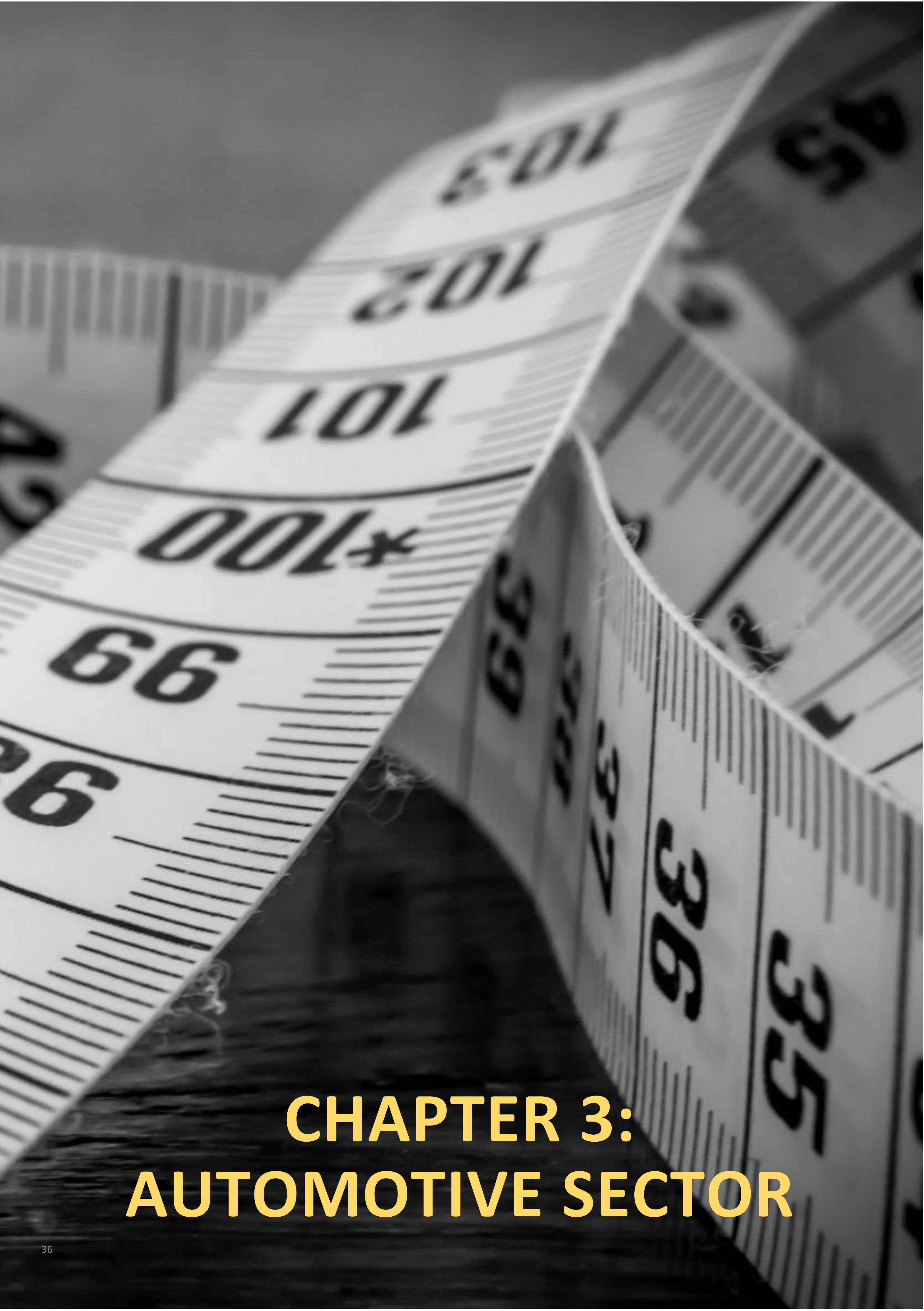


CHAPTER 3: AUTOMOTIVE SECTOR

3 AUTOMOTIVE SECTOR

GENERAL OVERVIEW

The transition risk story for the automobile sector plays out along a few general trends:

- **The switch to zero-carbon powertrains.** The IEA estimates that Internal Combustion Engine (ICE) powered cars (e.g. petrol, diesel) will only account for around 10% of total car sales in 2050 under the 2°C scenario, with a rise in electric and fuel cell alternatives. Zero-carbon powertrains are similarly set to grow under a 4°C transition, albeit at a less rapid pace.

- **Changing economics around car production.** The ‘car production chain’ will evolve with the introduction of new actors (e.g. battery manufacturers) and the associated shift in revenues and margins within that chain. This can work to the benefit of car manufacturers as they ‘internalize’ a larger part of the value-add of the car manufacturing process or to their detriment as this may squeeze their margins.

- **Increasing fuel efficiency standards (both policy- and demand driven).** Fuel efficiency standards now exist in basically all major economies at varying degrees of ambition. In the same vein, consumers are more sensitive to fuel efficiency considerations when purchasing cars (in part as a function of oil prices).

- **A broader context of changing consumption patterns and technology changes.** Beyond questions around decarbonisation, the car industry is undergoing other fundamental shifts, noticeably the growth of ‘car-sharing’ models, urbanization and associated changes in car ownership patterns, as well as the potential rise of autonomous driving, each potentially reinforcing each other and having impact an overall sales volumes.

The scenarios developed here focus on risk assessment for the passenger light-duty vehicle sector.

The scenarios involve the following parameters:

PRODUCTION & TECHNOLOGY	Sales by powertrain (%)
MARKET PRICING	Low-weight composites costs (e.g. carbon fibre) (USD/pound) Battery costs (USD/kWh)
POLICY MANDATES, INCENTIVES & TAXES	Fuel efficiency standards (% reduction) Effective carbon rates (EUR/tCO_2)

5 THINGS BEFORE GETTING STARTED

1. **Long-term Business Model Risk.** In addition to questions around decarbonisation, the automobile industry is facing a fundamental shift in the way mobility is delivered and used. This relates notably to the rise of car-sharing systems, changes in demographics, and the technological evolution of autonomous driving. Each of these on their own represent potentially disruptive risks for the automobile sector. They will also affect the individual risk drivers presented in this section (e.g. total automobile sales, etc.) and by extension both the probability of various decarbonisation scenarios and their nature. Considering these trends in the context of the risk drivers presented in this section is thus critical.

2. **Production Differentiation.** The automobile sector is arguably the sector with the highest level of product differentiation among the sectors discussed in this scenario. By extension, industry average estimates around drive train, fuel efficiency, and even qualitative assumptions around consumer preferences may affect different manufacturers differently. This differentiation may also extend to the cost structures faced in the supply chain by different manufacturers. For example, a review of the literature on battery prices suggests different manufacturers face significant differences in terms of battery costs. This may then extend similarly to the evolution of battery prices in the future.

3. **Variability in Usage.** As for other sectors, risk and climate considerations may not always align in the automobile sector. For example, sports vehicles may have a relatively low fuel efficiency, but emit significantly less GHG emissions over their lifetime, given less use than, for example, sedan commuter cars. This similarly complicates questions around the remaining carbon budget associated with various levels of car production associated with various levels of fuel efficiency and powertrains.

4. **Regional Differentiation**. While most of the automobile scenarios are presented as global scenarios, different manufacturers have more or less exposure to different markets and may thus be particularly affected by regulatory trends in one or the other market (e.g. Volkswagen in China, Ford in the United States, etc.).

5. **Subsidy Impact.** Current subsidies for the light-passenger duty vehicle sector accrue effectively exclusively to consumers (e.g. credits on EV purchases, gas subsidies etc.), the upstream supply chain (e.g. fossil fuel subsidies) or research and development. The role of policy prices or subsidies in risk assessment is unclear. This implies that many policy incentives may only indirectly affect producers and may have a higher impact in terms of changes in consumer preferences (responding to policy incentives), rather than direct exposure to policy incentives or taxes.

3.1 SALES BY POWERTRAIN

Overview. The primary GHG emissions driver in the automobile sector is related to the emissions from the internal combustion engine used in cars. Emissions can be reduced both through efficiency measures (see next section) and a switch to alternative low-carbon powertrains (e.g. electric vehicles, hybrid, fuel cells, etc.).

Risk pass-through mechanism. Changes in consumer preferences, relative prices, and / or policy signals will require companies to adjust their production profile to respond to these changes thus requiring capital and R&D expenditures. Failure to adjust is likely to primarily impact sales volume, although the economics of different drive trains will also impact margins associated with sales.

Sources. A number of industry data providers and consultants provide forecasts and future sales / production of light passenger duty vehicles by drive train. However, these are not usually designed to forecast trends with regard to specific climate scenario. The International Energy Agency has in the past not consistently provided this indicator and where it has, it usually is expressed as numbers of cars on the road, rather than production / sales, a figure which the IEA model generates internally, but doesn't always publish.

Methodology choice. The figures presented here are based on IEA information currently not published in their report. They can be derived from the estimates of cars on the road. An alternative source may be the forecasts, for example, from Bloomberg New Energy Finance (BNEF), although these are not explicitly linked to a climate outcome given their sector specific nature and thus may be more or less ambitious than the IEA.

Results. Given the lack of geographic granularity in the IEA data, the results are presented at global level. Due to inconsistencies identified in their more recent scenarios, the values are taken from IEA ETP 2014. The following table summarizes the results for the global market by powertrain, based on the classification provided by the IEA[3]. While the results are global, these can be complemented by some national targets on electric vehicle stock that may be relevant depending on car manufacturers market exposure in the United States (3.3 million by 2025), France (2 million by 2020), and Germany (1 million by 2020) (IEA 2016d). In the LCT scenario, the share of hybrid LDV sales grows to 6.0% and that of electric vehicles to 2.9% in 2040. In the ACT scenario, almost two-thirds of sales in 2040 will be of hybrid or electric vehicles. CNG sales remain in a lower single-digit range.

TABLE 3.1 PERCENTAGE OF TOTAL AUTOMOBILE SALES BY POWERTRAIN FOR THE ACT AND LCT SCENARIOS
(SOURCE: AUTHORS, BASED ON IEA 2014)

Year	EV		Hybrid		Petrol		Diesel		Fuel Cell		CNG / LPG	
	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
2020	3.1%	0.4%	6.0%	0.2%	74.0%	77.5%	12.5%	18.3%	0.1%	0.0%	4.2%	3.6%
2025	6.0%	0.7%	13.2%	0.6%	65.0%	77.4%	10.9%	17.4%	0.4%	0.1%	4.4%	3.8%
2030	11.0%	1.2%	22.3%	1.6%	53.1%	76.5%	8.3%	16.4%	1.1%	0.1%	4.4%	4.1%
2035	15.6%	2.0%	32.5%	3.4%	39.5%	74.4%	5.9%	15.6%	1.9%	0.2%	4.6%	4.4%
2040	20.4%	2.9%	43.4%	6.0%	26.6%	71.5%	3.7%	14.8%	3.1%	0.3%	2.6%	4.5%

3.2 LOW-WEIGHT COMPOSITE COSTS

Overview. Materials make up nearly 50% of the cost of producing a car (Market Realist 2015) and can thus be a critical risk driver in the context of the transition to a low-carbon economy. There are a range of materials that go into a car, with steel accounting for over 50% according to some estimates (Russo 2012). At the same time, new alternative low-weight composites are starting to compete (e.g. carbon fibre), influencing both the economics of electric vehicles and ICEs. Both, low-weight composite costs or high-weight alternatives (e.g. steel) in terms of price competition are considered here.

Risk pass-through mechanism. Estimates around the evolution of material costs can be positive or negative for a car producer. For example, lower costs of low-weight materials will support margins around electric vehicles that are likely to rely more on low-weight materials to sustain range. In addition, they may increase the probability of electric vehicle pick-up as they extend ranges. Should electric vehicle mandates be instituted without price drops around low-weight composite costs, margins are squeezed.

Sources. Estimates around future steel prices range widely (see Section 4.5). One key question is the extent to which carbon taxes on steel are passed on to car manufacturers (and in turn end consumers) and the impact this has on the relative economics of different materials and composites. Similarly, estimates are also lacking for low-weight composite alternatives (e.g. carbon fibre).

Method. The scenarios developed here focus on carbon fibre, a prominent low-weight composite alternative. Although there are no 2°C scenarios on carbon fibre, estimates for both scenarios were built following literature review. Research suggests a $5/pound price is necessary for wide-scale adoption (Lucintel 2012). Current estimates suggest carbon fibre costs around $7-11/pound [~$15-$24 / kg] (Das, et al. 2016, Bregar 2014).

Results. The ACT and LCT scenarios define the following indicators around projections for low-weight composite costs at the global level, using carbon fibre as an example, although the results are likely to be similar for other materials, independent of which exact material wins out.

TABLE 3.2 COSTS OF CARBON FIBRE IN THE LCT AND ACT SCENARIO (GLOBAL) (SOURCE: AUTHORS, BASED ON NREL)

Year	Carbon fiber costs (USD/pound)
2016	7-11
2020	7
2025	5

3.3 BATTERY COSTS

Overview. Battery costs differ across different market providers. Current estimates for 2015 around battery cost ranges as low as $190/kWh (Ayre 2015) to market average estimates between $273/kWh (ETC 2017) and $350/kWh (PRNewswire 2016). This makes market average forecasts difficult since the starting point is unclear and the range across the starting points quite significant. This relates to what has been highlighted earlier as to a non-homogenous capital cost curve faced by companies (see Page 37). As an example, Tesla already claims their battery costs could be of $ 100/Kwh by 2020 (Coren 2016).

Risk pass-through mechanism. Similar dynamics appear as for composites where the evolution of the cost structure can have both positive and negative effects on different producers and accelerate or inhibit scaling of the electric vehicle market.

Sources. In general, scenarios include battery costs assumptions as these are required to model the scale-up of electric vehicles. These are however not disclosed by these scenarios, the estimation of cost requires industry research coupled with company reporting (e.g. through announcements, etc.). Sources thus include academic research and BNEF.

Method ACT. 2016 estimates are taken from BNEF (ETC 2017). The ambitious climate transition scenario applies the 'optimistic market' approach, thus assuming optimistic technology assumptions around cost evolution and leaving policy as the remaining variable to offset price differentials. Thus, it takes the most optimistic estimates from Nykvist et al. 2015 meta-analysis. Battery costs in 2020 are in line with the US Department of Energy targets (USDEP 2016).

Method LCT. 2016 costs are taken from BNEF (ETC 2017). Future estimates are adjusted using the learning curve of its most recent public forecasts (Randall 2016). It should be noted that the BNEF estimates do not solve for a specific scenario and thus are considered to reflect a more 'central scenario'.

Results. The following table summarizes two different battery cost estimates, with estimates limited to 2025, given the lack of forecasts and the uncertainty around these predictions. It should be noted that individual battery costs for individual companies may still differ significantly, in particular, in the short-term given the relatively nascent market.

TABLE 3.3 FORECASTED BATTERY COSTS (USD/kWh) IN THE ACT AND LCT SCENARIOS (SOURCE: AUTHORS, BASED ON NYKVIST B. 2015, RUSSO 2012 AND BNEF)

Year	ACT	LCT
2016	273	273
2020	125	204
2025	110	142

3.4 FUEL EFFICIENCY STANDARDS

Overview. As outlined above, fuel efficiency is the other part of the decarbonisation equation for the automobile sector. For these scenarios, we assume that fuel efficiency standards will set the baseline for actual fuel efficiency with limited 'additional' impact from consumer preferences. Moreover, given the diversity in preferences, without fuel efficiency standards, certain car producers could still be expected to potentially produce automobiles with low fuel efficiency. As a result, the risk driver is presented in the context of policy costs and incentives.

Risk pass-through mechanism. From a risk perspective, efficiency standards create both potential additional costs as new car models have to be designed to satisfy the policy mandate as well as potential risks as consumer preferences shift to more fuel-efficient cars. Conversely, they create opportunity for those car manufacturers that produce more fuel-efficient cars.

Sources. There is no general information on fuel efficiency standards in the IEA scenarios, however some third party research from industry and NGOs provides insights into potential ambitious trends, even if not explicitly linked to a climate outcome (e.g. ICCT).

Method. The LCT scenario considers current policy announcements. To develop the ACT Scenario, the following assumptions are considered:

- A convergence around the US fuel economy target of 34% reduction relative to the respective baseline year that formed the basis of the existing country-level policy mandates by 2025. This assumption largely extrapolates the trends that the current policy mandates would suggest in the EU and China, and provide a somewhat more ambitious timeline for Brazil and Mexico, although for these countries the base year is earlier and thus less ambitious.
- A convergence to the Global Fuel Economy Initiative[4] target of 50% efficiency gains by 2030.

Results. The following table summarizes the current fuel efficiency mandates and their expected evolution under both scenarios. Since the US has already reached its 2025 fuel efficiency targets, market reduction rates could surpass the LCT data points through 2030 and potentially the ACT data points. The EU has already reached its 2020 target. This is not the case for Brazil and Mexico, whose current efficiency levels will have to more than double in order to reach the required policy targets under a 2°C scenario.

TABLE 3.4 FORECASTED FUEL EFFICIENCY TARGETS IN THE ACT AND LCT SCENARIOS (SOURCE: AUTHORS, BASED ON ICCT 2016)

Year	Brazil		EU		Mexico		USA	
	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Baseline year	2013		2015		2011		2016	
Implementation period	2013-2017		2020-2021		2014-2016		2017-2025	
Reduction in gCO_2/km	12.0%		27.0%		13.0%		34.0%	
Est. reduction 2020	17%	12%	27%	27%	17%	13%	34%	34%
Est. reduction 2025	34%	12%	34%	27%	34%	13%	34%	34%
Est. reduction 2030	50%	12%	50%	27%	50%	13%	50%	34%

3.5 EFFECTIVE CARBON RATES

Overview. Effective carbon rates in the automobile sector are the highest across all sectors in scope. These are mainly present in the form of specific sector taxes (e.g. road transport fuel taxes), with few countries integrating carbon taxes as well with a significant impact (OECD 2016). As with most of the market pricing instruments, effective carbon rates may influence both consumer preferences and production choices.

Risk pass-through mechanism. It should be noted that this indicator may not be a core risk driver in any event, since the effective carbon rates in most cases will be paid by the consumer (e.g. at the petrol station) and not the producer. The only quantitative impact then of ratcheting prices will be an increased preference for fuel-efficient vehicles as well as changes in use (e.g. car pooling, etc.).

Sources. There are no publicly available specific forecasts for effective carbon rates under a 2°C transition for specific countries, nor at global or regional level. This makes it difficult to quantify the expected future effective carbon rates under an ambitious transition. The challenge of estimating future effective carbon rates is exacerbated since in many countries, with existing high effective carbon rates, this policy lever may no longer be applied. For example, in Germany the current effective carbon rate is EUR 210 / ton CO_2. Thus, the current policy discussion in Germany has focused more on electric vehicle subsidies, fuel efficiency standards, and electric vehicle sales targets rather than ratcheting carbon pricing for the automobile sector.

Method. There are three options for defining changes in effective carbon rates: i) keep current rates constant, assuming alternative policy channels; ii) develop bottom-up, country-level estimates; iii) ratchet rates at a pre-determined level. The approach chosen here is a mix of different approaches:

- It estimates no change in effective carbon rates for Europe under the assumption that further ratcheting seems unlikely as existing effective carbon rates are already relatively high.
- For US, Mexico and Brazil, effective carbon rates hit carbon prices (see Page 26), however, the instruments achieving these rates can be either specific sector taxes, carbon taxes and/or permit prices from exchange trade systems. Data points marked with an asterisk were interpolated.

Results. The following table summarizes the results for both scenarios. Brazil, Mexico and the US will require a significant increase in the effective carbon rates of the sector in both, the ACT and LCT scenarios. However, these are not expected to reach EU effective carbon rates levels.

TABLE 3.5 FORECASTED EFFECTIVE CARBON RATES (EUR/tCO_2) (SOURCE: AUTHORS, BASED ON OECD 2016 AND ALBERICI ET AL. 2014)

Year	Brazil		France		Germany		Italy		Mexico		USA	
	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
2012	11		180		210		240		8		17	
2020	20	11	180		210		240		18	12*	54*	23*
2025	48*	11	180		210		240		53*	15*	75*	26*
2030	75	11	180		210		240		88*	18	100	30
2035	100*	11	180		210		240		105*	23*	120*	35*
2040	125	11	180		210		240		123	28	140	40

*Interpolated figures

MEET THE BUILDERS - ET RISK CONSORTIUM

The ET Risk consortium, funded by the European Commission, is working to develop the key analytical building blocks (Fig. 0.1) needed for Energy Transition risk assessment and bring them to market over the coming two years.

1. TRANSITION SCENARIOS

The consortium will develop and publicly release two transition risk scenarios, the first representing a 'soft' transition extending current and planned policies and technological trends (e.g. an IEA NPS trajectory), and the second representing an ambitious scenario that expands on the data from the IEA 450S /2DS, the project's asset level data work (see Number 2), and relevant third-party literature. The project will also explore more accelerated decarbonization scenarios.

2. COMPANY & FINANCIAL DATA

Oxford Smith School and 2° Investing Initiative will jointly consolidate and analyze asset level information across six energy-relevant sectors (power, automotive, steel, cement, aircraft, shipping), including an assessment of committed emissions and the ability to potentially 'unlock' such emissions (e.g. reducing load factors).

3. VALUATION AND RISK MODELS

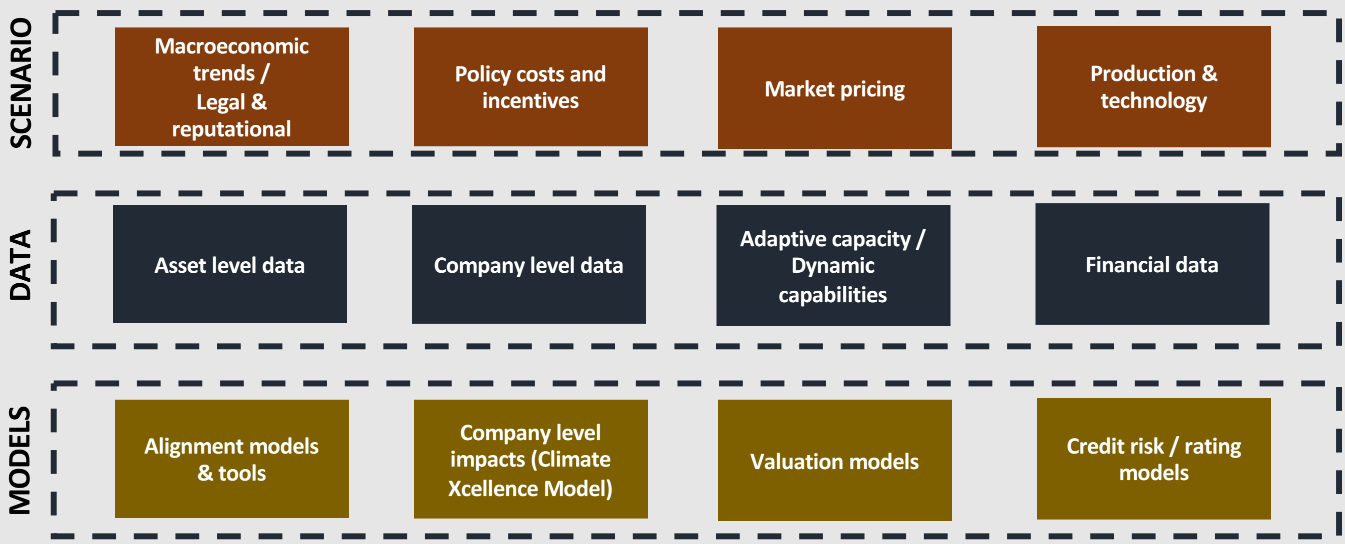
a) **2°C portfolio assessment – 2° Investing Initiative.** 2° Investing Initiative will seek to integrate the project results into their 2°C alignment model and portfolio tool and analytics developed as part of the SEI metrics project.

b) **ClimateXcellence Model – The CO-Firm**. This company risk model comprises detailed modeling steps to assess how risk factors impact margins and capital expenditure viability at the company level.

c) **Valuation models – Kepler Cheuvreux.** The above impact on climate- and energy-related changes to company margins and cash flows can be used to feed discounted cash flow and other valuation models of financial analysts. Kepler Cheuvreux will pilot this application as part of their equity research.

d) **Credit risk rating models – S&P Global.** The results of the project will be used by S&P Global to determine if there is a material impact on a company's creditworthiness. S&P Dow Jones Indices, a S&P Global Division, will explore the potential for developing indices integrating transition risk.

FIG. 0.0: ASSESSING TRANSITION RISK ACROSS THE INVESTMENT CHAIN (SOURCE: AUTHORS)



ABOUT 2° INVESTING INITIATIVE

The 2° Investing Initiative [2° ii] is a multi-stakeholder think tank working to align the financial sector with 2° C climate goals. Our research work seeks to align investment processes of financial institutions with climate goals; develop the metrics and tools to measure the climate friendliness of financial institutions; and mobilize regulatory and policy incentives to shift capital to energy transition financing. The association was founded in 2012 and has offices in Paris, London, Berlin, and New York City.

ABOUT THE CO-FIRM

The CO-Firm GmbH is a boutique consultancy specialized in developing climate and energy strategies for financial services providers, industry, and utilities. Based on financial risk modelling under a range of climate and energy scenarios, the proprietary ClimateXcellence Toolset, and a dataset of more than 200.000 assets and more than 15.000 different technical mitigation measures, The CO-Firm supports its clients in identifying, evaluating and realizing their specific economic opportunities in the national and global climate transition. Specifically, the CO-Firm serves its clients in adjusting their strategies, setting Science Based Targets, creating new business models, and identifying cost savings in their operations and their supply chain. Additionally, the consultancy provides regulatory monitoring services.

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