Exercise1

26 2 2019

1.1 Goal and system defintion

System boundaries

- Spatial reference: Europe
- Time reference: 2019 - 2050
- Substantial reference: E-Bikes

Guiding questions

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* Which impact factors and interrelations among them determine...
  * The penetration of different types of e-bikes and battery technologies on the EU market?
  * How the adoption of e-bikes changes the mobility behavior?
  * What modes of transport are being replaced (substitution) to which extent?
  * in Europe in the year 2050.
* What scenarios can result from different constellations of the identified impact factors?

By the way:
* What other consequences could a large scale adoption of e-bikes have?
* What factors could lead to a rebound effect?
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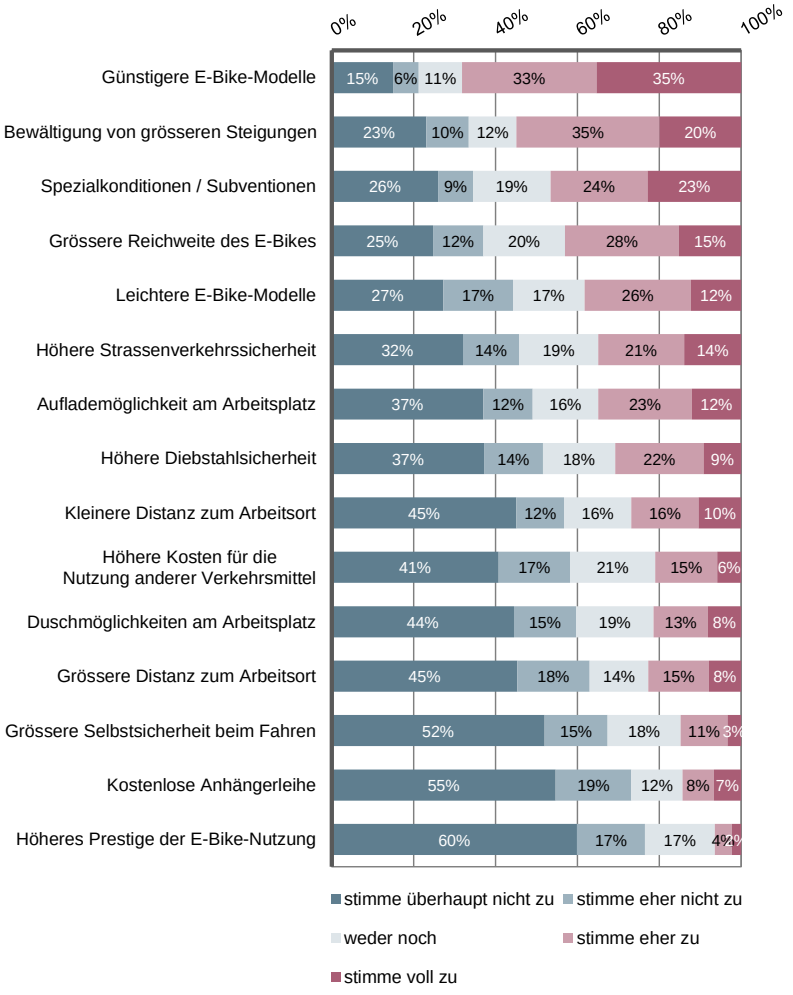
Abbildung 4-16: Kaufgründe für ein E-Bike

Wir wollen gerne etwas darüber erfahren, ob und in welchen Fällen Sie ein E-Bike kaufen würden. Geben Sie bitte an, inwieweit Sie den folgenden Aussagen zustimmen. Ich würde ein E-Bike kaufen, wenn…



N = 481 Personen der Gruppe „E-Bike-Miete/Ausleihe“

Source: Verbreitung und Auswirkungen von E-Bikes in der Schweiz: http://www.news.admin.ch/NSBSubscriber/message/attachments/36764.pdf

Table 1: CH Market 2016 - 2017

Segment	Total	Diff	Total2016	Total2017	DiffAbsolut
MTB 26“	17957 16694	-1263 -7.03%	17957	16694	-1263
MTB 27,5“	54202 52976	-1226 -2.26%	54202	52976	-1226
MTB 29“	30492 31672	1180 3.87%	30492	31672	1180
Cross 28“	9634 9429	-205 -2.13%	9634	9429	-205
Rennvelo / Vélo de course	15512 15471	-41 -0.26%	15512	15471	-41
Junior 20-24“, Freestyle inkl.	29331 35987	6656 22.69%	29331	35987	6656
Total Sport Segment	157128 162229	5101 3.25%	157128	162229	5101
Citybikes 28“	55595 63747	8152 14.66%	55595	63747	8152
Citybikes 26“	13362 8958	-4404 -32.96%	13362	8958	-4404
Junior 20-24“	18690 12010	-6680 -35.74%	18690	12010	-6680
E-MTB 26“, 25 km/h*	41 7	-34 -82.93%	41	7	-34
E-MTB 26“, 45 km/h**	81 0	-81 -100.00%	81	0	-81
E-MTB 27,5“, 25 km/h*	12525 21512	8987 71.75%	12525	21512	8987
E-MTB 27,5“, 45 km/h**	2509 2140	-369 -14.71%	2509	2140	-369
E-MTB 29“, 25 km/h*	2812 4548	1736 61.74%	2812	4548	1736
E-MTB 29“, 45 km/h**	2793 497	-2296 -82.21%	2793	497	-2296
City-E-Bike 26“, 25 km/h*	5247 5445	198 3.77%	5247	5445	198
City-E-Bike 26“, 45 km/h**	3990 5430	1440 36.09%	3990	5430	1440
City-E-Bike 28“, 25 km/h*	38851 39581	730 1.88%	38851	39581	730
City-E-Bike 28“, 45 km/h**	6816 8441	1625 23.84%	6816	8441	1625
Cargo-E-Bikes, 25 km/h*	n.a. 386	n.a. n.a.	NA	386	NA
TOTAL Sport / City / Elektrisch	324581 338229	13648 4.20%	324581	338229	13648

Source: Annual statistics velosuisse: http://www.velosuisse.ch/de/statistik_aktuell.html

Table 2: Factors Primary Energy and GHG Potential

mode	primary.energy.[MJ.equ..per.pkm]	GHG.potential.[CO2.eq..per.pkm]
Auto (Durchschnittliche Flotte)	3.37	197.64
Motorrad	NA	NA
Kleinmotorrad (Scooter)	1.58	121.07
Mofa/Motorfahrrad	NA	NA
Velo	0.16	9.36
Zu Fuss	0.00	0.00
Öffentlicher Verkehr (Durchschnitt)	0.96	24.82
E-Bike (Verbrauchermix CH, 3x Batteriewechsel)	0.37	16.49

Source: Verbreitung und Auswirkungen von E-Bikes in der Schweiz: http://www.news.admin.ch/NSBSubscriber/message/attachments/36764.pdf, Figure 2-15 page 49

Table 3: Effect of EBike for commuting on regular bike (% Answers)

group	Auto	Motorrad	Kleinmotorrad	Mofa	Bike	Walk	OeV
viel seltener	0.32	0.34	0.25	0.2	0.37	0.13	0.22
seltener	0.36	0.25	0.19	0.1	0.25	0.15	0.26
etwa gleich oft	0.12	0.19	0.13	0.1	0.13	0.25	0.23
oefter	0.01	0.00	0.00	0.0	0.01	0.02	0.01
viel oefter	0.00	0.00	0.00	0.0	0.01	0.00	0.02
nie genutzt	0.19	0.22	0.44	0.6	0.23	0.44	0.25

Source: Verbreitung und Auswirkungen von E-Bikes in der Schweiz: http://www.news.admin.ch/NSBSubscriber/message/attachments/36764.pdf, Figure 3-45, 3-46 page 105, 106

Table 4: European Cycling Federation EU capitals

EU.Capitals	Cycling.modal.share	Year
Copenhagen	35%	2010
Amsterdam	32%	2012
Berlin	13%	2008
Ljubjana	12%	2013
Helsinki	11%	2013
Zagreb	10.1%	2012
Stockholm	9%	2013
Dublin	7.9%	2013
Vienna	6%	2013
Riga	4%	2014
Brussels	3.5%	2013
Luxembourg	3.5%	2011
Sofia	3%	2010
Nicosia	2%	2010
Paris	0.02	2013
Athens	2%	2005
Budapest	2%	2014
Bratislava	2%	2012
London	2%	2009
Prague	1%	2013
Tallinn	1%	2012
Vilnius	1%	2010
Warsaw	1%	2009
Lisbon	1%	2013
Bucharest	1%	2007
Rome	0.6%	2012
Madrid	0%	2011

Source: Webpage European Cyclist Federation (ECF): https://ecf.com/resources/cycling-facts-and-figures/capital-cities

Table 5: European Cycling Federation EU market

Country	Est.market.value.Meur	Exp.per.capita.Eur	Market.value.30Eur.p.capita	Market.value.50Eur.p.capita
Germany	1727	21	2436	4060
Great Britain	1054	16	1943	3238
France	860	13	1992	3321
Italy	447	7	1824	3040
Poland	458	12	1140	1900
Spain	531	11	1393	2322
Total	5077	NA	10729	17882

Source: European bicycle market analysis 2015: https://ecf.com/sites/ecf.com/files/CONEBI%20market%20report%20analysis%202016_1.pdf, Table 1 page 17

Year	NL.Eur	GER.Eur	IT.Eur	U.K..Eur

Table 6: Prices conventional bikes

Year	NL.Eur	GER.Eur	IT.Eur	U.K..Eur
2011	745.52	495.00	270.00	280.00
2010	744.65	459.35	259.77	321.43
2009	726.00	445.93	279.62	246.76
2008	664.95	385.98	288.27	251.89
2007	602.86	366.96	239.24	192.26
2006	582.01	348.47	193.00	204.08
2005	578.69	341.05	191.80	182.89
2004	584.00	341.06	198.68	181.31
2003	579.63	344.08	215.80	160.99
2002	556.65	353.04	218.21	139.13
2001	529.67	361.06	262.47	158.33
2000	481.21	346.09	301.97	186.96

Source: Electrification of road transport – an analysis of the economic performance of electric two-wheelers: https://dspace.library.uu.nl/bitstream/handle/1874/275936/Thesis%20P.W.K.%20Dekker%2012%20May%202013.pdf?sequence=1, Table 10 page 50

Table 7: Prices and Battery Power 2011 - 2012

Year	Brand	Model	PriceEur	Battery.powerkWh
2012	Dutch ID	Sport Lady	2400	0.288
2012	Flyer	C8 De Luxe	3100	0.432
2012	Gazelle	Excellent Innergy	2600	0.396
2012	Koga	E-Tour	3000	0.250
2012	MC	Elegance-E	2900	0.270
2012	Qwic	Trendˆ3	1850	0.360
2012	Qwic	Urban2	1380	0.216
2012	Raleigh	Dover Impulse	2100	0.558
2012	Sparta	Ion GLS+	2700	0.360
2012	Trek	L300+ Navigator	2200	0.300
2012	Union	Switch (Dames)	1199	0.252
2012	Union	Switch (Heren)	999	0.252
2012	Union	Ace	999	0.240
2012	Union	Elegance	1099	0.192
2011	Antec	Vela	2149	0.378
2011	Batavus	Intermezzo Easy	1850	0.266
2011	Batavus	Intermezzo Easy Royal	2499	0.360
2011	Bikkel	Ibee2	1599	0.276
2011	Cumberland	Energy V6	899	0.192
2011	Cumberland	Connect N7	999	0.192
2011	Flyer	T8	2850	0.432
2011	Flyer	C5	2499	0.312
2011	Gazelle	Orange Pure Innergy	1699	0.252
2011	Giant	Twist Go Double	2100	0.576
2011	Infineum	I-centiv	1799	0.225
2011	Kalkhoff	Tasman City E-Series	2399	0.430
2011	Koga	E-Runner	3000	0.360
2011	Montego	Elan	1549	0.270
2011	Powabyke	X-24	1299	NA
2011	Qwic	smart e3 urban	1499	0.360
2011	Rivel	Mingle	1649	0.240
2011	Sparta	E-motion C2	1650	0.240
2011	Sparta	E-motion C3	1749	0.240
2011	Trek	T500+	2300	0.320
2011	Union	Switch (Dames)	1399	0.252
2011	Union	Switch (Heren)	1399	0.252
2011	Union	Ace	1099	0.240
2011	Union	Elegance	1299	0.192

Source: Electrification of road transport – an analysis of the economic performance of electric two-wheelers: https://dspace.library.uu.nl/bitstream/handle/1874/275936/Thesis%20P.W.K.%20Dekker%2012%20May%202013.pdf?sequence=1, Table 12, 13 page 50 -52

Table 8: Mikrozensus CH: Tagesdistanz

mode	MeanDistKm	TotalDistKM
Alle Mittel	9.17	73.3
Anderes	0.02	0.2
Auto als Fahrer	4.32	34.6
Auto als Mitfahrer	1.64	13.1
Bahn	1.77	14.1
Bus	0.26	2.1
Fahrzeugähnliche Geräte	0.01	0.1
Flugzeug	0.01	0.1
Kleinmotorrad	0.02	0.2
Lastwagen	0.06	0.4
Mofa	0.01	0.1
Motorrad als Fahrer	0.07	0.5
Motorrad als Mitfahrer	0.02	0.2
Postauto	0.03	0.3
Reisecar	0.10	0.8
Schiff	0.01	0.1
Taxi	0.01	0.1
Total LV	0.71	5.6
Total MIV	6.09	48.7
Total ÖV	2.15	17.2
Total Übrige	0.22	1.8
Tram	0.09	0.7
Velo	0.20	1.6
Zahnradbahn, Standseilbahn, Seilbahn, Sessellift, Skilift	0.01	0.1
zu Fuss	0.51	4.1

Source: Bundesamt für Statistik, & Bundesamt für Raumplanung. (2012). Mobilität in der Schweiz, Ergebnisse des Mikrozensus Mobilität und Verkehr 2010. (http://www.portal-stat.admin.ch/mz10/files/de/00.xml), Sheet ‘’Tagesdistanz”

Table 9: Development proportion of population over 50 years old

Jahr	unter50	ueber50	Total	pctUeber50
2013	3966831	2859763	6826594	42
2014	3985886	2927297	6913183	42
2015	3990700	3004104	6994804	43
2016	3988940	3072663	7061603	44
2017	3982686	3130770	7113456	44

Source: Bundesamt für Statistik, & Bundesamt für Raumplanung. (2012). Altersaufbau der ständigen Wohnbevölkerung ab 15 Jahren, nach Migrationsstatus und Geschlecht, 2013-2017 . (https://www.bfs.admin.ch/bfs/de/home/statistiken/bevoelkerung/alterung.assetdetail.6046027.html)

Other Source: Schwegler, R., Iten, R., Spescha, G., & Schäppi, B. (2015). Umfrage Grüne Wirtschaft und Klima. Technischer Bericht zur Konzeptionierung. Bundesamt für Umwelt BAFU.

Actors to be involved

-

Target group

-

2.1 Impact factors

preliminary identification:

Table 10: Names of preliminary impact factors

E-Bike price	gasoline price	air pollution
Regular Bike Price	electricity prize	traffic congestion
attractivity of biking	Battery tech	commuters willingness
Bike lanes	laws and regulations	environmental awareness
regulation e-bike 25kmh	Commuting distances	subventions
regulation e-bike 45kmh	integration publ trans	power and range
charging infrastructure	road safety	weight of e bike

`Impact factors structuring, clustering, relevance assessment`

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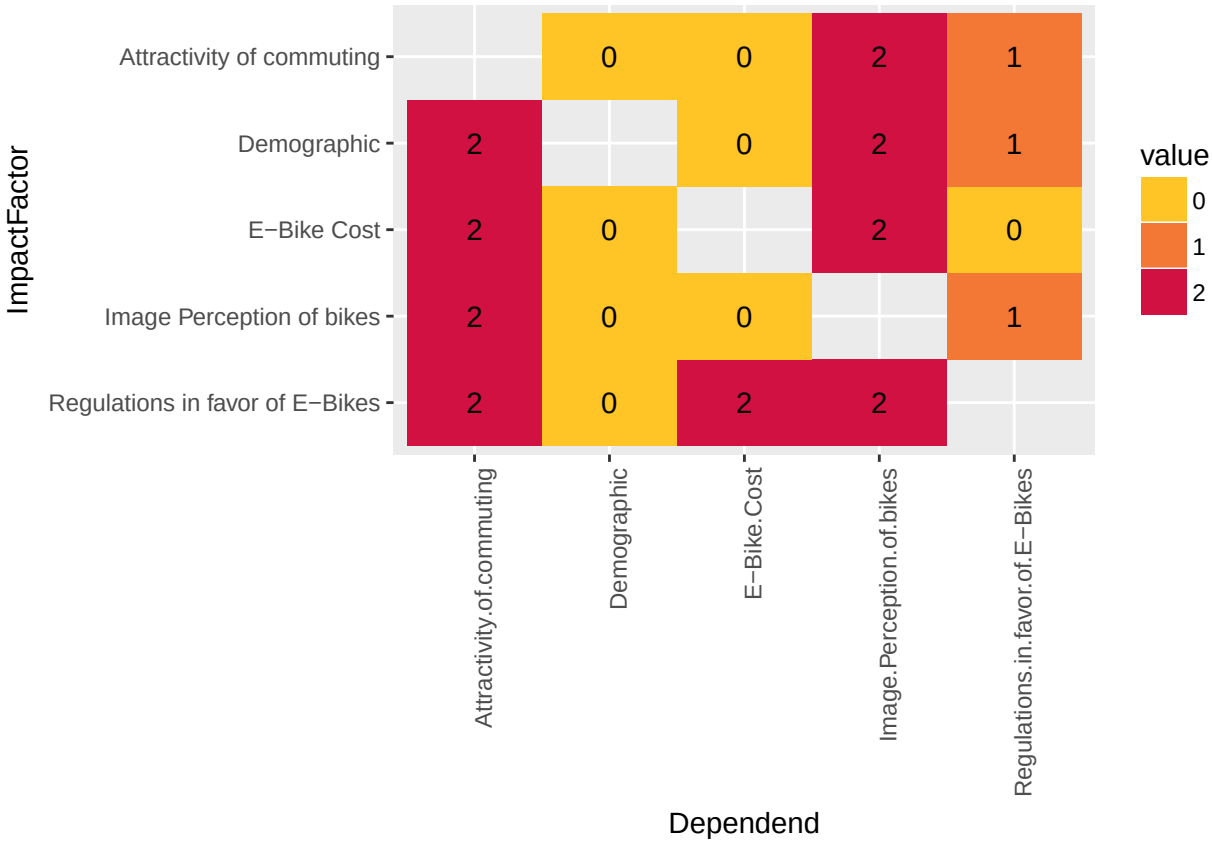
`Impact factors selection`

Table 11: Description of seleceted impact factors

ImpactFactor	Indicator	Current_Stat
E-Bike Cost	CHF	1800
Attractivity of commuting	low, medium, high	medium
Regulations in favor of E-Bikes	impact	none
Image Perception of bikes	nuisance, neutral, desirable	desirable
Demographic	proportion of pop. over 50 year	0.45

2.2 Impact assessment



2.3 Impact analysis

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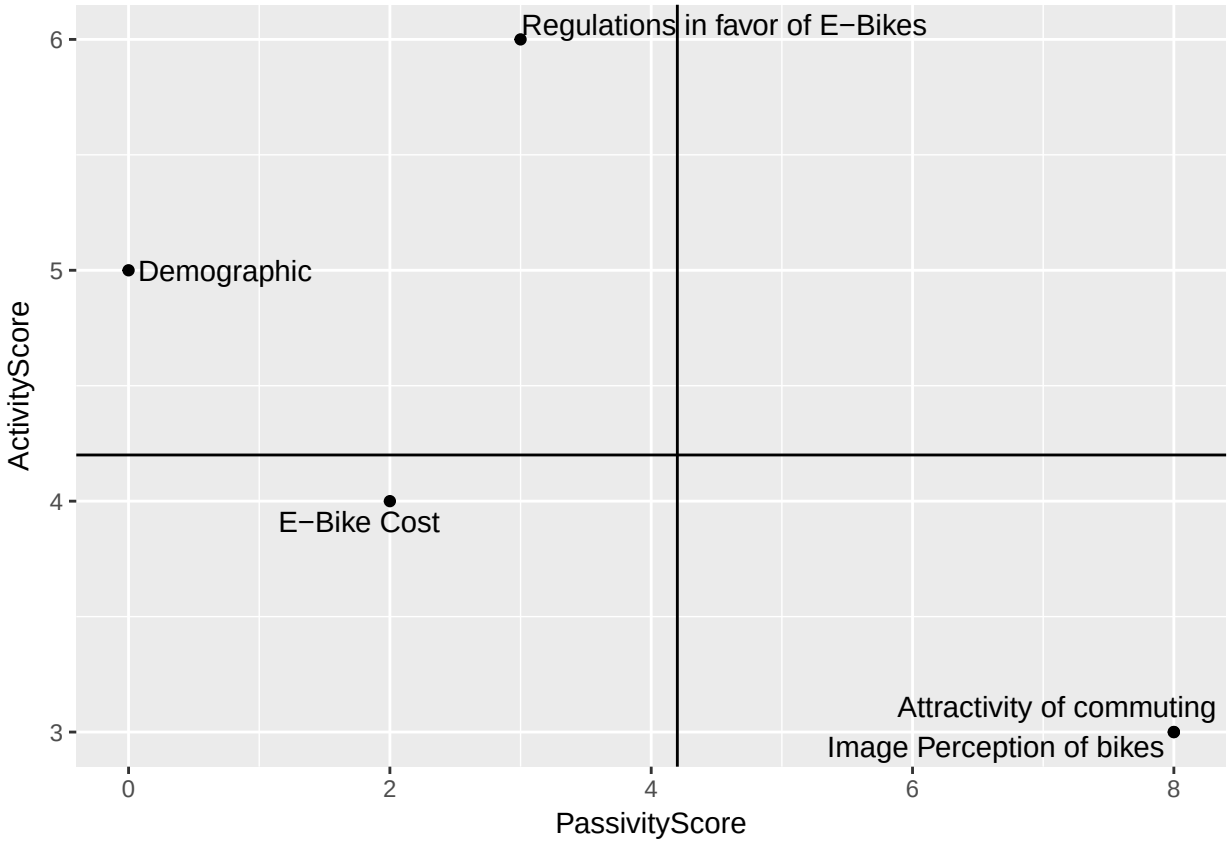
Table 12: Impact Factor matrix

	E.B.C	A.o.c	R.i.f.o.E.B	I.P.o.b	D	A
E-Bike Cost	NA	2	0	2	0	4
Attractivity of commuting	0	NA	1	2	0	3
Regulations in favor of E-Bikes	2	2	NA	2	0	6
Image Perception of bikes	0	2	1	NA	0	3
Demographic	0	2	1	2	NA	5
PassivityScore	2	8	3	8	0	21

System grid



Feedback loops

System structure

Table 13: Description of impact factor levels

ImpactFactor	Indicator	Current_Stat	trend	min	max
E-Bike Cost	CHF	1800	1600	1800	500
Attractivity of commuting	low, medium, high	medium	medium	low	high
Regulations in favor of E-Bikes	impact	none	some	none	many
Image Perception of bikes	nuisance, neutral, desirable	desirable	neutral	nuisance	desirable
Demographic	ratio of over 50 year	0.45	0.47	5	0.44

3.1 Future level definition

Goal: 3 future levels (ni = 1,2,3) for each impact factor d_i

- 1 future level outlining trend extrapolation
- Two future levels outlining extreme developments (min. vs. max.)

Table 14: Development price per kWh

Year	amPrice	amPricePerPower	sdPricePerPower
2011	1674.5	0.0001684	3.89e-05
2012	2150.0	0.0001680	5.74e-05

Table 15: Simulation linear trends price EBike

year	trendCHF	worstCHF	bestCHF
2020	1802.778	1839.96	1566.36
2030	1756.302	1839.96	1224.36
2040	1709.825	1839.96	882.36
2050	1663.348	1839.96	540.36

From: Electrification of road transport – an analysis of the economic performance of electric twowheelers: "We find that e-bike prices will decrease by 3% from €1614,- ± 674 in 2012 to €1561,- ± 609,- in 2025"

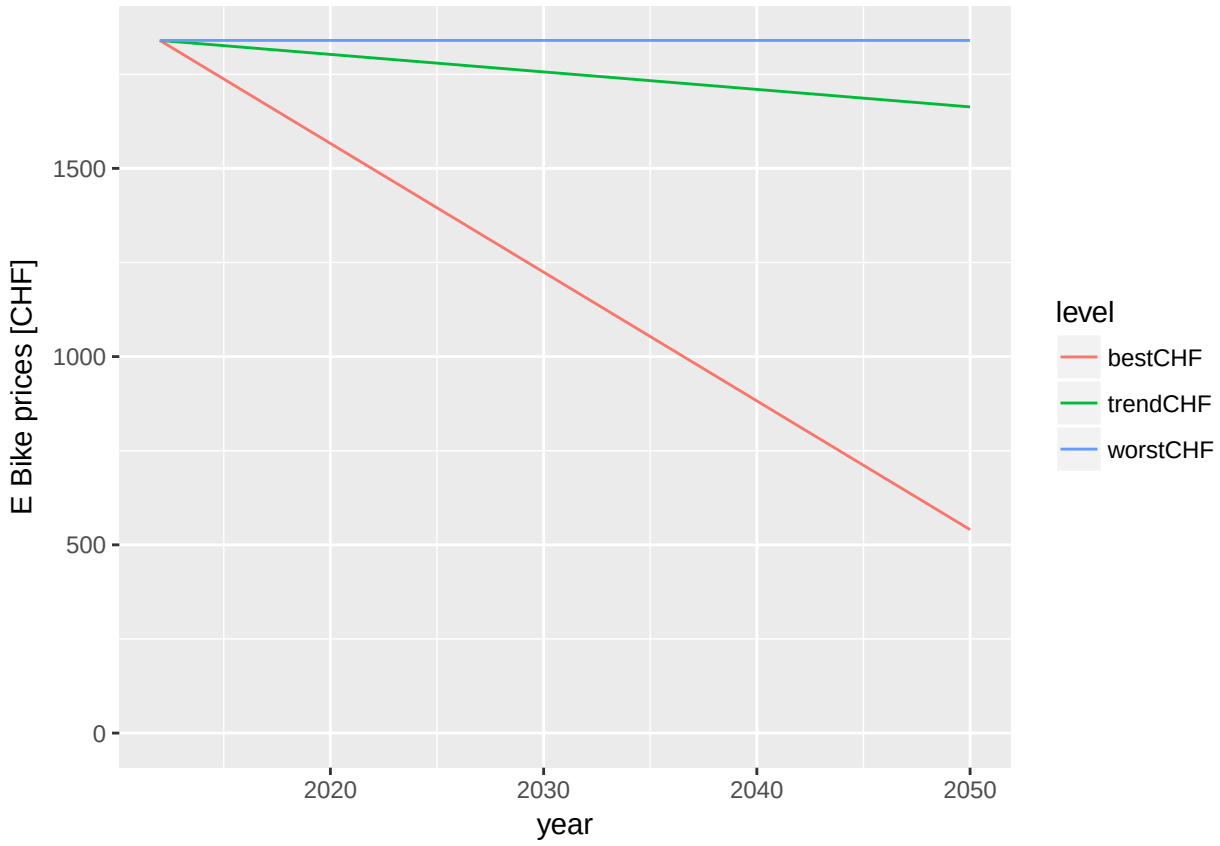


Figure 1: Simulation linear trends price EBike

Table 16: Prediction age distribution proportion over 50 [%]

Jahr	AnteilUeber50_trend	AnteilUeber50_min	AnteilUeber50_max
2020	45	43	46
2030	46	44	48
2040	46	44	49
2050	47	44	50

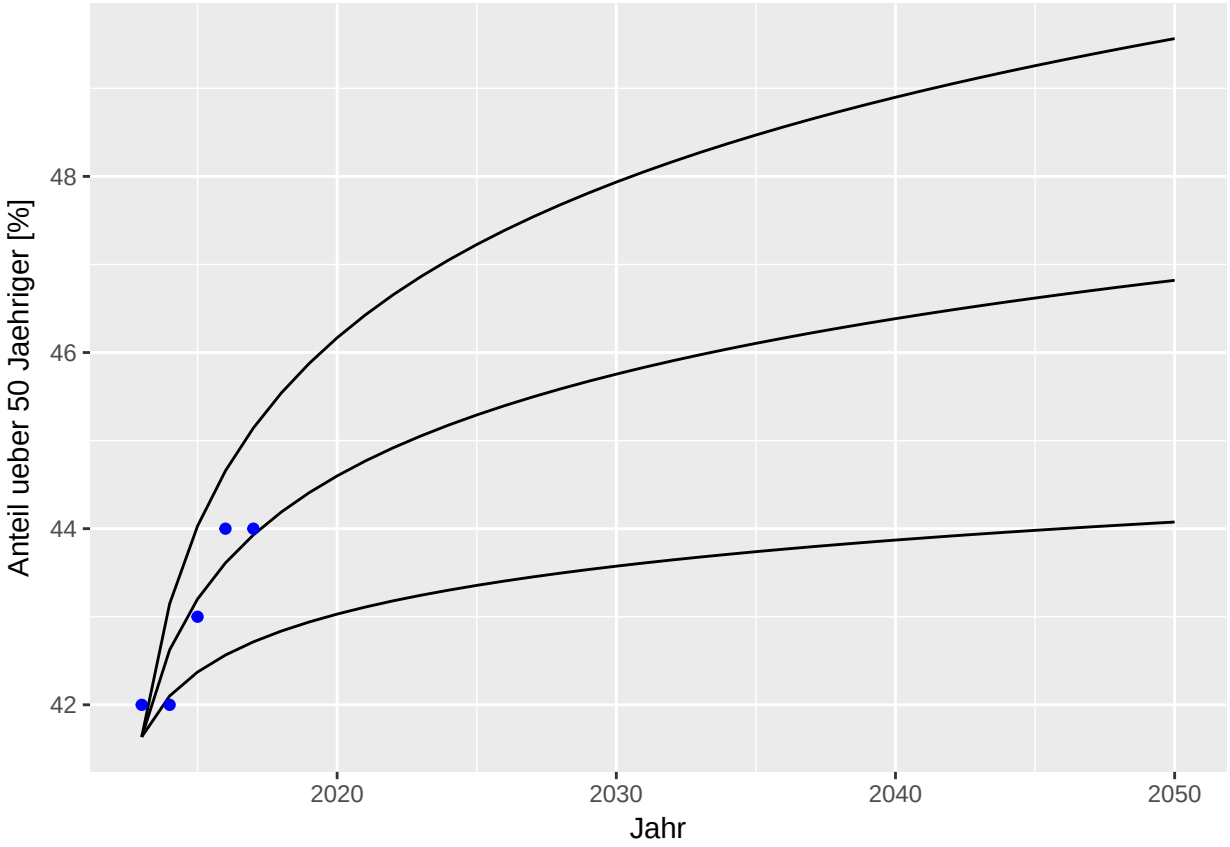


Figure 2: Prediction age distribution proportion over 50

3.2 Consistency assessment

3.3 Scenario construction

4.1 Scenario selection

4.2 Scenario description and interpretation

Requirements

- Impact factors and their dynamic relevance
- Final scenarios and their rationale (storyline)
- Parameters values indicated above for each scenario as a time series until 2050 (cf. Table above)

Table 17: Impact Factor levels for the seleceted scenarios

ImpactFactor	scenario1	scenario2	scenario3
Attractivity of commuting	medium	low	high
Demographic	0.45	0.47	0.46
E-Bike Cost	1600	1800	500
Image Perception of bikes	neutral	nuisance	desirable
Regulations in favor of E-Bikes	some	none	many

Table 18: Information requirements for scenarios

Parameter	Description	PhysicalUnit
Market penetration	Market penetration	[no. per year]
E-bike transport	Kilometers driven per e-bike annually	[km per year]
Battery technology	Share of different battery technologies used in e-bikes sold annually	[% per year]
Other transport	Kilometers driven by other means of transport (annually)	[km per year]