HOW TO FOSTER EV MARKET PENETRATION?

A model based assessment of policy measures and external factors

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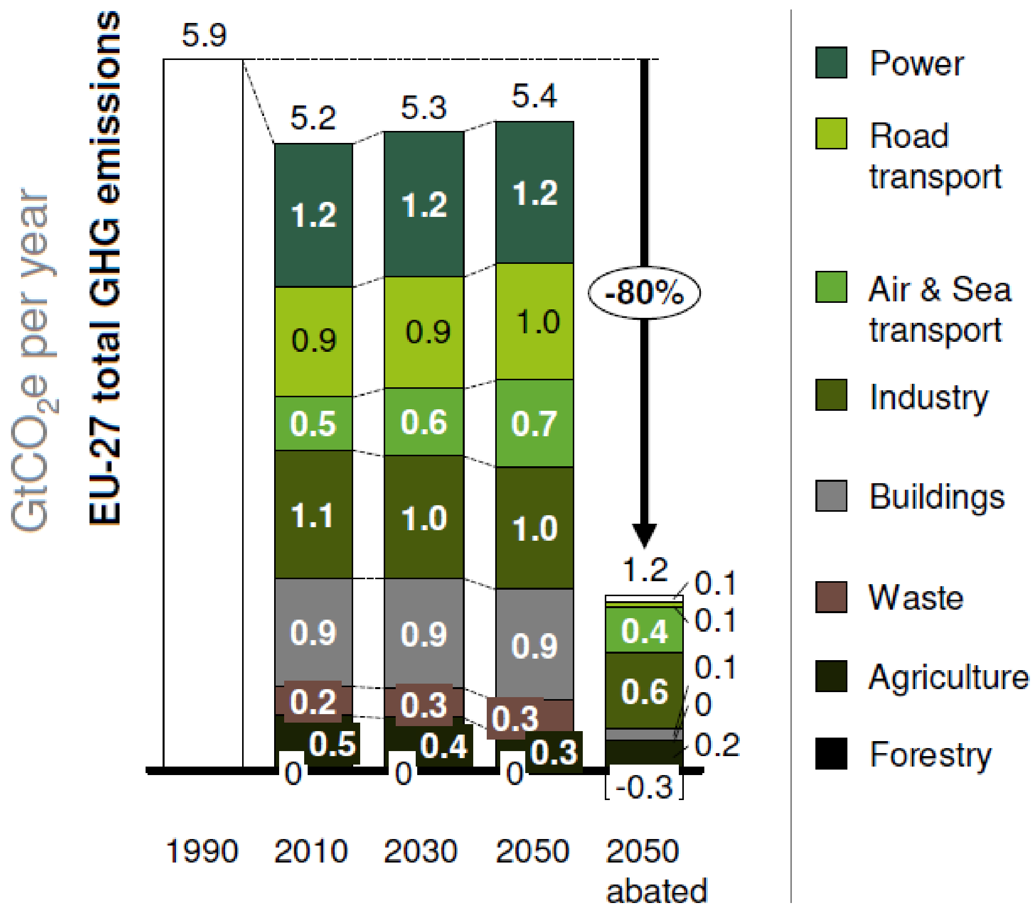
To achieve Europe's climate targets, a drastic reduction in transport CO2-emissions is needed



- The EU's long term goal is to reduce GHG emissions by 80%
- Power production and road transport have to become almost CO2-free
- This is **impossible with** efficiency gains in **combustion engines**
- New technologies and concepts are clearly needed.
- **Electric vehicles powered by renewable energies** can contribute significantly

Source: www.roadmap2050.eu

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Different policies are being discussed to foster EV market diffusion

➢ **Federal target in Germany: One million in EV in stock by 2020**

Different potential ***policy measures*** are discussed:

- **special depreciation** for commercial vehicles
- **low-interest loans** for private vehicles
- **direct subsidy** for private + commercial E

One million
EVs by 2020!

➢ ***Aim of this talk*: Analyse and compare policy measures**

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An agent-based market diffusion model is used to estimate policy effects

User-specific analysis

aggregated

User behaviour

Driving profiles

one week: distance, duration, purpose, dep. & arrival time
- Owner information: gender, age, income, garage, city size
- Vehicle size, brand, age

EV user acceptance

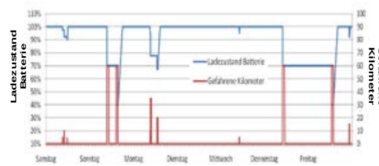
- Willingness-to-pay-more by adopter status (innov., early adopter, majority, laggards)
- Limited charging infrastruc.
- Limited vehicle choice EVs

Differentiation

ate, commerc. fleet, company car
- *4 vehicle sizes*: S, M, L, LCV
- *5 technologies*: BEV, PHEV, REEV, gasoline, diesel

Model steps

Individual EV simulation



For each user i:
- Feasibility BEV
- Electric driving share PHEV / REEV

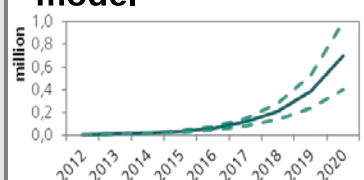
Individual utility maximisation

For each user i and propulsion technology p:

$$\max_p \left(-\mathrm{TCO}_{ip} + \text{willingness-to-pay-more}_{ip} + -\text{limited choice}_{ip} - \text{home charging cost}_{ip} \right)$$

- Optimal vehicle choice for each user

Stock model



Projection of:
- Sales in user group
- Vehicle stock
- Primary charging points stock

Parameters

Vehicle dependent

- *Technical*: battery sizes, DoD, el./conv. consumption
- *Economical*: car prices, taxes, O&M costs, resale values
- *Policies*: subsidies, taxes,

Vehicle independent

- Fuel/battery/electricity prices until 2020
- Costs for home charging
- Future EV availability

Car market

- Registrations in user group and vehicle size class
- Stock & sales parameters
- Future EV availability

The Model has been published as Plötz, P., T. Gnann, and M. Wietschel (2014). *Modelling Market Diffusion with real-world driving data -- Part I: Model Structure and validation*. Ecological Economics 107, 411-421. See also: Gnann, T.; Plötz, P.; Kühn, A.; Wietschel, M.(2015): *Modelling Market Diffusion of Electric Vehicles with Real World Driving Data – German market and Policy options*. Transportation Research Part A, Vol. 77, 95-112

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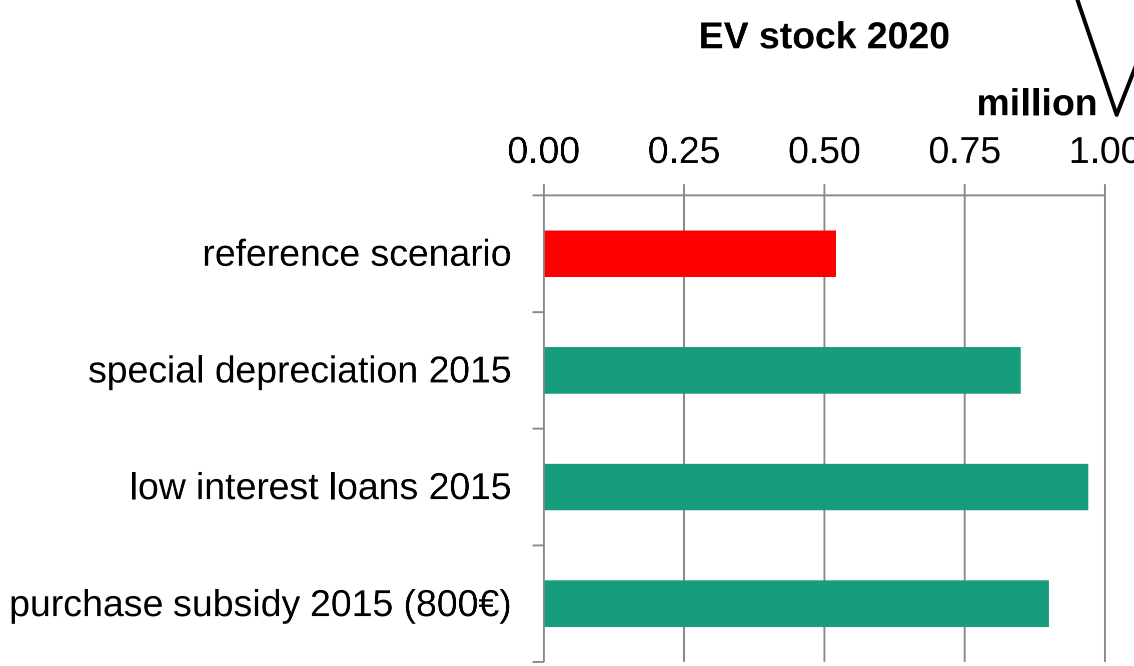
Techno-economical results for EV stock in 2020 under different policy measures

- **Policy measures change EV stock in 2020:**

Federal target



	Subsidy per add. EV ['000€]	Windfall gain
reference scenario		
special depreciation 2015	1.600	37%
low interest loans 2015	3.580	58%
purchase subsidy 2015 (800€)	1.030	63%

➢ **Target difficult and expensive to reach under reference scenario.**

Notes: Shown subsidies are costs per *additional* EV in stock until 2020. All monetary values in EUR-2014.
Windfall gains are shares of purchases that would also have taken place without policy measure in action.

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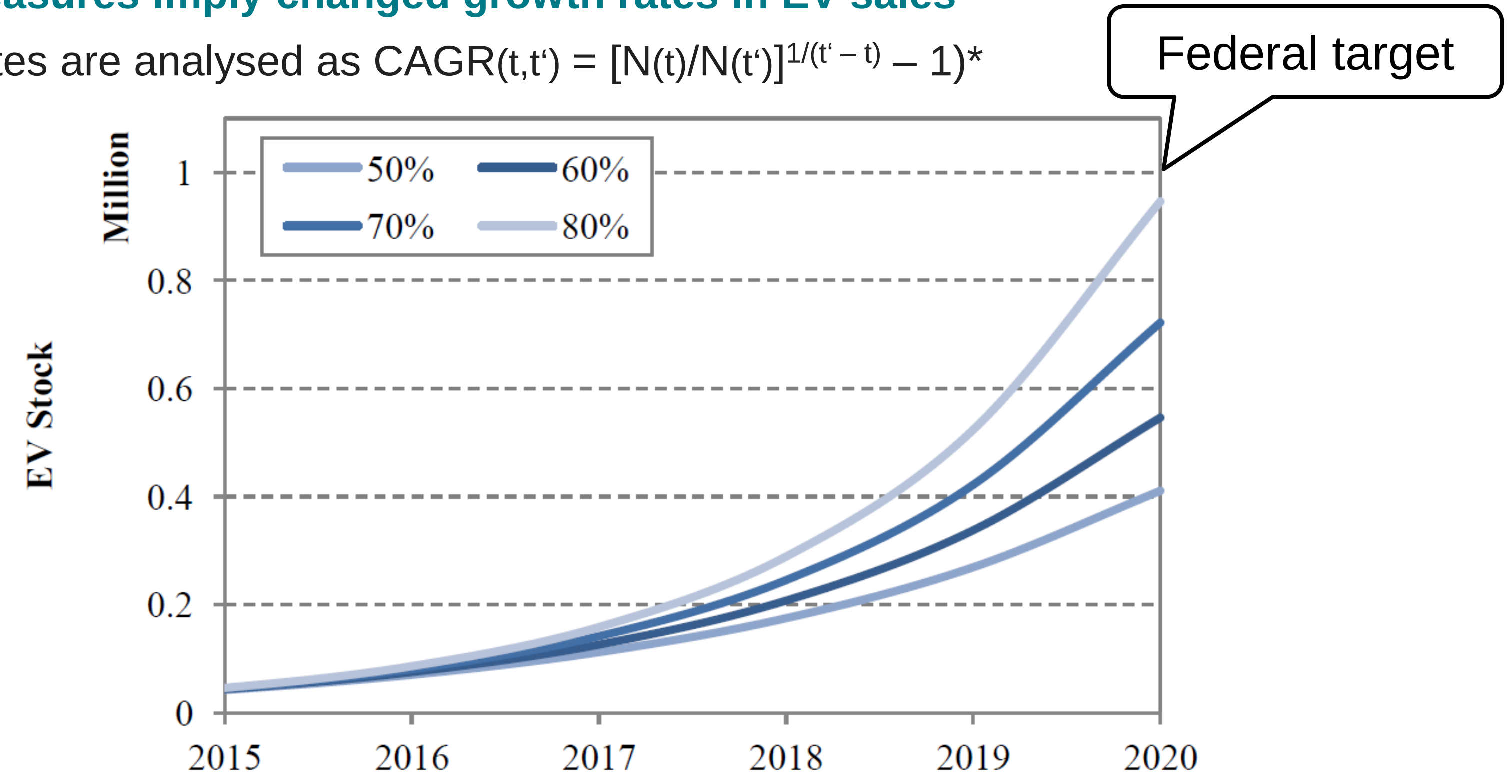
How realistic are the stimulated market evolutions?

- **Policy measures imply changed growth rates in EV sales**
- Growth rates are analysed as CAGR(t,t‘) = $[N(t)/N(t')]^{1/(t'-t)} - 1)$*



➢ **High growth (> 60% p.a.) rates are required to reach federal target**

Notes:
Base year for the analysis is 2014.
*$N(t)=N(t')*(1+CAGR)^{(t'-t)}$

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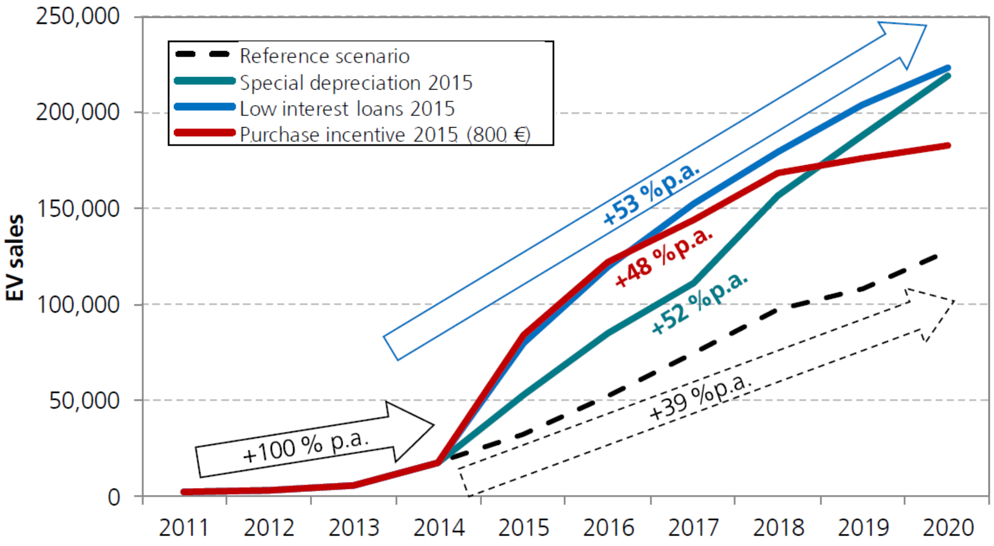
Required and historical growth rates in comparison reveal ambitious target setting.

- **Stimulated** (left) **and historical** (right) **growth rates** (CAGR)*



Technology (country)	CAGR	Period
Diesel engine (GER)	9 % p.a.	20 years
Natural gas vehicle (GER)	19 % p.a.	15 years
Hybrid vehicle (GER)	25 – 40 % p.a.	8 years
Natural gas vehicle (Italy)	30 – 85 % p.a.	12 years
Electric vehicles (NOR)	80–100 % p.a.	6 years
Automatic transmission (US)	15 % p.a.	20 years
Front wheel drive (US)	17 % p.a.	20 years
Biomass (FIN)	15 % p.a.	33 years
Heat pumps (SE)	11 % p.a.	29 years
Nuclear (FR)	15 % p.a.	39 years
Photo voltaic (global)	22 % p.a.	28 years
Wind (global)	26 % p.a.	16 years

- Usually 10 – 30 % p.a. growth rates in automotive and energy industry, but higher for alternative fuel vehicles and short observation periods

➢ **Policy evaluation implies ambitious growth rates**

Notes: Ranges in CAGR are lower and upper quartiles under variation of initial and final year. *Sources*: HEV, NGV (GER) and EV (NOR): own calculations. Diesel, NGV (GER), Automatic (US) and Front wheel drive (US): Hacker et al. (2011). Other energy technologies: Lund (2006).

*Base year of the analysis is 2011.

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Discussion

- The model used for the impact assessment is mainly techno-economical: focus on monetary instruments → psychological effects, expansion of public charging infrastructure or the possibility to use bus lanes and information-campaigns neglected
- Only one scenario of framework conditions considered: Oil and battery prices have high impact but where not varied here
- The analysis of growth curves is subject to a high degree of uncertainty in particular, the reference period lead to significantly different growth rates
- Economic effects (e.g. on employment) have been neglected

Conclusions

- **Federal 2020 target for Germany is possible yet ambitious**
- Uncertainty framework conditions: **policy measures should be dynamically adaptable** to be able to respond quickly to changes.
- Large differences in **efficiency and windfall gains** between policy measures
- Private and commercial buyers do not benefit equally → politically difficult?

Thank you for listening!

References

Federal Government (2009): Nationaler Entwicklungsplan Elektromobilität der Bundesregierung. Berlin.

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Results of policy assessment

Scenario	Stock EV 2020	government aid [Mio. €]	windfall gain [Mio. €]	government aid per EV [€]	windfall gain
reference scenario	520.000	-	-	-	-
1) special depreciation 2015*	850.000	529	195	1.600	37%
2) special depreciation 2018*	750.000	383	143	1.670	37%
3) low interest loan 2015	970.000	1.610	936	3.580	58%
4) low interest loan 2018	790.000	1.047	608	3.880	58%
5) purchase subsidy from 2015 (800€)	900.000	391	245	1.030	63%
6) purchase subsidy from 2018 (500€)	710.000	196	137	1.030	70%
7) special depreciation 2018 plus incentives from 2018 (500€)	1.120.000	961	267	1.600	28%
8) special depreciation 2018 plus incentives from 2018 (275€)	1.000.000	749	227	1.560	30%

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Scenario assumptions

(all prices including VAT)			Pro-EV	Medium scenario	Contra-EV
	Assumptions for EV are		optimistic	indifferent	pessimistic
Diesel price		2013		**1.45**	
	Euro/Liter	2020	**1.73**	**1.58**	**1.43**
Gasoline price		2013		**1.57**	
	Euro/Liter	2020	**1.79**	**1.65**	**1.54**
Electricity price private		2013		**0.265**	
	Euro/kWh	2020	**0.29**	**0.29**	**0.33**
Electricity price commercial		2013		**0.20**	
	Euro/kWh	2020	**0.215**	**0.215**	**0.25**
Battery price (all EVs)		2013	**470**	**520**	**575**
	Euro/kWh	2020	**300**	**335**	**370**

- Die folgenden Auswertungen basieren auf dem Mittleren Szenario

Quellen: BCG (2013): *Trendstudie 2030+ Kompetenzinitiative Energie des BDI*. McKinsey (2012): *Die Energiewende in Deutschland – Anspruch, Wirklichkeit und Perspektiven*. WEO (2012): International Energy agency (IEA) (2012): *World Energy Outlook 2012*. NPE (2011): Nationale Plattform Elektromobilität (NPE): *Zweiter Bericht der Nationalen Plattform Elektromobilität – Anhang*.

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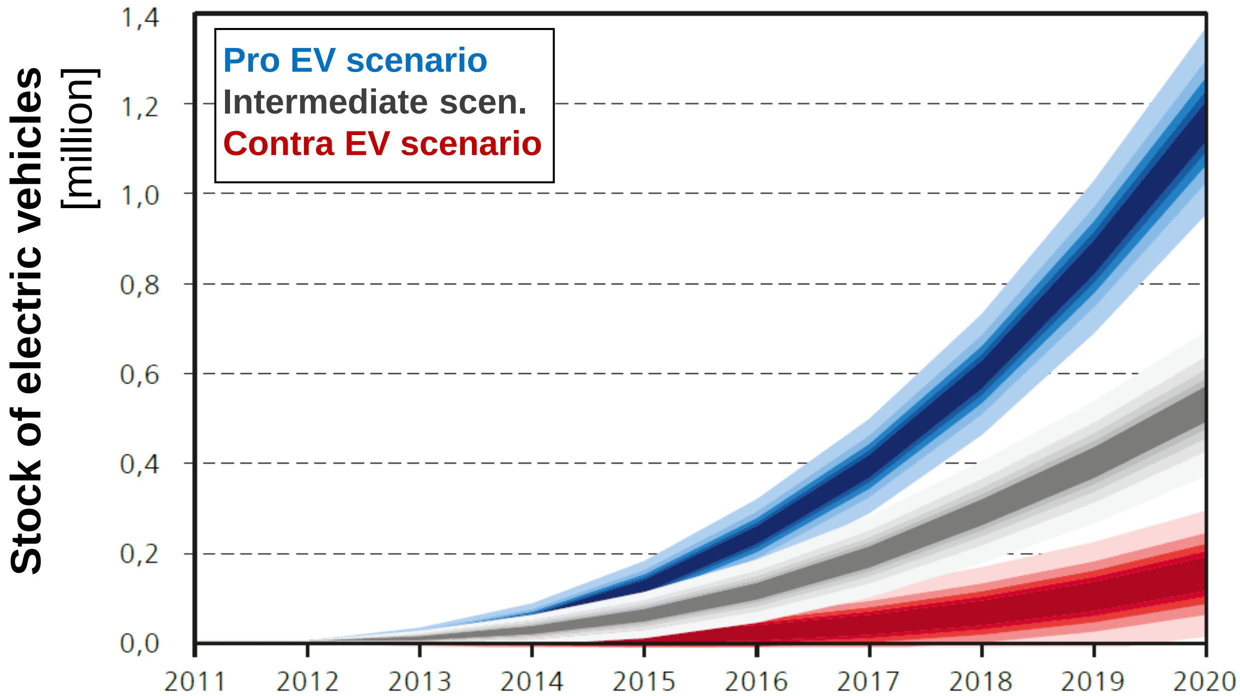
Market diffusion:
External conditions are highly important.

Stock evolution EVs in Germany incl. Cost for primary charging point, limited availability and willingness-to-pay-more in the three scenarios:



Shaded areas show the stock projection with confidence bands from the finite sample size with 10%, 30%, 50%, 70% and 90% confidence level.

Confidence bands are Clopper Pearson with gaussian error propagation.

2020	Gasoline price	Electricity private	Electricity industry	Battery price
Scenario	*Euro/Liter*	*Euro/kWh*	*Euro/kWh*	*Euro/kWh*
Pro	1,79	0,29	0,215	300
Intermed.	1,65	0,29	0,215	335
Contra	1,54	0,33	0,25	370

➢ **External conditions have high impact.**

Confidence bands quantify uncertainty only due to finite sample size. Uncertainties concerning future prices or high willingness to pay are not included. Source: Plötz et al (2013) – ALADIN (2013_04_26) – IP1IG1Sm/p/cOpt111).