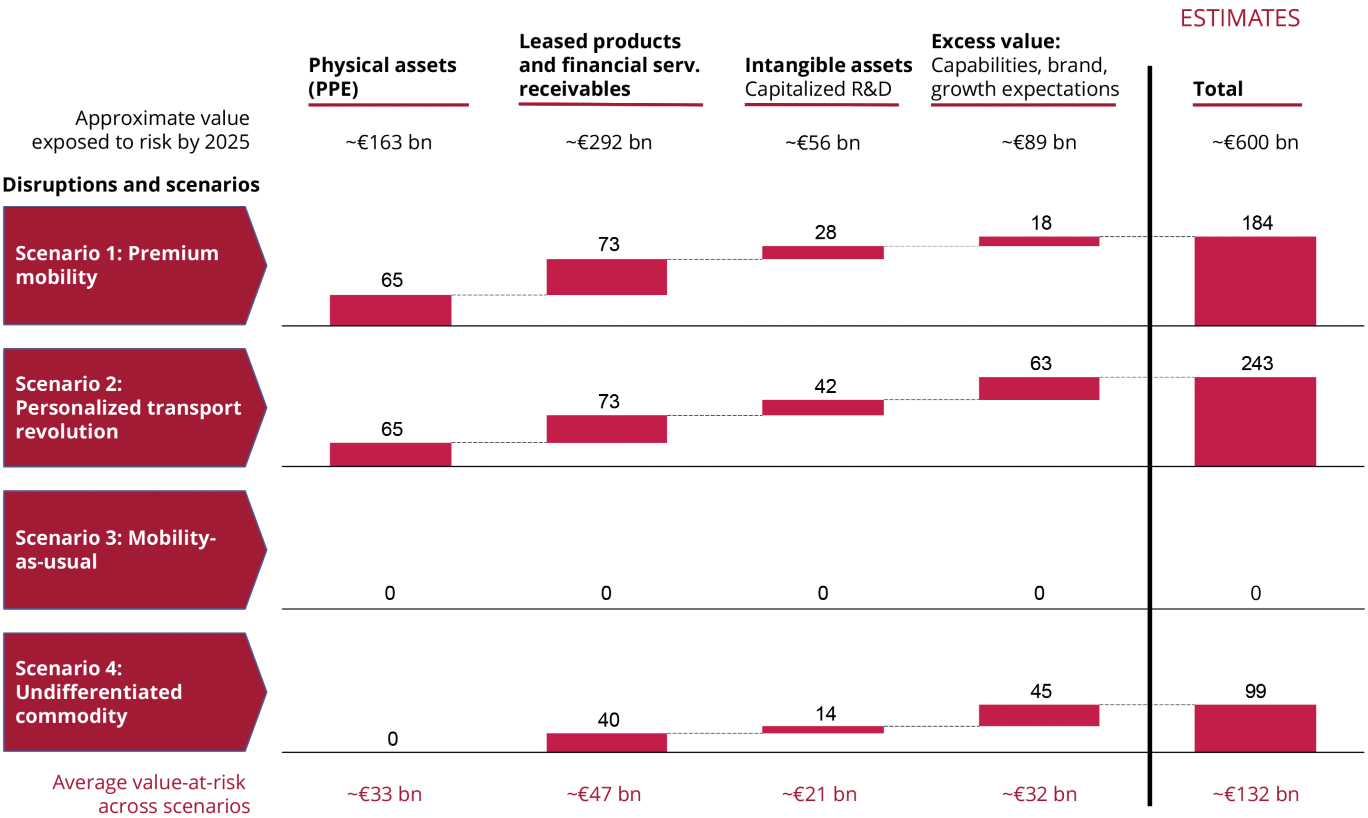


Figure 4.12 Asset groups exposed to risk for the European automotive industry

Early warning signs

1	**Premium mobility**	• Rapid development and acceptance of the self driving car • A shift amongst policy makers from viewing the car as undesirable • A slow reply from automotive sector on new business models and product design
2	**Individual transport revolution**	• The self driving car develops for public transport use primarily, not a premium product • Car ownership numbers decrease • Car fleets continue to expand • Strong preferences emerge for shared electric vehicles versus conventional cars
3	**Mobility as usual**	• People adjust their habits to new regulations but do not take action to find other solutions • Yearly sales of EV's continue to grow slowly or decline • The resistance towards adoption of public transport increase
4	**Undifferentiated commodity**	• A problem in the development of batteries or infrastructure of the EV which delays the industry substantially • Increased public awareness about the environmental effects of cars leading to customers actively searching for new ways to commute • Policy makers restricting car use

Figure 4.13 Early warning signals to look out for when deciding relevant scenarios

5

STRANDED ASSET RISK IN THE EUROPEAN APPAREL INDUSTRY

The European apparel industry shows very different dynamics and stranded asset risks compared to the electricity and automotive industries: The apparel industry itself has a limited environmental footprint, but its supply chain abounds with ESG-related issues, including water use, labor conditions, release of chemicals. A key input – cotton – also creates a much higher exposure to the physical risks from climate change than we saw for the other industries analyzed. Another key difference is that the total assets on the balance sheet of the companies investigated only make up for about 20% of the total enterprise value, the rest being attributable

Summary of findings in the apparel industry

Step 1: Assess potential disruptions and combine them to scenarios

A Two major disruptions include e-commerce and sustainability in the apparel value chain.

B One future possibility is that the encouraging signs in ESG that we see from some of the industry's leaders remain marginal compared to the size of the industry. The opposite would be large-scale efforts in ESG. For e-commerce two possible developments include (1) brand owners stay strong, and (2) online Amazon-type aggregators prevail.

C Four scenarios can be formed combining developments from e-commerce and sustainability. Each scenario is very different in its implications for the European apparel industry. The most threatening one is European brand owners losing out on both ESG and e-commerce.

Step 2: Test for spiraling negative dynamics

A The scenarios all have a likelihood of becoming the base case in the industry, since either aggregators or apparel brand owners will win the e-commerce battle, and either ESG efforts are scaled up or remain marginal.

B A negative growth scenario could come from economic slowdown, ESG-related issues raising prices and creating negative sentiment, and e-commerce taking market growth from the European brand owners. These changes could affect the industry's annual growth in revenues 2015-2030 from +2.5% to -3.2%.

Step 3: Translate to asset-type implications

A Main asset groups include property, plant and equipment (€26 bn), real estate (€57 bn, includes operating leases), and excess value of e.g. brand and growth expectation (€285 bn).

B Assets at risk include intangible assets of brand and growth expectations, which could lose value if the reputation of the brands get tainted due to ESG issues or lower growth expectations because of challenges to develop e-commerce. Also real estate could be at risk if the shift to online continues, forcing companies to shut down physical stores.

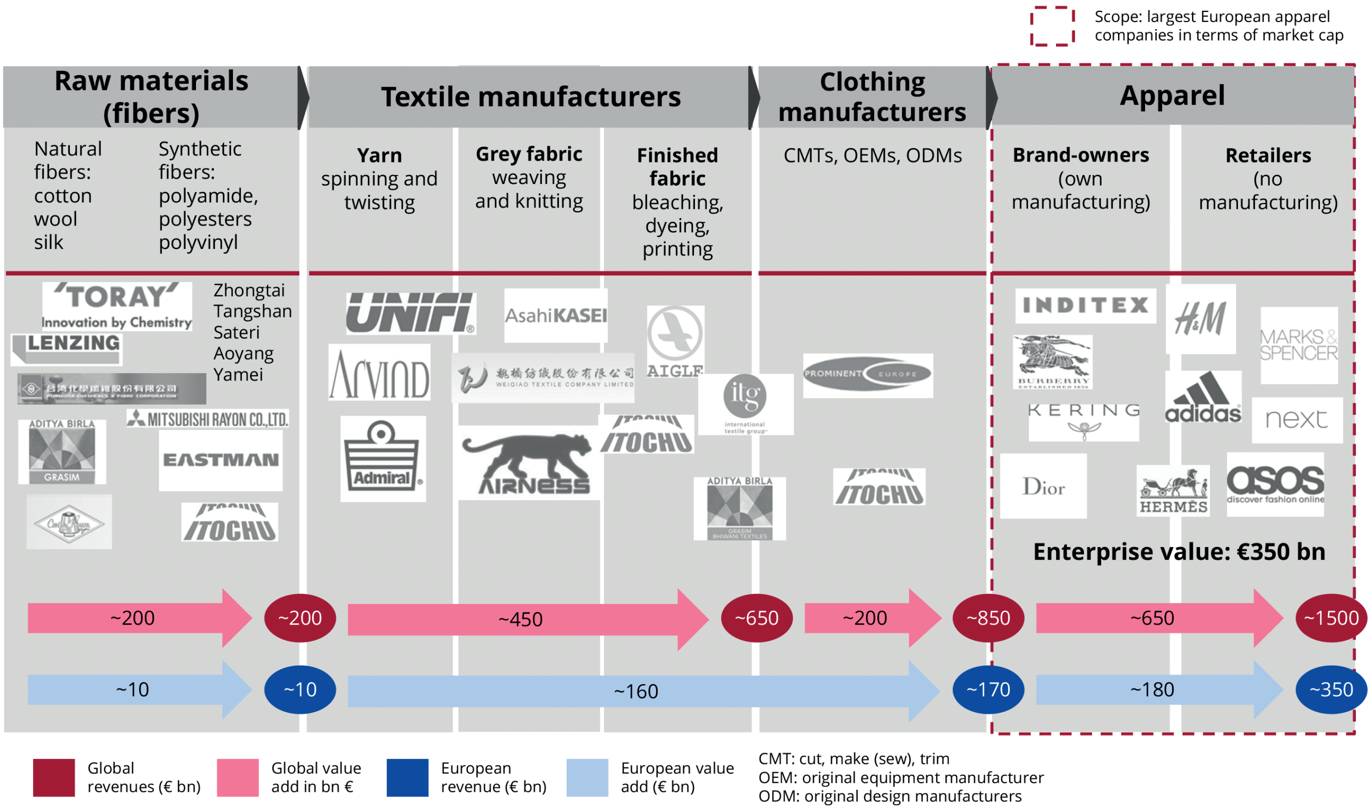
C We have not put a number to the stranded asset risk in apparel, but it could be a substantial share of the €351 bn in total enterprise value.

to different capital market expectations such as growth, brand values and marketing capabilities. Therefore, the key value question from an ESG perspective becomes how supply-chain ESG issues and physical risks can spill over to the brand and growth prospects of the leading apparel companies and their business models. In a dramatic scenario, could it taint the reputation of the apparel industry to such an extent that it takes part of the fun out of shopping for pleasure? Again, it turns out that this key ESG question cannot be analyzed in isolation, but needs to be addressed together with e-commerce, the other megatrend that is reshaping the industry.

5.1 Introduction: the apparel industry and its assets

Figure 5.1 shows the structure of the apparel industry: it is a huge global industry, with total revenues of approximately €1 500 billion, out of which ~€350 billion is in Europe. More than half of the value-add is created in the last apparel and retailing part of the value chain, which is populated by large consumer brands. The earlier steps of the value chain – manufacturers of fibers, textiles, clothes – are fragmented industries and largely located in the southern hemisphere. Out of all

Global apparel sales of €1500 billion; European apparel sales of ~€350 billion



Sources: GFA, BCG report: Pulse of the Fashion Industry (2017), Market line Report: Market Size of the Global Textile and Apparel Industry: 2015 to 2020, Euratex key figures 2016 report, Companies' annual reports for 2016

Figure 5.1 Overview of the apparel value chain[42,43,44,45]

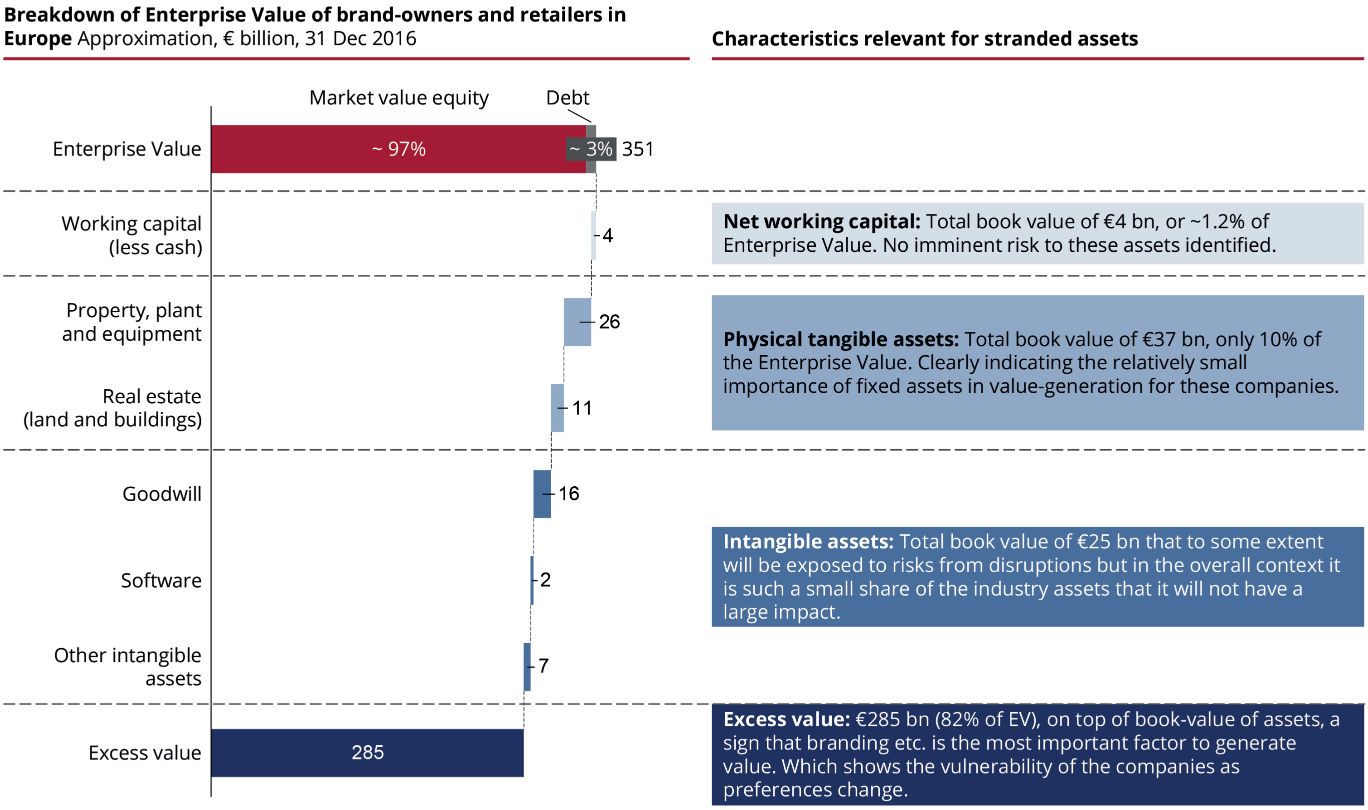
[42] Seara et al., "Pulse of the Fashion Industry."
[43] Lu, "Statistics: Global Apparel Market 2016-2020."
[44] Lu, "Market Size of the Global Textile and Apparel Industry."
[45] "Euratex Keyfigures."

textiles, approximately 70% is used for apparel, and out of this, about half is used for womenswear, with the rest split between menswear and children. In terms of fibers, the apparel industry has in recent decades shifted towards synthetic fibers, which now constitute 70% of all fibers used for apparel.

On 31 December 2016, the 10 largest apparel companies in Europe had a combined enterprise value of €351 billion, with the breakdown shown in figure 5.2. As the figure shows, the combined book value of the top-10 companies is only ~€80 billion, or just 23% of the total enterprise value. This is in stark difference to the automotive industry where most of the enterprise value could be explained by balance sheets. Three quarters of the enterprise value instead has to be attributed to different types of capital market expectations, such as growth, brand values, design capabilities. Property, plant and equipment ('PPE') is one of the largest asset types with a total value of €26 billion.

Leased real estate merits special attention. In the books of the top-10 apparel companies, real estate assets (land and buildings) total only €11 billion. This is because most apparel companies lease stores rather than own them. But these leases are often long-term (one-third for more than 5 years for the top 10 companies), and hence imply future financial obligations. An analysis of the annual reports of the top-10 companies gives the view in figure 5.3. In total, their operating leases imply a future financial commitment of €46 billion, out of which 16 billion has a timeline of more than 5 years. While these obligations have always been there, new International Federation of Accountants (IFAC) accounting rules will increase transparency by forcing apparel companies to put these obligations on their

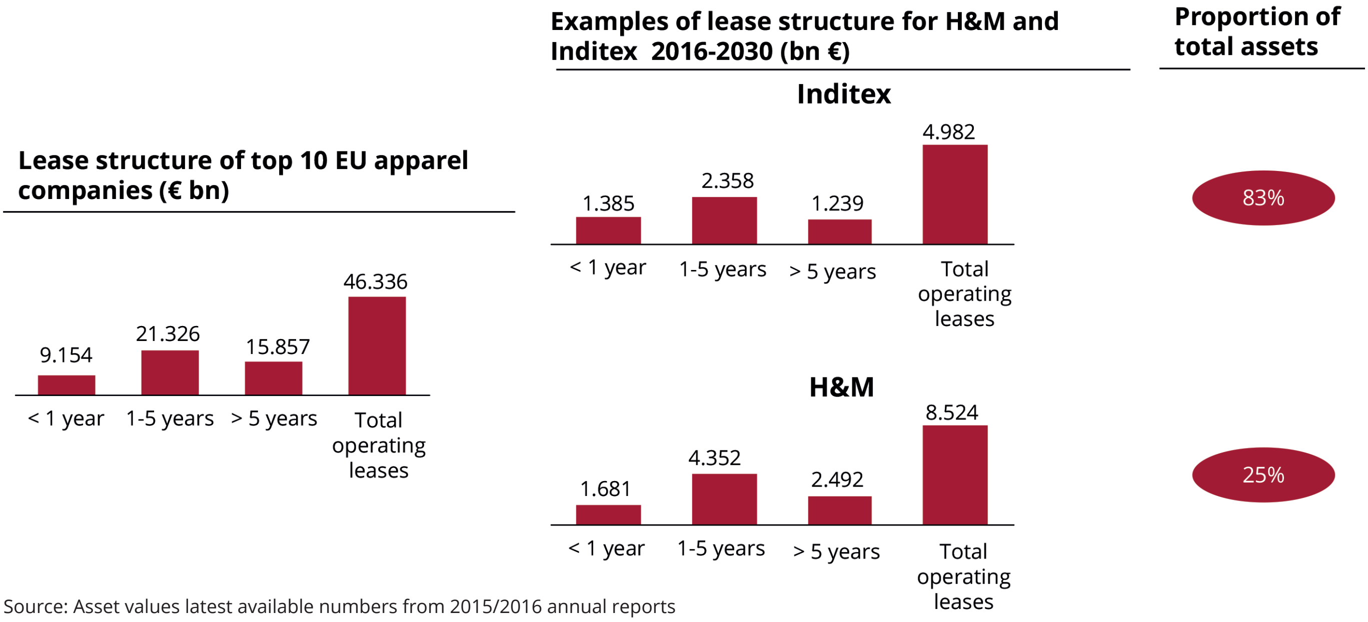
The Enterprise Value of the European apparel industry is ~€351 billion, out of which only ~€66 billion on balance sheets



Note: Market cap for the 10 largest apparel companies in Europe (including subsidiaries): Kering, H&M, Inditex, Hermes, Dior, Next, Marks & Spencer, Burberry, Adidas, and Asos.
Source: Asset values latest available numbers, from 2015/2016 annual report

Figure 5.2 Enterprise value breakdown of European apparel companies

Operating real estate leases of the top 10 European apparel companies



Source: Asset values latest available numbers from 2015/2016 annual reports

Figure 5.3 Operating real estate leases of European apparel companies

balance sheets starting in 2019. This means balance sheets will on average expand close to 60%, and for some companies even more.

5.2 Two major disruptions in the apparel industry

This project has identified two major and possibly disruptive developments: e-commerce and sustainability. These are both well-known developments, and not surprisingly they are the focus of our analysis. We hope to add value by describing how each of these disruptions could play out, how they could interact, and what the implications for apparel companies and their assets could be.

5.2.1 Sustainability in the apparel value chain

5.2.1.1 Historic sustainability developments

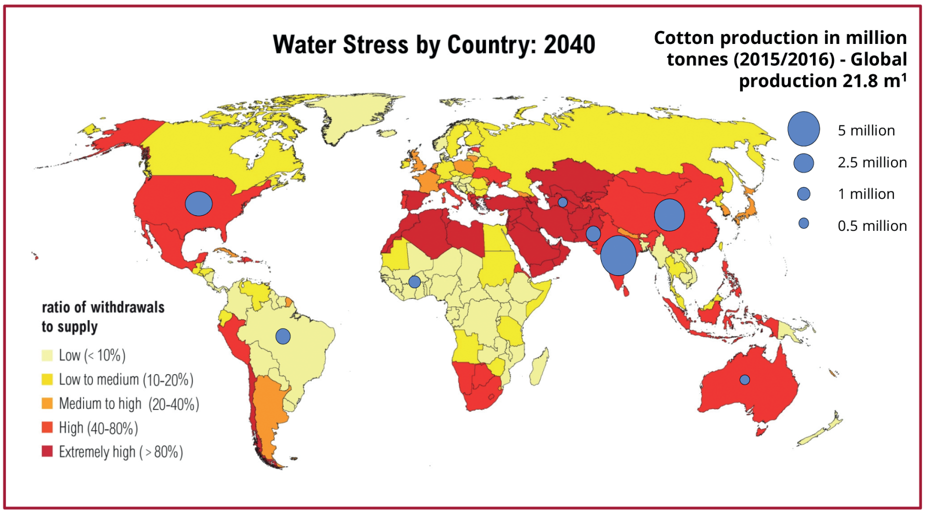
Sustainability problems abound in the apparel value chain: it has plenty of major environmental problems such as water use and chemicals release, but also a dire list of social problems such as health and safety, 'sweatshop' labor conditions, and remuneration levels below the minimum living wage in the local country. Let us look at some of these issues in more detail.

Water and chemicals. Cotton production is extremely water intensive; it takes approximately 10 000 liters of water (or 10 m^3) to produce 1 kg of cotton. Globally, cotton production consumed 79 billion m^3 in 2015, a figure that with current growth trends is set to increase by 50% by 2030[46]. And cotton is largely produced in water-scarce areas: 51% of global production comes from India and China, and other large producers include Pakistan, southern USA, and Australia. Globally, 57% of all cotton is produced in areas where the UN considers water stress to be 'high' or 'extremely high'[47]. In 2013, environmental consultancy Trucost[48] estimated the natural capital costs (their word for environmental damage costs) of cotton production in Southern Asia at USD 58.7 billion, compared to the revenues of that same industry of USD 9.7 billion – a ratio of 6.1. In other words, for every dollar of revenue the industry created, it destroyed approximately USD 6 worth of natural capital. Some environmentalists would say such numbers show the basic business model of cotton production is one of plundering the planet. On the other hand, cotton production is often one of very few options for local people to make a living, and they are often desperate to produce and sell their cotton, so painting a better alternative is often not easy.

[46] Seara et al., "Pulse of the Fashion Industry."
[47] Gassert, "One-Quarter of World's Agriculture Grows in Highly Water-Stressed Areas."
[48] "Natural Capital at Risk: The Top 100 Externalities of Business."

Very high correlation between water stress and cotton production

- 79 bn m^3 water is consumed by the fashion industry today
  - By 2030, 50% more water (39 bn m^3) will be required to support the fashion industry while the gap between supply and demand will reach 40%
- Water stress is expected to impact further top cotton producing countries like India and China which together account for 51% of the global cotton production
  - Future dilemma: cotton production vs. securing clean water



Source: 1. World Resources Institute: Water stress by country 2040 (2015), OECD-FAO Agricultural Outlook 2017-2026

Figure 5.4 Global cotton production and areas with water stress[49,50,51]

The high level of water consumption should be seen in a local context: freshwater availability is a basin-by-basin issue, and cotton production often competes with other large agricultural water uses such as rice and wheat production (agriculture consumes 60-70% of all water in many developing countries)[52] as well as domestic and industrial uses. When water use grows larger than sustainable water supply, typically local water stocks (in the form of lakes and underground aquifers) are run down during one or a few decades, allowing water use to continue as before. But eventually, water supply dwindles, and some of the water-using activities are closed or outcompeted.

Besides the water issue, chemicals are another major issue associated with cotton production: cotton is responsible for a full 16% of the world's use of pesticides[53]. Also, the fabric and garment dyeing processes are very chemical and water intensive.

There are several responsible sourcing initiatives set up to help improve this situation. Best known is perhaps the Better Cotton Initiative ('BCI'), which is supported by several high-profile global brands, such as Marks & Spencer, H&M, IKEA, and others. BCI trains farmers so they can use less water and pesticides, with good results at the farm level: BCI's website has case stories of farmers reducing water and pesticide use by more than half. In total during the 2015/2016 growing season, BCI's website states it trained 1.6 million farmers in better production techniques, and that 2.5 million tonnes of Better Cotton were produced.

While these achievements are certainly laudable, BCI also acknowledges the total farm-level investment it mobilized in 2015/2016 was €8.9 million, and that all cotton production independently verified as grown in a more sustainable way (other such initiatives include Fairtrade, myBMP, and ABR) amounted to less than

[49] Maddocks, Young, and Reig, "Ranking the World's Most Water-Stressed Countries in 2040."
[50] "OECD-FAO Agricultural Outlook."
[51] Seara et al., "Pulse of the Fashion Industry."
[52] Northoff, "No Global Water Crisis – but Many Developing Countries Will Face Water Scarcity."
[53] Lusted, *Inside the Cotton Industry*.

20% of the global production in 2016. So, while these initiatives are certainly a step in the right direction, they only start to address the issues. They still only cover a minor share of the market, and more importantly, even this cotton is hugely water intense and is still largely grown in very water-stressed parts of the world. From an apparel company point of view, we would argue these initiatives only marginally lower the supply-chain risk: cotton is still hugely water intense compared to the economic value created, and typically, reducing the water stress in the local basins requires not only addressing cotton, but also addressing rice farming, wheat farming and other water-intense agriculture.

While the environmental issues associated with cotton production are the most obvious, synthetic fibers also come with some issues. Primarily, recent research suggests they are responsible for a sizeable share of global micro-plastics pollution.

Social issues. The apparel value chain is a huge employer in developing countries, representing 34% of all employment in key cotton-producing countries. But still, a recent report estimated that less than 50% of employees were paid the local minimum wage, and that this minimum wage, in turn, was frequently set far too low to be a living wage[54].

This situation is highly problematic for the apparel industry. While few, if any, of the large brands are vertically integrated back to the cotton fields, indirectly contributing to, and being associated with so deep and pervasive sustainability issues is enough to cause major headaches for industry leaders. Even more so since many apparel consumers hardly *need* more clothes to stay warm or covered. Instead, as we all know, 'fashion' and 'fast fashion' have for many consumers become a way of expressing themselves, of showing identity, and shopping for fashion has for some become an enjoyed pastime. If now consumers become increasingly aware of the issues their consumption cause, this might have major consequences for some consumer groups' appetite to continue shopping.

In response, several industry leaders are setting ambitious targets. H&M, as an example, in April 2017, publicly set some very high ambitions for themselves: to become 100% renewable and circular, 100% fair and equal, and to 100% lead the change in the industry. In many areas, these ambitions were backed up with concrete targets, such as becoming climate positive throughout their value chain by 2040, allowing zero discharge of harmful chemicals by 2020, and using 100% recycled or otherwise sustainable materials by 2030[55].

In general, the large brands are leading the change in the apparel industry. The Pulse Score – a sustainability benchmarking score developed by the fashion industry – unequivocally shows that the large brands have come furthest in almost all areas of sustainability. But it also shows that even the industry's leaders have a very long way to go. There is not yet a 'Tesla equivalent' – an industry leader aiming to prove that sustainability, customer appeal and shareholder value can be combined at scale. Even the Better Cotton Initiative does not yet call itself the 'Good Cotton Initiative'.

5.2.1.2 Future sustainability developments

We have identified two different developments for how sustainability factors could impact the fashion industry over the next 10-20 years:

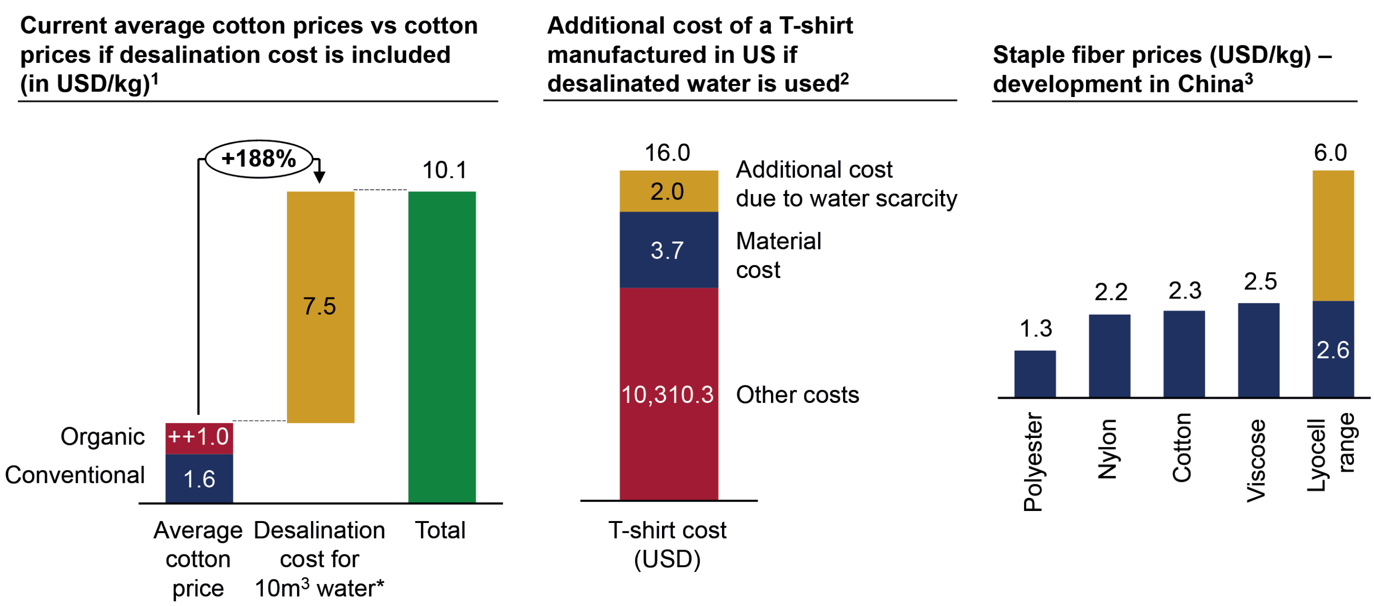
A 'soft drink' reputation. One distinct possibility is that the encouraging signs we see from some of the industry's leaders remain marginal compared to the size of the industry. The fiber and textiles production steps have several characteristics that make them difficult to reform: they are highly fragmented, and are largely located in developing countries with low education levels and weak governance structures. At the same time, global apparel consumption is forecast to grow 63% by 2030, driven by the global population and wealth increase, so there will be strong incentives for fiber and textiles manufacturers to continue to increase production[56].

[54] Seara et al., "Pulse of the Fashion Industry."
[55] "H&M Group Sustainability Report 2016 Circular And Renewable."
[56] Seara et al., "Pulse of the Fashion Industry."

The consequence will be that the already serious environmental issues outlined above will get considerably worse, both because of the scaling, but also because many of the water basins are already in an overdraft situation, where lakes and underground aquifers are depleted. As the effects of water mismanagement become clear not only to earth scientists but increasingly to local voters, the so-called 'license to operate' of cotton producers will be increasingly challenged. Eventually, with current trends, quite a few basins will simply run out of freshwater reserves. Then it is not a bold guess that cotton producers will be among the first water-intense industries to be shut down.

The result would be supply shortages and price hikes. All agricultural industries suffer temporary supply shortages occasionally, if weather conditions are unfavorable in large producing regions, but this would be different: here we are talking about supply from large regions potentially being cut permanently, or at least during a decade or two. Also, many of the large producing regions look to physically hit these limits in a 2025-2035 time frame and might start to scale back water-intense industries even before that. So, this is a systemic global supply shift of a completely different magnitude than the ordinary ups and downs of agricultural markets.

Water scarcity may result in a much higher cotton price, but not add much to final consumer price



*Cost of desalination is at current average prices and may decrease in future
Source: 1. Textile exchange; Material snapshot: Organic cotton, International Cotton Advisory Committee, 2. South Israel 100 million m³/year Seawater Desalination Facility Build, Operate and Transfer (BOT) Project (2006), 3. Textile Exchange: Preferred Fiber Market Report (2016), Lenzing Investor presentation 2016
Calculations: Average price per m³ of water desalinated: 0.75 USD/m³, Cotton required for a T-shirt: 0.2 kg cotton, additional cost due to water scarcity is calculated as 1/5 of the cost for producing 1 kg of cotton under conditions of water scarcity using desalination

Figure 5.5 Competitiveness of cotton as a resource under water scarcity[57,58,59,60,61,62,63,64,65,66]

[57] Lokiec and Kronenberg, "South Israel 100 Million M3/y Seawater Desalination Facility: Build, Operate and Transfer (BOT) Project."
[58] "Material Snapshot: Organic Cotton."
[59] "Organic Cotton Market Summary."
[60] "Global Cotton Production Continues to Recover."
[61] "Seawater Desalination Costs."
[62] Westwood, "What Does That $14 Shirt Really Cost?"
[63] "Nylon Market Bound to Face a Downturn."
[64] "Lenzing Investor Presentation Annual Result 2016."
[65] "Development and Market of Lyocell in China 2016-2020 – Research and Markets."
[66] "Preferred Fiber Market Report."

What would the effects of such a development be on the European apparel industry, the focus of this chapter? Possibly they would be quite severe. The most obvious consequence is that the supply shortages will make cotton more expensive. But the results of this might at first be quite limited for European apparel. As figure 5.5 shows, even for cheaper garments, the actual cotton cost is only 10-15% of the final consumer price, so even if the cotton price was to double, the effect on the final consumer price would be limited. Cotton would also lose competitiveness against other fibers; as figure 5.6 also shows, the other 3-4 big fiber sources for textiles are quite close in cost, and a substantial increase of the cotton price would likely create a material substitution effect. The same figure also shows that desalination is not a solution to cotton's water issues anytime soon: apart from the capital and governance issues of getting desalination equipment in place, it would also increase cotton price by a factor of 4-6.

But this development goes way beyond the fiber competition question above: it also risks the reputation of and customer sentiment towards the apparel industry. If a scenario such as the one described above plays out, it will have very dire consequences for the local communities affected. Kazakhstan is a good, but perhaps somewhat extreme, example: Lake Aral – which used to be the world's largest freshwater lake – has all but disappeared over recent decades, due to deeply unsustainable water management practices. Of course, this means fish populations and all other types of marine life have died out, but also insects, birds, and all types of land-living fauna that depended on the water of Lake Aral have disappeared. The direct human impact can be seen in derelict fishing, agricultural and tourism villages, and a major migration to other, more hospitable landscapes.

Hopefully, the impact of development in other regions will not be as serious, but we use the example to illustrate the deep social traumas that water crises create, in addition to the environmental ones. And such crises will attract major attention, due to social media and well-organized environmental groups. Even if it is hard to hold any single European apparel company responsible, it might still damage the reputation of the entire industry considerably – the contrast between wealthy consumers shopping for fun and the troubling consequences in developing countries might become too obvious. This could lead to the industry being seen with different eyes for big consumer groups. The soft drinks industry is a good comparison: both it and apparel are consumer industries, and both meet an obvious human need (clothing, drink), but the industries also have significant negative consequences for humans. In the soft drinks industry, obesity and other health concerns have stopped growth in many markets (including the US, where soft drinks growth is now negative), and regulators have become increasingly active (e.g. in the form of sugar taxes or bans on selling soft drinks close to schools). Our scenario assumes that, similarly to soft drinks, the negative environmental and social consequences of the fashion industry become increasingly transparent, and that this taints the reputation of the industry enough to take away the growth in mature markets.

Large-scale change. The second scenario is that the industry, together with local administrations, massively scales up its sustainability transformation to avoid many of the above developments. This would include scaling initiatives such as the BCI to cover a larger share of the market, and also increasing the industry's ambition level. This is not easy: increasing irrigation efficiency requires major infrastructure investment and effective pricing mechanisms, which is challenging for apparel companies to support given that the fiber production is, in fact, not theirs. There are also tricky free-rider issues at play: if apparel companies were to support such investment, local governments and other aid institutions might scale back their support, and less conscientious competitors would benefit without contributing. What's worse, water is also used for many other purposes locally (rice and wheat farming are often big culprits) and to really impact the local water balance, these other major sources of demand would also need to be reformed. And again, all the industries involved can with some justification say that buying cotton, rice, and wheat is better than nothing for the local communities.

What is then the bar for how much the apparel industry can be expected to do? It is hard to define any single metric or action, but in our minds, it would make a difference if the apparel industry could *credibly show that it undoubtedly makes a positive difference, i.e. that the 'net' of all its impacts is clearly positive*. It goes beyond this report to assess what such a program would look like and what it would cost, but *Pulse of the Fashion Industry* makes a top-down estimate of 3.4 percentage points EBIT for the global fashion industry, to take care of the negative ESG effects that this report identifies.

5.2.2. E-commerce in the apparel value chain

5.2.2.1 Historic e-commerce developments

Online apparel sales have been a major trend during the last 10-15 years. The phenomenon is so well known that we will here limit ourselves to giving some of the key statistics, and then move on to discuss implications for European apparel companies. Also, online success (or lack thereof) is a carefully guarded secret of many companies, and therefore it is surprisingly hard to get company-level or local geographic insights.

Globally, 2015 apparel e-commerce was €332 billion, or ~28% of all apparel sales[67]. So, apparel e-commerce has already scaled, and one can presume that in technologically advanced markets, the number is even higher. It is growing at approximately 20% per annum, while offline sales growth is at ~0%. Most apparel companies, of course, have a presence both online and offline and are investing major marketing resources to capture a larger share of the online growth. But already now, it is interesting to note that we might be approaching the 'negative growth' tipping point that proved so important for electricity and cars.

It is also noteworthy how many of the online retailers are new players, as opposed to offline successes: think about Amazon, Alibaba, eBay, Acea, and (locally in Northern Europe) Zalando. We have not found an exact figure for what share of online sales goes to new players versus offline incumbents, but our best estimate based on annual reports, is that new players represent two thirds of online sales. It is also noteworthy that all the largest and best-known online retailers are aggregators who sell multiple brands in each category. A simple comparison between H&M and Zalando illustrates the point. H&M is by a factor of 6.4 larger in sales (€23.3 billion versus €3.6 billion), but only by a factor of 3.6 larger in market capitalization (€37.5 billion and €9.9 billion, respectively), and Zalando enjoys a price–earnings ratio (P/E ratio) that is 4.8 times higher than that of H&M (93 versus 19)[68].

The effects of the e-commerce revolution can already be seen. In the US, where the trend has perhaps come further, 'death of malls' is already a familiar concept, as offline stores go into the red as a result of sales moving online.

5.2.2.2 Future e-commerce developments

The fast development of online sales raises many deep questions for apparel companies:

- Who will win the online battle – aggregators or apparel brand owners? Aggregators like Amazon can offer many more products and brands on one platform, which appeals to customers. Some of them (Amazon, Alibaba, etc.) also have a scale that gives them an advantage in logistics. And they probably have an advantage in quickly picking up new customer preferences, and more quickly being able to respond to new demand trends. Also, aggregators are digital from the start, and it may be easier for them to develop highly analytical online marketing skills. However, the profitability per item sold is much higher for apparel companies, and the online aggregators clearly need to have a high representation of the best brands to stay relevant over time. Also, the online aggregation role might over time be commoditized; when these online platforms mature, it is hard to see what distinctive features they could install that competitors could not copy. Indications so far show aggregators picking up a big share of the growth.
- Is the whole 'shopping' and store browsing experience at risk over time, due to the death of malls syndrome? What to do with the existing store network is a difficult issue for many apparel companies. On the one hand, they have painstakingly built their store network; it used to

[67] Statista, "Statista: E-Commerce Fashion Outlook."
[68] Revenue from annual reports, Market cap from Forbes for H&M and Zalandos webpage for Zalando, P/E from Ycharts.

be (and still is, in many markets) a key competitive advantage, and much of the profits often still comes from the stores. Now aggressively shifting growth investments online, consciously outcompeting these same stores, is difficult, especially since online success is by no means guaranteed. For this reason, it is not at all clear if offline incumbents will be fast and aggressive enough to capture a major share of the online market.

- Related to the above, will today's brand owners be able to keep the strength of their brands if more of the shopping experience moves online? Will customers be willing to pay as much more for a strong brand, when the clothing item is displayed on a screen next to many other brands? And how will online aggregators' private label strategies develop? In food, for instance, many strong offline retailers have pursued a private label strategy, where they have systematically identified the most profitable categories, and established their own private label products there, in direct (and often successful) competition with brand owners.
- To what extent will outbound logistics systems, e.g. same day delivery, be a key competitive advantage in distribution, with logistics companies therefore getting part of the value?

Based on this, two distinctly different possible developments have been identified for how e-commerce might impact incumbent European apparel companies:

- **Online Amazon-type aggregators prevail**. For the reasons stated above, one distinct possibility is that Amazon-type players will continue to capture most of the online growth. As they become larger and stronger, they will put ever more pressure on brand owners. The large food retailers are notoriously tough purchasers, as are the large car manufacturers, and capture some of the value that previously went to their respective supply chains. So, a continued fast growth of online aggregators will likely mean offline incumbents will have to take a simultaneous hit on both growth and profitability, with weak brands taking a disproportionate hit.
- **Brand owners stay strong.** There is also the possibility that online sales get commoditized fast. It is no wild guess that online competition will increase fast, as the existing online giants scramble for a large market share, and offline giants shift their marketing resources online. In addition, online platforms are comparatively easy to copy, and analytical online marketing talent is already being recruited from the most successful online firms to second tier competitors. Entry barriers are also possibly decreasing since there are now logistics and payment solutions available also for smaller online retailers (even though they are perhaps not as low-cost as those of Amazon). If this development materializes, the brand owners might still sit on the most important asset in the value chain – the design ability and access to a brand that consumers want to be associated with.

5.3 Scenario analysis based on disruptions

The two developments described have been combined to create four scenarios, as shown in figure 5.6. Each scenario is very different in its implications for the European apparel industry, and ranges from the most benign scenario where apparel companies hold their own in the online world and responsibly manage the sustainability transition, to the most threatening where they lose out on both these dimensions.

5.4 Implications and assets at risk of becoming stranded

The most easily identified stranded asset risk for the European apparel industry is the real estate risk. As explained above, the total real estate exposure of the top-10 companies amounted to €57 billion on 31 December 2016 (€11 billion on the balance sheets, €46 billion as operating leases), out of which €16 billion had a lock-in of more than 5 years. If the quick shift to online continues, the apparel companies might well want to shut down some of these stores before the end of the lease, forcing a payment to the landlord to break the lease contract.

Four scenarios for the apparel industry by 2025-2030

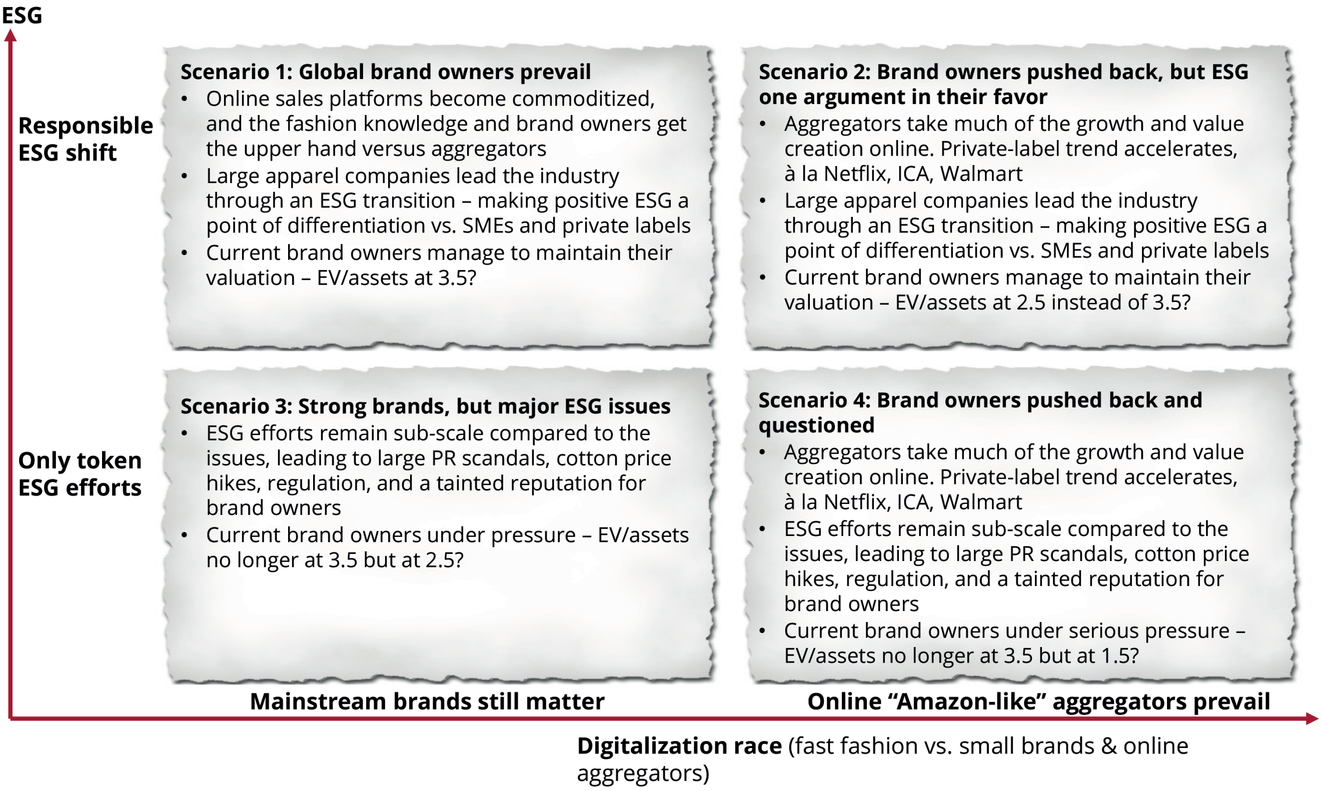
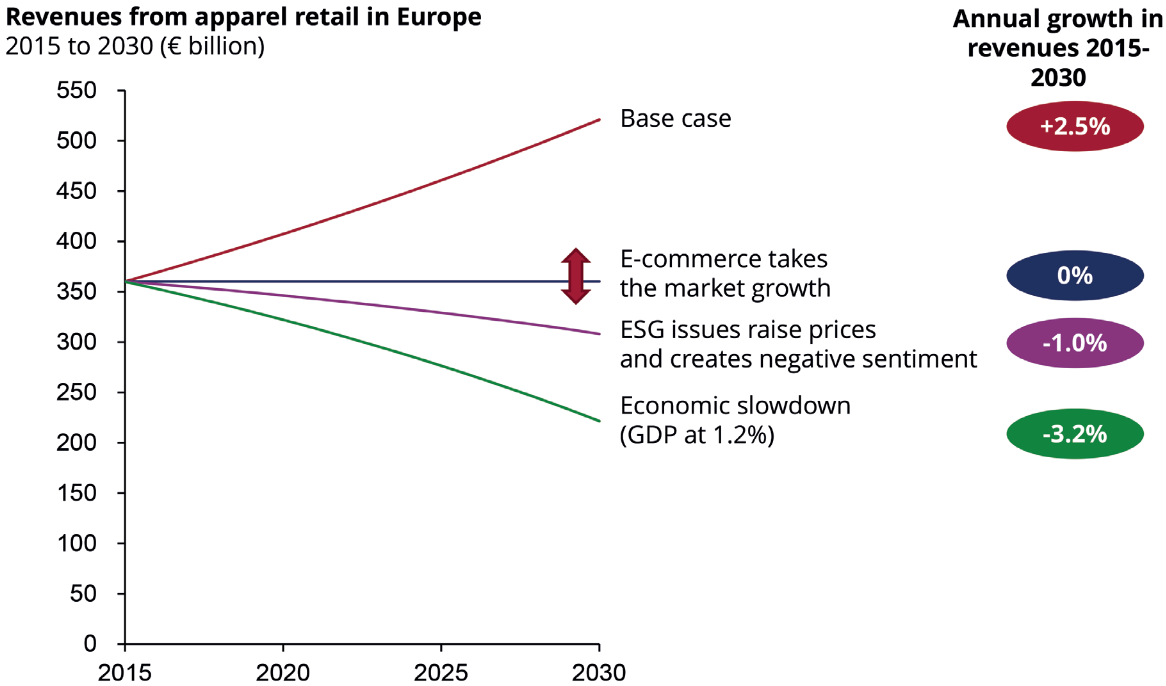


Figure 5.6 Scenarios for the European apparel sector

Top-down growth scenario



Source: Euromonitor Passport report on Global Apparel and Footwear Industry

Figure 5.7 Negative growth scenario for the European apparel sector

But the scenarios above hint at a bigger story, and larger stranded asset risks. Looking again at the breakdown of the asset values, it is clear that most of the enterprise value of the industry (€270-290 billion, or more than 70% of the total enterprise value) sits in intangibles: brand value (i.e. that consumers like to be associated with the brand or choose the brand because they like the design or quality), perceived capabilities, and future growth expectations. If the reputation of these brands gets damaged, or if a consensus view develops that these apparel companies will play second fiddle to the aggregators' first place, then it is not unreasonable to assume a considerably lower growth and valuation. Figure 5.7 shows what a 'negative growth' scenario could look like for apparel companies.

Gap and Benetton, two previous stars of the industry, are today valued at P/E ratios of 14.3 and 14.6 respectively, compared to H&M which is at 20.4 and Inditex which is at 29.4. If these valuation ratios are taken as a rough proxy for what could happen if some of the luster goes out of the top European apparel companies, then 40% of the market value could be at stake. A very clear example of this development came on 15 December 2017 with the H&M stock falling by 16% (the company's steepest intraday decline since March 2001) resulting from a drop in quarterly sales and increasing inventory[69]. Sales (excluding value-added tax) fell 4% to USD 6 billion in the fourth quarter due to fewer customers visiting physical stores[70]. H&M's sales have declined in only three quarters during the past 10 years and analysts had expected revenue for the quarter to increase by 2-4%[70]. The H&M share price is now half the level of its 2015 peak[71] and the operating profit margin, which was 23.5% in 2007, is now, at the end of 2017, 9.6%, roughly half the level of that of Inditex[70]. H&M has said that it is expanding its cooperation with Alibaba to boost e-commerce.

[69] Mulier, "H&M Plunges Most in 16 Years After Trouncing by Rival Zara."
[70] "The Long and Short of H&M's Travails."
[71] "Wind Tops EU Installation Charts as Renewables Shine."

6

STRANDED ASSET RISK STILL PREVAILS IN THE EUROPEAN UTILITY SECTOR

As outlined earlier in this report, the top 10 utilities have been through a very rough period since 2010, with €129 billion costs in impairments in 2010-2016. This development was largely unforeseen and was driven by the joint effect of the economic downturn, restructuring of the economy and energy-intensive industry and a policy-driven build-out of renewables. In addition, the industry was hit by the drastic action on nuclear in Germany after Fukushima. These drivers led to lower demand, lower prices and declining plant utilization. Now renewables are taking an even larger role going forward with wind power in Europe representing 51% of all new power in 2016[71], and solar is growing at a dramatic global pace of 39% per year, 2010-2017.

A key question in 2017 is has this now already played out or will the development of renewables make this downturn for utilities continue over the next 10 years?

6.1 The wind and solar disruption is now really taking off globally

Wind and solar power have been on the market for a very long time and they have been a marginal source of electricity with a few regions being exceptions (Germany and Denmark). The build-out that has happened has been primarily policy-driven through subsidies and mandates. This is, however, changing now very quickly with wind and solar power actually becoming the cheapest source of electricity, not just the greenest. Given that these industries are still scaling up volumes and becoming more and more professional and that there are no indications of firm technological limits, this price development is expected to continue quickly in the foreseeable future. In addition, electricity consumers, large and small, are starting to invest in their own renewable electricity supply, becoming their own utilities. This is building up to a completely unfamiliar territory for utilities and the electricity market that will have profound consequences for the whole industry.

6.1.1 Recent development for wind power

Wind power has been thought of as a mature technology, but it has grown by 16% per year since 2010 and prices continue to drop – with the most dramatic shift happening for offshore wind, which shocked many in the industry. Onshore wind is expected to grow rapidly on its own economic terms going forward and offshore wind will soon be in a similar position given the development with many records beaten in 2016 and 2017. Five cases that stand out are:

- April 2017: The first subsidy-free bid on offshore wind in Germany[72]
- May 2017: Bids for 2 979 MW onshore wind in Spain at €43/MWh[73]
- November 2016: Kriegers Flak in Denmark, 600 MW offshore wind at €49.9/MWh[74]
- December 2016: Bid in Morocco for onshore wind at €21.5/MWh[75]
- December 2016: Borssele III/IV 700 MW offshore in the Netherlands at €54.5/MWh[76]

The rapidly declining prices on wind power have been primarily driven by costs being taken out of

[71] "Wind Tops EU Installation Charts as Renewables Shine."
[72] Andresen, "Offshore Wind Farms Offer Subsidy-Free Power for First Time."
[73] "Spain Returns to Wind Energy with Record Low Prices."
[74] "Vattenfall Wins Tender to Build the Largest Wind Farm in the Nordics."
[75] Parkinson, "New Low for Wind Energy Costs."
[76] Hill, "Shell Consortium Sets New Lowest Offshore Wind Price For 700 Megawatt Borssele III & IV Wind Farms."

Summary of findings for the utility sector

Step 1: Assess potential disruptions and combine them to scenarios

- **A** The overarching disruption is the pace of build-out of renewables (wind and solar), driven by prices declining, policy mandates and storage and other demand-side management technologies emerging.
- **B** Renewables are growing rapidly with wind power in Europe representing 51% of all new power in 2016 and solar growing at a dramatic pace of 39% per year globally.
- **C** Scenarios for how the sector will be impacted are determined by how fast the renewable transition moves and how the economic development in Europe continues, determining demand growth.

Step 2: Test for spiraling negative dynamics

- **A** Renewables are already becoming the new norm and in Southern and Continental Europe, all-in solar and wind power costs (i.e. including capital payments) for new installations are already below the running cost of incumbent coal and gas power plants
- **B** The industry's book-value of long-term assets is €692 bn, which is ~50% higher than its enterprise value, a significant discrepancy between market valuation and book-value. It either implies that the market is wrong and significantly undervalues these companies, or that the market sees the ongoing disruptions in the market and has taken them into account, but the books of the companies are still trying to catch up. Assuming that the market is correct, then many billions of Euros in write-downs are imminent.

Step 3: Translate to asset-type implications

- **A** Major asset-groups include property, plant and equipment (€442 bn), financial assets (€133 bn), and goodwill (€55 bn).
- **B** The assets most exposed to the ongoing disruptions are goodwill as well as property, plant and equipment, which together sum up to €496 bn. Physical assets for thermal generation are at significant risk given an accelerated build-out of renewable energy.
- **C** It is no exaggeration to say that €300-500 bn of these assets are at risk of getting economically stranded. So it looks like the European utility sector is far from through its transition.

the projects, through the industry becoming more mature, standardization of input materials and components and an increase in scale. In addition, the IRR for the projects has dropped over time as a result of lower project risks paired with increasing competition. The prices listed are also not fully comparable as the projects in UK and Germany include parts of the transmission costs but the projects in Denmark and Netherlands do not. Subtracting transmission costs will increase the price by some €15-20/MWh for Borssele and Kriegers flak.

The subsidy-free bid in Germany in April of this year has a final investment decision (FID) milestone in 2021 and thus reflects the expectation on the future development, not actual prices today.

6.1.2 Recent development for solar PV

Compared to wind power, solar PV has grown at an unbelievable pace of 39% per year 2010-2017 and this growth could likely continue at a similar pace – since policy as a driver can give way to business rationale as a driver. Prices have followed on a dramatic downward trajectory with several new record lows being set that each surprised the world when they happened:

- May 2016: 800 MW solar PV in Dubai UAE at €25.7/MWh[77]
- November 2017: 289 MW solar PV in Mexico at €14.9/MWh[78]
- October 2017: 300 MW solar PV in Saudi Arabia at €15.4/MWh[79]
- November 2017: 2 200 MWh solar PV in Chile at €18.5/MWh[80]

The lowest bids at €14.9 and €15.4/MWh in Saudi Arabia and Mexico would translate to €20/MWh with Southern European solar irradiation conditions (1 400-1 600 versus 1 900-2 000 kWh/Wp[81]).

The price in Saudi Arabia and Mexico is much lower than the current cost of solar PV in Europe, but indicates where the market is moving already today, especially since it was European companies like Enel and EDF who won these bids, in local partnerships. It is likely just a question of a few years before the price in Southern Europe for solar PV will reach below €20/MWh. Solar PV has followed Swanson's law, a variant of Moore's law for semiconductors, since 1980[82], and the industry believes improvements will continue for many years on both cost efficiency and the technical module efficiency – given the range of different technologies that are scaling up and being tested. Given the large number of different technologies in use and under development and with new breakthroughs coming regularly, there is no technological reason to believe that this price development would halt, as long as volumes continue to grow.

The learning rate has been 24% on module price per doubling of cumulative production since 1980[83] and this indicates that a 30% annual growth rate over the next 5 years would imply an LCOE in Southern Europe of ~€12/MWh – assuming that the current historically low capital costs continue. This would completely revolutionize the utility sector.

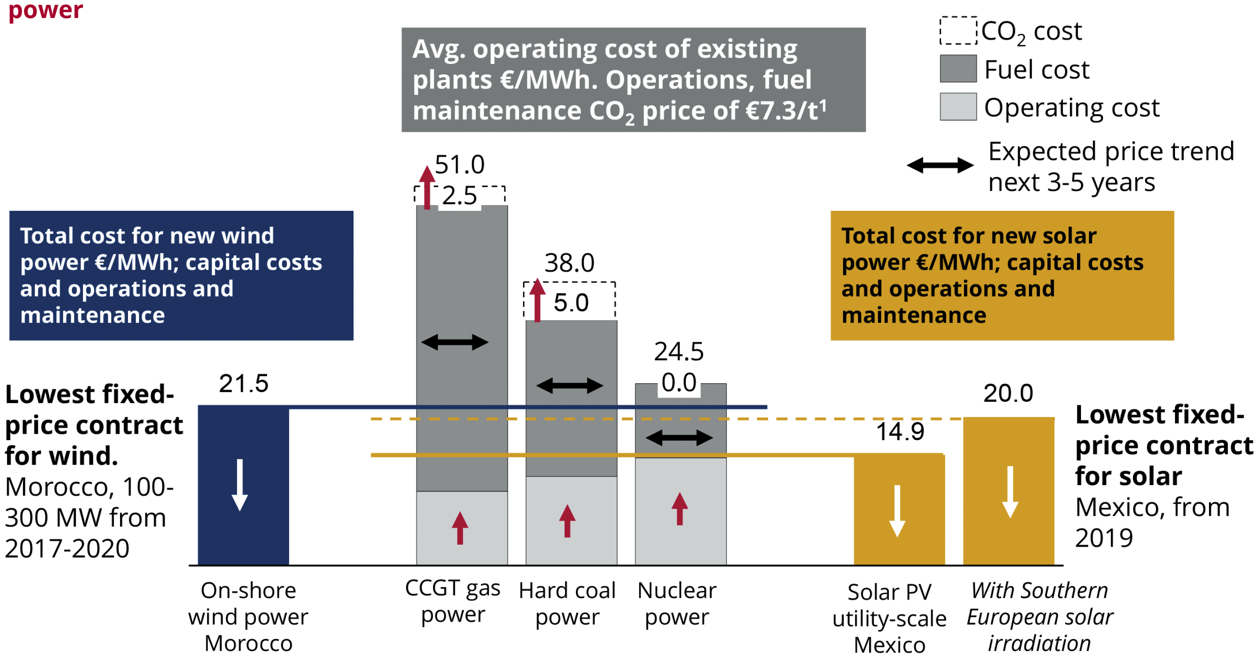
6.2 The renewable disruption in a European context

The electricity grid in Europe is a well-functioning system and over the last 5-10 years renewables have been built out through subsidies and mandates. Even including the European Trading Scheme solar and wind power have not been economically competitive with only a few exceptions. This situation is, however, about to change dramatically. The record-low total electricity costs for new wind (€21.5/MWh) and solar (€14.9/MWh) in the last 12 months as outlined above are actually significantly lower than just the operating cash costs for current coal, combined cycle gas turbine (CCGT) and nuclear power plants in Europe, as outlined in figure 6.1. The operating costs of power plants only include operations, maintenance, fuel and a CO_2 price of €7.3/t (average price Sep-Nov 2017 in the EU ETS[84]). This does not include any of the capital cost for building the power plant. For the solar and wind power plants, the costs include all project and financing costs, capital expenditure and capital cost as well as all operating and maintenance costs.

Solar in Mexico and wind in Morocco will of course not compete with European power plants, but this comparison indicates where the market is heading, and it is a matter of a few years until this applies to Europe as well, given the current price development of solar and wind. When Europe reaches this tipping point, it means that from a pure economic standpoint, it would in many cases be economically rational to build new wind and solar power and only keep the conventional power plants that are needed when the sun is not shining and the wind is not blowing. The rest of the power plants could be shut down. This is a profound change compared to the policy-driven situation we have today – a shift that

77 Mahapatra, "Dubai Gets Record-Low Bid of 2.99¢/KWh for 800 MW Solar PV Project."
78 Weaver, "Cheapest Electricity on the Planet Is Mexican Solar Power at 1.77¢/KWh."
79 Dipaola, "Saudi Arabia Gets Cheapest Bids for Solar Power in Auction – Bloomberg."
80 Bellini, "Chile."
81 "Global Solar Atlas."
82 "Photovoltaics Report."
83 "Photovoltaics Report."
84 "CO_2 European Emission Allowances in EUR – Historical Prices."

Operating costs of existing plants in Europe are today higher than the lowest total cost for new solar and wind power



Note: 1. Based on average actual CO_2 price in the EU ETS in the last three months (27 September to 27 November 2017).

Figure 6.1 Comparison of OPEX for existing power plants and total cost for new renewables[85,86,87]

was unbelievable to the electricity sector just a few years ago with profound consequences for the whole electricity sector in Europe and with the potential to significantly impact, or erase, the value of the conventional generating assets.

The most common arguments as to why this will not have a large impact on Europe are that we do not have enough sun and that we need stability in the grid. Those arguments are to some extent qualitatively correct but as outlined in the below sections, we do not believe they will save the value and cash-generating ability of the existing power plants for three reasons:

1) The cash cost for operating conventional power plants is actually increasing in Europe due to new safety and environmental regulation, thereby further worsening the cash-flow of the assets.
2) The sun shines less in Europe than in Saudi Arabia, but the difference is much smaller than many think. For Southern Europe the difference is 25% less annually, which would be compensated for by 1-3 years of the current price development of solar.
3) Backup capacity will be required from conventional power plants, for when the wind does not blow or the sun does not shine. But these plants will thus operate much fewer hours and with a lower electricity price – impacting the valuation negatively and erasing it for some.

1) The operating cash cost of conventional plants is increasing, not decreasing.

A series of safety and environmental regulations has been introduced and is being phased in, which will increase the operating cash cost for the conventional power plants in the near term. This means that the cash-generating ability of the power plants, even in the market today, will deteriorate. Some, but not all, of the cost increases can likely be passed on to the customers. These regulations are related to stricter safety regulation, local air pollution and the CO_2 price:

[85] Fürstenwerth, *Calculator of Levelized Cost of Electricity for Power Generation Technologies*.
[86] Parkinson, "New Low for Wind Energy Costs."
[87] Graves, "World's Cheapest Prices Submitted for Saudi Arabia's First Solar Project."

- For coal power the new European Union's Industrial Emissions Directive (LCP BREF, 28 April 2017) with new stricter standards on NO_x and SO_x emissions that apply by 2021 will require significant investments to retrofit existing coal power plants.
- Nuclear is facing a similar situation with increasing prices every year to cover for new safety requirements and re-investments in old plants.
- Moreover, the European parliament put forward a reform proposal for the EU ETS on 9 November endorsed by the EU council on 22 November 2017. The ETS reform will help the EU to deliver on its target of cutting greenhouse gas emissions by at least 40% by 2030, as agreed under the 2030 climate and energy framework and the Paris Agreement. This proposal means a faster reduction of the volume of emissions, increasing the price of CO_2 by 100-200% in the next 5-10 years, with significant impact on the cost of power production for coal and gas power plants.

2) **The sun shines less in Europe, but the difference is smaller than many think.**
One common belief is that it is such a large difference between solar irradiation in Europe compared to along the equator that solar PV will remain a marginal phenomenon in Europe. However, the difference is not as big as many believe. The record-low bid in Mexico and Saudi Arabia of €15/MWh would translate to €20/MWh when using the solar irradiation in Southern Europe. With the price of solar PV following a learning rate of -24% price per doubling of installed capacity, it means the difference in solar irradiation would be compensated for by one doubling for Southern Europe (~3 years) and two doublings for northern Germany (~5 years).

Solar irradiation – kWh / kWp for solar PV

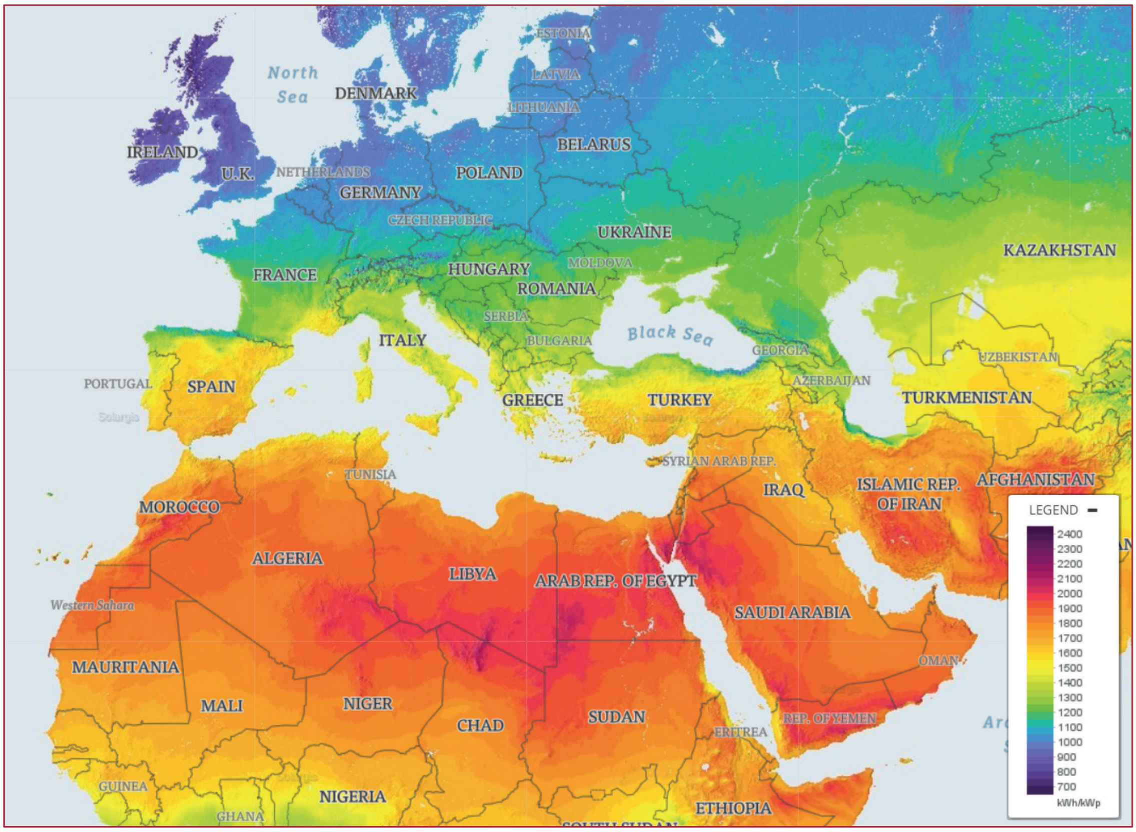


Figure 6.2 Map showing solar power potential for solar PV (kWh/kWp)[88]

[88] "Global Solar Atlas."

Using the record-low in Saudi Arabia as a benchmark translates to the following costs in Europe (assuming all but solar irradiation constant).

- Saudi Arabia: €15/MWh, solar irradiation: ~1 900-2 000 kWh/Wp
- Southern Europe: €20/MWh, solar irradiation: ~1 400-1 600 kWh/Wp
- Northern Germany: €30/MWh, solar irradiation: ~1 000-1 100 kWh/Wp
- Southern Sweden: €33/MWh, solar irradiation: ~900-1 000 kWh/Wp

3) **Conventional power plants needed as backup capacity.**
There has been a long discussion in the electricity sector on the risks and problems with a weather-dependent power production system and how much backup capacity will really be needed. However, the experience from the countries which have come far in this transition (e.g. Germany, Denmark) suggests there are many more stabilizing factors than previously believed, and hence the need for dedicated backup capacity is smaller than foreseen. Conventional power plants will be needed to secure parts of the base load and peak capacity, especially when the wind doesn't blow during the winter and the sun cannot contribute much – but just filling this role will imply a much lower valuation and profitability than today.

With a very large share of zero-marginal cost, wind and solar and using conventional power plants as primarily backup capacity will mean very few operating hours, and the average price of electricity will be much less than today. So even if conventional power plants are needed as backup capacity, without the electricity market changing completely, their cash-generating ability and thus valuation will be much lower than today.

Policy makers are focused to meet the Paris Agreement and promote renewable power and are thus unlikely to intervene to hold renewables back and protect the value of fossil fuel power plants. In addition, grid-scale battery storage is growing rapidly and with the whole transport sector moving to batteries, a backup storage capacity will be provided at the scale that only hydro has provided historically. Another development providing a new dynamic likely to take off even more, is deals where industrials (or other large electricity consumers) partner with specific companies to build renewable power plants and sign long-term power purchase agreements (PPA), to fulfill their own need of green energy. This is often done through smaller entrepreneurial customer-focused firms or technology providers, and not just the traditional utilities. One example is Norsk Hydro securing a 19-year PPA with Macquarie and GE for the 650 MW Markbygden wind farm, something that Apple, Facebook and Google have already done at scale in the US.

With power almost for free during large parts of the day, a completely new approach to demand management will be stimulated. It will be driven by consumers that want to cut their electricity bills as much as regulators wanting to stabilize the grid.

Taking all this together builds up to a perfect storm of technology and business model disruptions that will ensure a continued, and likely worsening, trajectory of write-downs, defaults and value-erosion for the electricity sector.

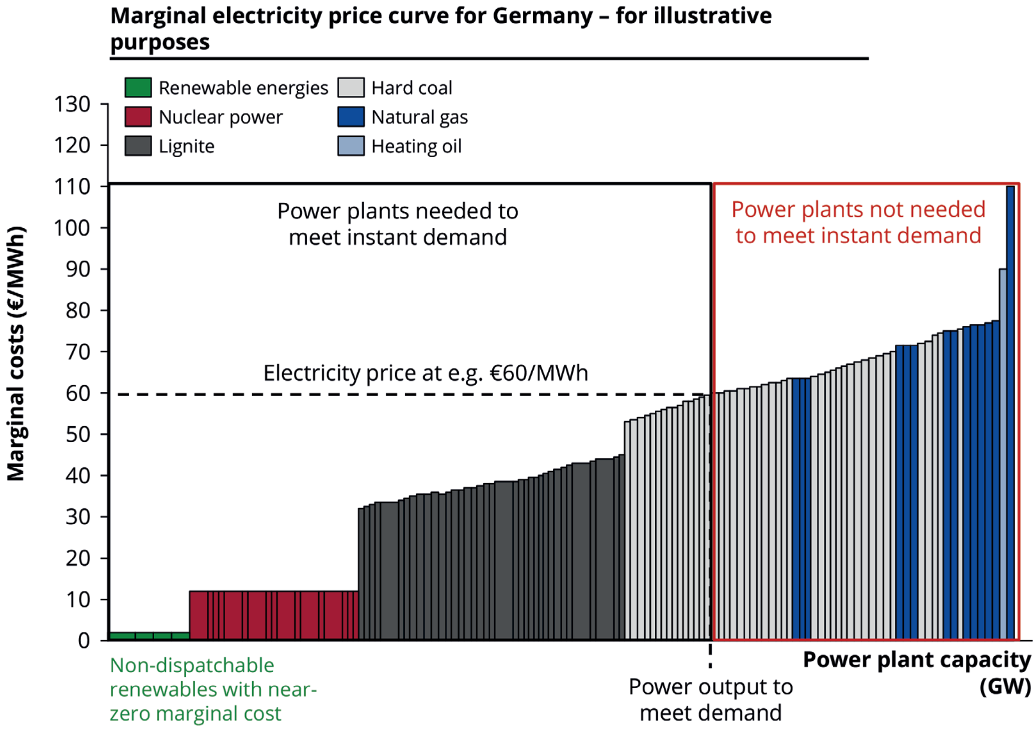
6.3 Implications and scenarios for the European electricity market

When renewables grow in the European energy system, they have two primary effects if not matched by increasing demand or a planned decrease in production, as illustrated in figure 6.4 below:

1) Lowering the overall power price on a daily and seasonal basis.
2) Decreasing the number of operating hours for conventional power plants.

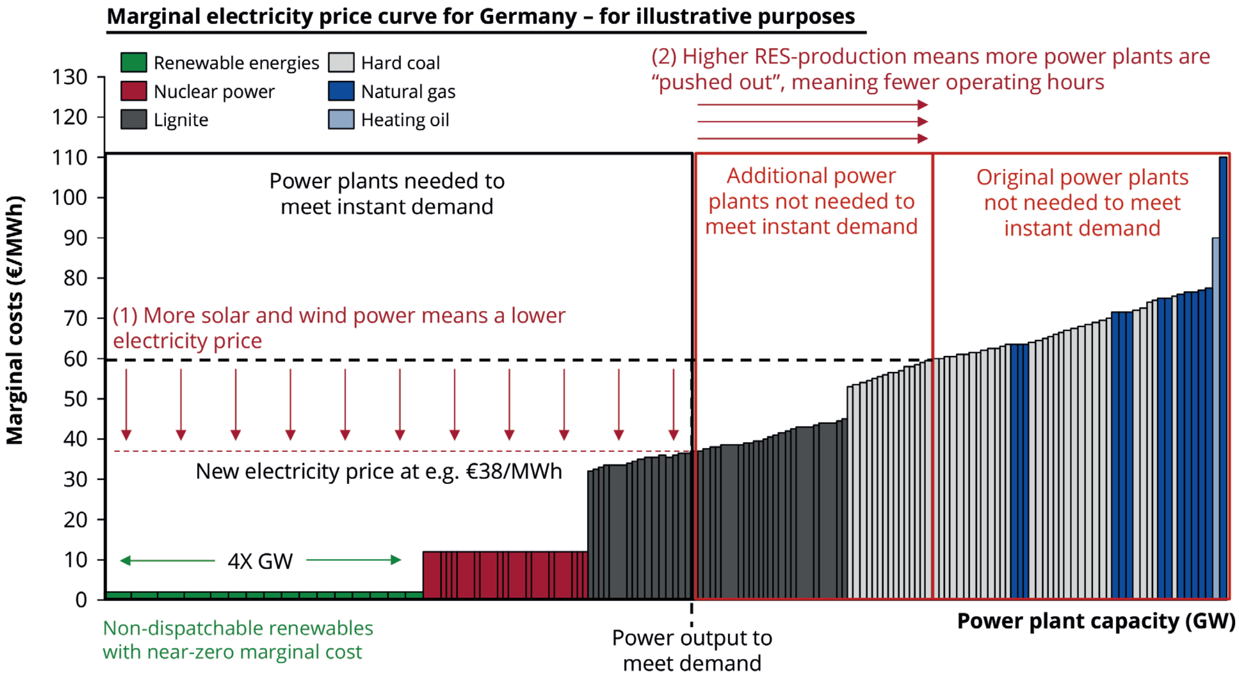
Combined with a stagnant demand, a continued build-out of renewables, faster than the retiring rate of nuclear power, will lead to fewer operating hours for coal and gas power plants and the hours they run will be less profitable. This will have a direct effect

Electricity market – the last power plant needed to meet instant demand sets the electricity price



Source: OEKO-INSTITUT, 2013

Higher penetration of renewables lowers the electricity price and reduces operating hours for conventional power plants



Source: OEKO-INSTITUT, 2013

Figure 6.3 Effects on conventional power plants when building out renewable energy

on the cash-generating ability of these plants and thus a direct effect on their valuation. Many analysts believe that the increasing build-out of renewables will be more than countered by the retirement of nuclear power in Germany and other places, leading to an increasing power price in Europe over the next 5-10 years. In a scenario with a much faster pace of build-out than expected, especially for distributed and utility-scale solar PV and offshore wind, the underlying assumptions on power price for the conventional power plants book value might be proven wrong.

We believe two factors are inherently uncertain and will have a large impact on the European electricity market: the economic growth and the build-out of renewables in the next 5-10 years. These developments are driven by several underlying trends that will shape the sector and the risk for stranded assets. There is also a series of other factors likely to have an impact but with a higher degree of certainty (e.g. the nuclear phase-out in Germany) or with a smaller impact in the medium term (e.g. electrification of transportation).

- **Renewables build-out.** The most obvious ongoing disruption has a large impact, but the big question is how fast will the transition be? The pace for the European market will largely depend on four main factors:
    - **Price development.** Given the current trajectory of rapidly declining prices, when will the price of new renewables go below the operational cost of conventional power plants in Europe? In the next 5 years or 10 years?
    - **CO_2 price.** For coal power the CO_2 price constitutes roughly 10-15% of the operational cost, for gas CCGT it is about 5% at the current level of ~€7/tCO_2. In November 2017 the European Parliament put forward a proposal to limit the emission volume in the ETS and thus quickly increase the price of CO_2 after 2020, which would mean a significant price increase for coal and gas power plants – making renewables outcompete these power plants even earlier.
    - **Policy mandates and subsidies.** How much will policy makers continue to push for the build-out of renewables through subsidies or renewable mandates, especially when they become competitive on the market and when it becomes more apparent that it further erodes the value of current assets and contributes to an over-supply situation?
    - **Storage and digitization.** How fast will solutions scale to improve grid management to allow for an even more rapid development of renewables, without the grid setting any limits? This will be driven by how fast storage solutions become cost competitive and scale and how fast digitization can drive demand-side management solutions. In addition, the electrification of transport can be integrated with grid storage solutions to further provide a good foundation for renewables to continue to grow. These are solutions already being practiced today to some extent and the big question is how fast will they grow, not will they emerge?
- **Economic growth, driving electricity demand.** Even though the link between GDP growth and electricity demand is weaker today than in the last 30 years, economic development will be a key driver of electricity demand. In a situation with sluggish economic development, it is likely that electricity demand would continue to be negative, given the fast development of energy efficiency. In a fast-growing economy, demand would rather stabilize or grow slowly. This is of course an inherently uncertain factor over the next 5-10 years, but very important in keeping track of going forward.
- **Other factors.** These are important but less uncertain or with a smaller overall impact:
    - **Retirement of nuclear capacity in Germany.** The current plan is to phase out nuclear power in Germany completely by 2022. About half has already been taken out, going from 20.4 GW in 2010 to 10.8 GW (80 TWh) in 2016[89]. This can be compared to solar PV (40.7 GW, 37.5 TWh) and wind power (49.6 GW, 77.8 TWh) in 2016, with an increase

[89] "Net Installed Electricity Generation Capacity in Germany."

from 2016 to 2017 of 5.7 GW wind and 2 GW of solar PV in Germany alone, which would generate approximately an additional 10.5 TWh per year. The increase in Europe was 19.2 GW solar and wind 2016 to 2017, which would generate approximately 25 TWh per year (12.5 GW wind[90] and 6.7 GW of solar in 2016). This means that Germany alone would need ~8 years of the 2016 pace of solar and wind installations to compensate for the nuclear phase-out and Europe as a whole would cover it in 3 years. Although the phase-out is significant and implies a major impact to the whole electricity market and asset values, even at the current pace of renewable installations, it would be compensated for in a few years. In addition, this is not a key uncertainty for scenario analysis, as few believe that the decision will be reversed or changed.

- **Increasing demand from electrification of transportation.** Although a major transformation of the transportation system, this will not mean a dramatic change to electricity use. Even in dramatic electrification scenarios, electricity use will only increase marginally. Total energy consumption for road transport in EU28 was 294 million tonnes of oil equivalent in 2015[91], and about 60% for light-duty vehicles. This would correspond to ~510 TWh of electricity if all cars were electric (assuming 75% lower energy use per km for electric engines versus internal combustion engines and no growth 2018 to 2030). The total EU28 net electricity generation in 2015 was 3070 TWh[92]. Ambitious electrification scenarios of 10-30% of the car fleet fully electric by 2030 would mean a growth of 0.14-0.41% per year in electricity demand 2018-2030 or 2-6 years of the solar and wind installations in 2016. This is not a negligible development, but also not a large reason for believing in significant growth for the European electricity market. As a rule of thumb, for one household driving 10 000 km per year with an electric car, 8 standard solar panels of 260W would generate the same amount of electricity the car would use in the whole year.

Based on the pace of renewables and economic development, we have outlined four illustrative scenarios for the electricity sector. In each of these the assets of the sector will be impacted very differently in the medium term.

The scenarios will result in very different implications for the industry.

Scenario 1: Stable market short-term. For the next 5 years in this scenario, the build-out of renewables is matched by demand growth and phase-out of nuclear, to create a stable average electricity price. Renewables are quickly covering ground and scaling up with more and more distributed energy systems coming online. By 2022 when all of the nuclear power plants have been phased out, the price decline of renewables will have further accelerated the growth of renewable power which now out-paces demand growth. This will create a situation of over-supply and over-capacity in the electricity market, resulting in quickly dropping prices and a large reduction in the operating hours for the conventional generating assets. This situation would mean a stabilization of cash-flows for conventional power plants in the near term. In the longer term post 2022, the accelerating build-out of renewables and distributed power would lead to a rapid price decline – and thus a rapid value-loss for conventional power plants. Since distributed generation with storage would play a significant role in this scenario, the value of backup capacity provided from oil and gas power plants would be especially negatively impacted.

Scenario 2: Green transformation. This scenario will form another perfect storm for the electricity market and utilities going forward. Demand is stagnant with a slow economic development, and the price development of renewables, paired with storage, accelerates. The impact of the nuclear

[90] "Wind in Power."
[91] "Energy Consumption of Transport, by Mode."
[92] "Electricity Production, Consumption and Market Overview - Statistics Explained."

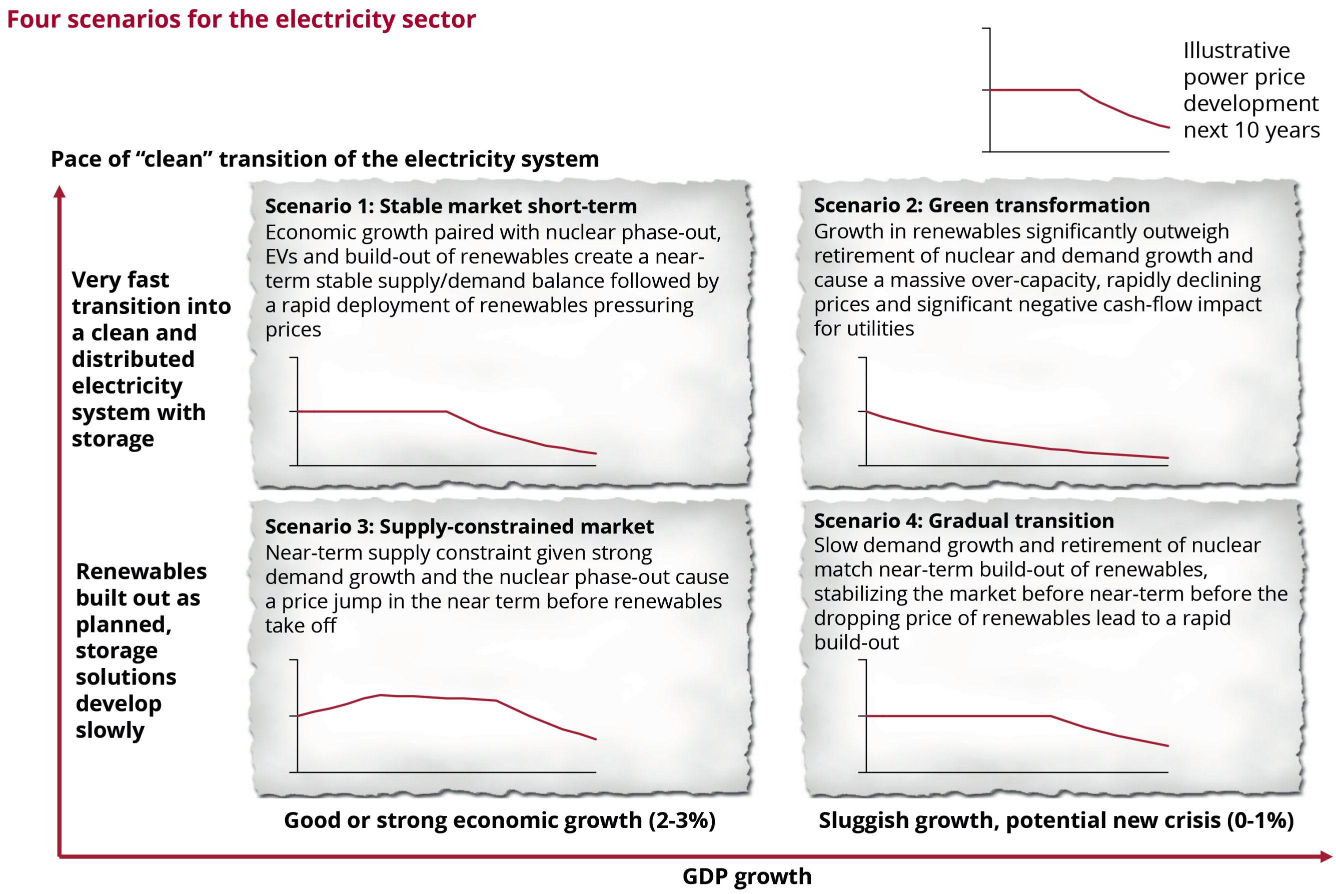


Figure 6.4 Scenarios for the European electricity sector

phase-out is not compensating for the rapid scale-up of renewables. Paired with local energy storage, low-cost renewables can be built out at a much faster pace than the demand development would warrant and without major constraints from grid stabilization issues. This leads to a situation with significant excess capacity from renewables and over-supply of electricity during major parts of the season and days across Europe. The development yields a drastically lower average power price and significantly fewer operating hours for conventional power plants, especially those with a relatively high marginal cost of production, like hard coal and CCGT. Cash-flow of the power plants would be negatively impacted leading to significant value-erosion, write-offs and likely many defaults.

With distributed generation combined with local energy storage, for some parts of the grid, the consumer price of electricity might even go below the cost of transmission and distribution – especially for regional markets with relatively high electricity taxes. This would mean that the value of transmission and distribution assets for some regions can be negatively impacted, and even become redundant in some exceptional cases – especially in Southern Europe which does not have much of the seasonal disadvantages for solar power.

Scenario 3: Supply-constrained market. This scenario depicts a situation many market experts believe in as a base case. A situation where the economy grows at a healthy pace stimulating electricity demand and the build-out of renewables is not able to fully match the phase-out of nuclear. In this scenario the market would be supply-constrained, especially in some regional markets, and prices would increase in the medium term with conventional power plants required to run more operating hours than today. This means a positive cash-flow development for the conventional power plants and maintained or even increasing asset value. Over the longer term, the price development of renewables would lead to a gradual scale-up and stable or even oversupplied market. Over time, this would lead to asset impairments and deteriorating profitability, but from a much stronger starting point than in the other scenarios.

Scenario 4: Gradual transition. This scenario will result in a stable electricity market in the near term, much like scenario 1, but with other drivers. In the next 5 years the stagnant economy and phase-out of nuclear will together match the build-out of renewables, creating a stable electricity price. After 5 years the price of renewables would have dropped significantly and with the phase-out of nuclear completed, the build-out of renewables would outpace the stagnant demand growth from a slow economic development. This gradually creates a situation of over-supply, lowering prices significantly. This situation would mean a stabilization of cash-flows for conventional power plants in the near term but over time a worsening position implying a significant lower valuation.

6.4 Assets at risk of becoming stranded

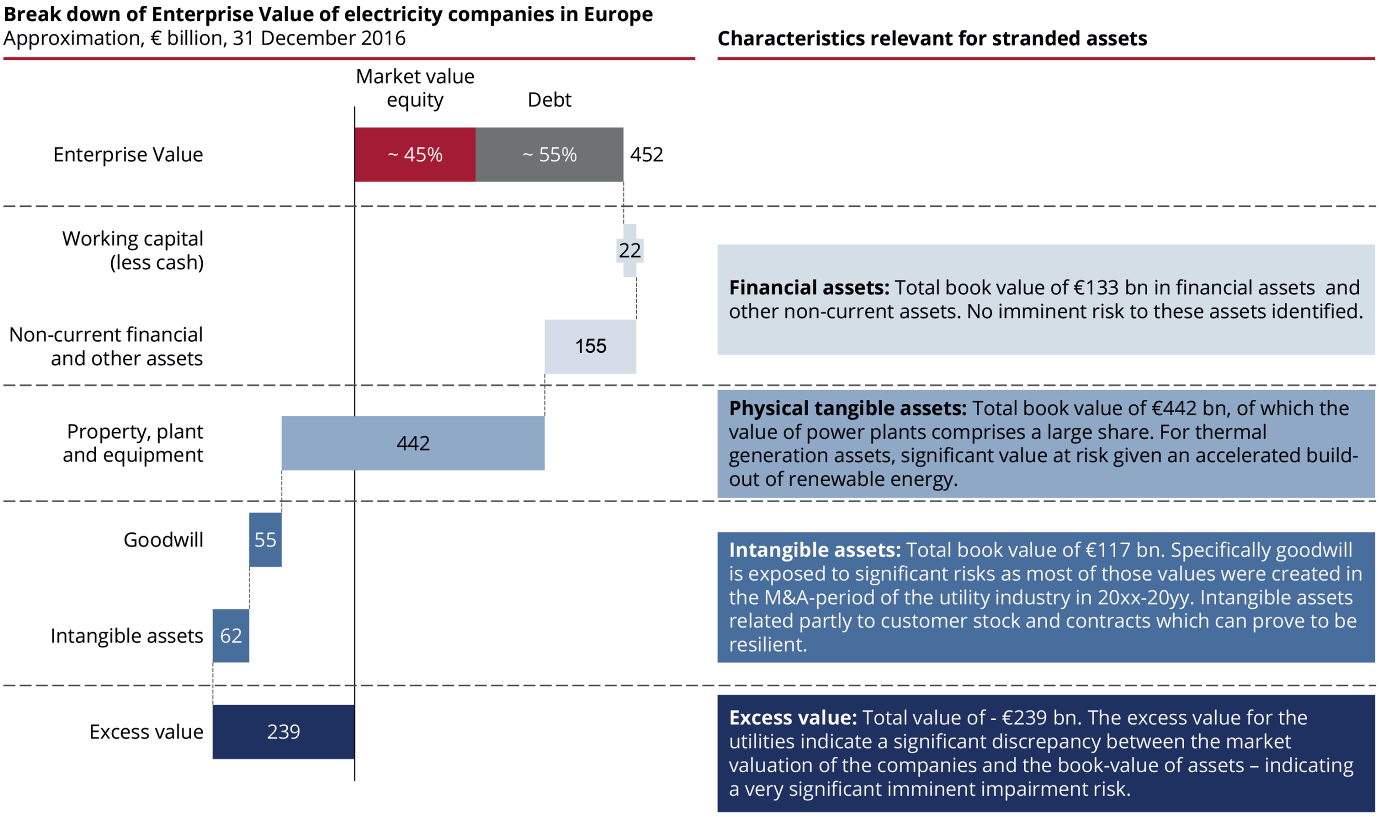
The 12 largest utilities in Europe have a combined enterprise value estimated at €452 billion, of which market capitalization was €203 billion by 31 December 2016. The sector has gone through a long period of write-downs, losses and carve-outs, e.g. the carve-out of thermal assets from E.ON, to the new companies Uniper and RWE carving-out renewable, network and retail businesses to Innogy.

It is interesting to note that the book value of long-term assets on the balance sheet of these utilities (€692 billion) is ~50% higher than their enterprise value, as of 31 December 2016. The assets most exposed to the ongoing disruptions are goodwill and property, plants and equipment which sum to €496 billion. This is a situation where the discrepancy between the market valuation and the book value of the assets is enormous. It either implies that the market is wrong and significantly undervalues these companies, or that the market sees the ongoing disruptions in the market and has taken them into account in the valuation, but the companies have been lagging behind with the actual write-downs and many assets thus maintain an artificially high value on the balance sheets. Assuming that the market is correct, then the end of the decline of utilities in Europe is far from over. Hundreds of billions of Euros in write-downs are to be expected – and potentially several defaults.

Conventional power plants as coal, gas and nuclear have faced significant write-downs which will continue, probably at an accelerated pace. The sector will undergo a complete transformation with whole asset categories at much lower value. The question is whether or when will the economic lifetime actually become much shorter than the technical lifetime for these plants. It has been called the utility sector for a reason – the very stable cash-flow and predictable returns – but for these assets it is likely to be a shaky future.

The 10 largest listed utilities, representing ~80% of the total electricity generated in Europe, are exposed to significant risk as outlined above. As the companies are listed, they are under continuous scrutiny by external analysts acting as a forcing device for impairments – and still it seems that the market is far further ahead in downgrading the value than the books imply. There is normally a time-lag between market valuation changes and actual write-downs, but it seems that the size of the discrepancy is out of proportion. For unlisted power producers, this story could be even worse. The forcing device of external scrutiny does not exist to the same extent for the unlisted companies and they represent ~20% of power generation in Europe. Many are municipal or regional conventional power plants, CHPs or small-scale wind or solar farms – with little incentive to publicly announce impairments as that can of course be an embarrassment for management and the owners. Given this, the discrepancy between book value and market value is higher for these companies, implying that assets at risk and potential write-downs needed, as a share of current book value, are likely much higher than for the listed companies.

The Enterprise Value of electricity companies at ~€452 billion, with physical assets close to 98% and intangible assets close to 26%



Note: Market cap for 12 larger public electricity companies in Europe (including subsidiaries): CEZ Group, E.ON, EDF, Enel, Engie, Fortum, Iberdrola, Innogy, PPC, RWE, SSE and Uniper. Asset values latest available numbers, from 31 December 2016.

Figure 6.5 Enterprise value breakdown of European utility companies

7

APPENDIX: AUTOMOTIVE SECTOR SCENARIO ASSUMPTIONS

This section outlines the assumptions used to estimate the total asset value exposed to risk across the scenarios for the automotive sector. These assumptions are based on publicly available data and sourced from company annual reports.

7.1 Overview of assets in the automotive sector

7.1.1 Physical assets (property, plant, and equipment)

The categories of PPE assets in the automotive sector include firstly plants and machinery, with an asset lifetime of 10-20 years (plants) and 6-8 years for machinery (same as vehicle model lifetime). Secondly, other equipment consists of mainly tools and equipment specifically designed for different car models with a lifetime of normally 5-6 years. Lastly, there is land, buildings and offices, which are more flexible and resilient to changes in the car drivetrain and business models.

Based on a review of balance sheets and interviews, we have estimated a total of 60% of the PPE assets to be related to non-specialized physical assets that would be resilient to a rapid decline in the demand of conventional vehicles as electric vehicles start to scale. A resilient asset in this case is defined as an asset which would be in use regardless of the car model produced, or with only minor costs for adjustments, e.g. property and facilities, non-specialized machinery, tools and production assets. This proportion of PPE is not likely to be exposed to risk of stranding across any of the scenarios. The remaining estimated 40% of PPE assets (€65 billion) are tightly tied to conventional cars through specialized production lines, machinery and tools. The value of these assets assumes a high utilization and production of the cars they were specialized for – and would thus be exposed to any rapid growth of the sales of electric vehicles at the expense of conventional vehicles. Based on interviews our understanding is that this type of asset also would require significant resources to adapt to an electric vehicle production line, if at all possible. In conclusion, across the scenarios with a rapid development of electric vehicles, this category of assets (~€65 billion) would be exposed to significant risk of value-erosion, depending on the pace of electrification.

7.1.2 Leased products and financial service receivables

The book value of leased products and financial service receivables are tied to the financing arm of specifically BMW, Volkswagen and Daimler, representing 95% of the total of €292 billion. The financial service receivables (€166 billion) are to a large extent tied to contracted payments for the leasing periods and are assumed to be under limited risk – unless a large share of customers start to return their cars early due to anticipated price declines or other reasons, e.g. following the diesel scandal. The book value of leased products (€126 billion) is, however, more exposed to risk as it to some extent carries the risk of the residual value of the cars, after the leasing agreement ends. If the residual value of the cars changes dramatically, it would mean significant risk to the financing arm of the auto manufacturers. This change could happen because of strict regulation against diesel and petrol cars or a more attractive market for electric vehicles.

The overall risk exposure for the asset values comes from the assumption that a situation of over-supply of ICE-cars could emerge, either because of growth in the electric vehicle market or due to a declining demand of cars due to sharing models scaling. This would mean that when the leasing agreement comes to an end, the residual value would be significantly lower than anticipated. The leasing agreements often have a length of 3 years and then the car is taken back by the original equipment manufacturer (OEM) and sold back to the market. A prospective buyer of the previously leased car often considers the remaining value of the car in 5 years, which in turn is dependent on the market and policy development. This means that the cars on lease today need to be attractive on the market in about 5-8 years from now.

Given the very small market of electric cars, we have assumed that the majority of leased cars are conventional diesel or petrol cars (close to 100%). Contracts with a short remaining lifetime will likely be less exposed to risk compared to contracts with more time left. Given an even distribution of contracts, we assume that 33% of the lease-contracts end within 1 year and that these cars are mainly affected by the diesel scandal, but we assume that this has been integrated in the valuations. For the remaining 66% of the cars on lease, with contracts lasting more than one year from now, we see increased risk exposure to the residual value of the cars across the electrification, car sharing and intermodal scenarios.

For the scenarios, in a rapid electrification scenario, we assume 25% of the cars under lease with a contract time less than 1 year exposed to significant risk, 50% of the cars with 1-2 years remaining and 100% of the cars with 2-3 year contracts remaining. We have assumed no risk exposure for the book value of the financial service receivables. This gives a total of €73 billion exposed to risk.

For car sharing and intermodal transportation scenarios we have assumed a smaller risk exposure to the leased assets compared to electrification; 0% of the cars with 1 year remaining are exposed to risk and 25% and 70% respectively of the cars with 1-2 years and 2-3 years remaining on their contracts. We have assumed no risk exposure for the book value of the financial service receivables. This gives a total of €40 billion exposed to risk.

For scenario 2, with an overlap between electrification and car sharing, we assume that the assets exposed to risk from car sharing are a subset of the assets at risk due to electrification.

7.1.3 Intangible assets (capitalized R&D)

Typical life length of capitalized R&D is 6-7 years corresponding to the lifetime of a new car model. In recent years investments have been concentrated to develop diesel and petrol vehicles with lower emissions and better fuel standards, which also include electric drivelines but to a smaller extent.

Based on reviewing the annual reports and notes to the balance sheets of the automotive manufacturers, we have concluded that approximately two-thirds of capitalized R&D is tied to products already in use and on the market, while one third corresponds to products under development and not yet for sale. For the capitalized R&D tied to products in use, we assume 95% is related to internal combustion engine vehicles, given the EV share of sales at 1% but with a higher development cost. For the products under development the numbers are not disclosed, but given the pipeline of new model launches with a significant amount of internal combustion engine models, we assume that they make up 40% of the capitalized R&D. Given that not all of this capitalized R&D would be tied to the drivetrain, we assume two-thirds directly related to the internal combustion engine and one-third to other aspects of the car. Across the scenarios, we assume that a rapid electrification scenario would lead to a significant risk exposure for all capitalized R&D tied to the internal combustion engine, estimated at a total of €28 billion. For a scenario of rapid development of car sharing it is challenging to estimate what share of the capitalized R&D assets that are fully exposed to risk – given the diverse implications for the cars – it would implicate. We have assumed that it is primarily the non-drivetrain part of the capitalized R&D that would be exposed to risk and of that we assume 75% to be exposed to risk in a rapid car-sharing development, totaling €14 billion.

7.1.4 Excess value (capabilities, brand, growth expectation)

Based on the review of the balance sheets the total 'excess value' is calculated to be €89 billion; a large part of this is assumed to be related to the brand of the company. The brand is today crucial in the automotive sector and the automotive manufacturers use marketing to create the right brand image and attract the right customer base to their products. However, when the car becomes self-driving and shared, the link between the driver and the car is likely to weaken, which in turn results in a lower brand value and a different value perception of different cars and therefore a worse outlook for premium pricing for example.

The worst-case scenario for the OEMs would be if the car becomes a shared-use commodity similar to trains so that the operator owns the high-value brand whereas the vehicle producer only makes the cars. For some manufacturers a significant portion of the brand value and rationale of premium pricing is tied to the engine and driving experience, and both of these are likely to be exposed in a scenario of rapid electrification and self-driving technology. For this most intangible part of the balance sheet it is of course very challenging to quantify risk exposure. Based on the disruptions outlined above we have assumed that electrification and self-driving technology both expose 10% of the excess value to significant risk, €9 billion. The much larger effect would be expected from a large-scale development of shared business models where the cars would be seen as a mode of transport, much more commoditized than today. Here we have assumed that 50% of the excess value would be exposed to significant risk, totaling €45 billion.

7.2 Summary of assets at risk under different disruptions and scenarios

Scenario 1: Premium mobility
A quick transformation to electric and self-driving vehicles would imply a total of €184 billion exposed to significant risk, combining the exposure across self-driving and electrification disruptions.

Scenario 2: Individual transport revolution
In the same way as scenario 1, a rapid development of self-driving EVs will create a risk exposure of €184 billion. In addition, the rapid development of car sharing will add another €59 billion of asset value exposed to risk, to a total of €243 billion. For the leased products, we assume that the risk exposure from car sharing is a subset of the value at risk from electrification.

Scenario 3: Mobility as usual
This assumes the base case with slow transformation of the car sector allowing for the automotive manufacturers to adapt to the changing market and thus we assume no significant value exposed to risk.

Scenario 4: Undifferentiated commodity
In this scenario of a rapid development of the car-sharing business model commoditizing the car it will add up to a total of €99 billion exposed to significant risk across the different asset categories.

ASSETS	Physical assets – PPE (€ bn)	Leased products and financial serv. receivables (€ bn)	Intangible assets – capitalized R&D (€ bn)	Excess value – capabilities, brand, growth expectation (€ bn)	Total (€ bn)
Total asset value	163	292	56	89	600
DISRUPTIONS					
Electrification	65	73	28	9	175
Self-driving cars	0	0	0	9	9
Car sharing	0	40	14	45	99
Intermodal transport	0	40	14	45	99
SCENARIOS					
Scenario 1: Premium mobility	65	73	28	18	184
Scenario 2: Individual transport revolution	65	73	42	63	243
Scenario 3: Mobility as usual	0	0	0	0	0
Scenario 4: Undifferentiated commodity	0	40	14	45	99

Figure 7.1 Asset values exposed to risk for the European automotive sector

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