University of California, Davis



UCDAVIS CHINA CENTER FOR ENERGY AND TRANSPORTATION

China Center For Energy and Transportation (C-CET)

China—U.S.— Netherlands ZEV Policy Lab

China--U.S. ICV and "3 Revolutions" Policy Lab

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Good News and Bad News, the Bad...

• Chinese auto market is slowing down for the first time in 28 years, but premium market was up 10.9% in the first 9 Months to 13% share of the total market, while non-premium was down by 3.7%. Vehicle replacement year: 7.3. From 5/1000 in 1990 to 150/1000 in 2017.



Graph: ADC CATARC





Sales performance of PV, truck and coach



2018 NEV Credit Number is > 2019's Target: 10%							
	2017	2018 (1-10)					
Total Vehicles Produced	2474	1897					
Export	57	49					
Total (w/o Exports)	2417	1848					
NEVs	54.8	70					
ICEV Total (domestic)	2362	1778					
NEV Credits	<u>159.5</u>	240					
NEV/Total Domestic	2.3%	3.9%					
<u>Credits. %</u>	<u>6.8%</u>	<u>13.5%</u>					
Credits per Vehicle	2.9	3.4					
(unit: 10'000)							





More Good News...and Bad...

- Number of available PEV models doubles every year
- BEV Ranges increase rapidly in respond to the new subsidies policy
- CAFC credit price is low RMB 200/500 per credit; BAIC hasn't sold any yet
- With subsidies gone and credits worth little, there will be challenges for startups:

















NEV Models Approved by the MIIT						
	2016	2017	2018			
PHEV	48	43	239			
BEV	166	361	641			
FCEV	1					
Total	215	404	<u>880</u>			

BEV Models and Ranges Approved by the MIIT						
	km	2017	2018			
	150-199	175	47			
	200-249	27	58			
BEV	250-299	79	146			
	300-399	63	267			
	>400	17	122			
<u>Total</u>		<u>361</u>	<u>640</u>			

Source: MIIT





The Top Five EV Makers Account for 64% of the Total NEV Credits Generated (1-10)

- BYD Sold 130,367 PEVs; BAIC: 67,472; SAIC: 62,242
- 36% of BYD cars sold outside the 6 "license plates restrictive" cities; 71% of them by private buyers
- BYD's PHEVs/BEVs ratio at 50% ish ; SAIC 77%

BYD Leads the Five BIG NEV Makers (1-10)						
	NEV Crdits	Credit/V	% of total			
BYD	511,575	3.33	21%			
BAIC	356,710	3.70	15%			
SAIC (Passenger)	244,975 2.83		10%			
Geely	211,624	3.82	9%			
Chery	209,755	4.28	9%			
Above Big Five	1,534,639		64%			
Rest of the OEMs	865,361		36%			
Total	2,400,000		100%			



Source: MIIT



Research at China Center for Energy and Transportation

1. Will China achieve near 100% ZEV sales? If yes, when? (X. Zhang, Y. Wang, A, Jenn; and L Fulton)

2. What are the optimal e-ranges for BEVs and PHEVs in Chinese cities? (Y. Xing;

Y. Wang and others)





Vehicle stock in China and selected countries; up fast







Vehicle stock and GDP per capita: China up fast with space to grow







Total vehicle stock projection

• Others' are much slower than the rest of the major forecasters: *the frog-shaped gap*



汽车保有量总量预测_Wang, 2011

相关预测研究结果对比





Vehicle Saturation level (vehicle ownership / 1,000 people)

Source	Button,	Kobos,	Dargay,	W	ang 20	12	Wh 2014	Peng et al. 2018			CATARC,
Source	1993	2003	2007	High	Mid	Low	wu 2014	High	Mid	Low	2018
Saturation	300-450	292	807	600	500	400	807	497	376	250	350-400





Population and structure 2015-2050

- In 2017/18 China's age structure matched that of Japan in 1990
- Chinese women can retire at the age of 50 and will very long; 52.5 in 2020; 55 in 2025
- By 2050 49% of the population will be 50 and older, 36% will be 60 and older



Data source: US Census, 2018





Long Live the Chinese, but vehicle ownership...



Life expectancy in 2017: Hong Kong: 87.66 (w) and 81.70 (m) Japan: 87.26 (w) and 81.09 (m)









Vehicle stock projection based on population age structure

- Study shows that after 50 years old, car ownership starts to decline rapidly
- The 5-year dataset in China shows that 50 and above own few cars



Figure 1a: Mean distance driven and car ownership by age of household head

Source: Prskawetz, etc., 2004, Demographic composition and projections of car use in Austria



Vehicle registration owners' age structure 2010-2015



New Energy Vehicles Sales and Goals

• Sales and Goals; both increase rapidly



China New Energy Vehicles Production a Planning Goals Data source: MIIT, SAE-China Automobile Development Technology Roadmap

The average growth rate is 142.7% taking out the 2011 rate

Manufacturers

UCDAVIS INSTITUTE OF TRANSPORTATION STUDIES

Projection with linear model (decreasing growth rates)

- With Government Targets
- With slow total vehicle sales rates 2.3% to 1% YoY



			2.3%	
			1%	
	Year	Total ZEV Sal	Total Vehic	ZEV/Total
80%	2018	140	2876	4.86%
60%	2019	224	2942	7.61%
50%	2020	336	3009	11.15%
40%	2021	470	3079	15.26%
30%	2022	611	3149	19.40%
25%	2023	764	3222	23.70%
25%	2024	955	3296	28.96%
20%	2025	1145	3372	33.97%
20%	2026	1375	3406	40.36%
20%	2027	1649	3440	47.95%
15%	2028	1897	3474	54.60%
15%	2029	2181	3509	62.17%
15%	2030	2509	3544	70.79%
10%	2031	2759	3579	77.10%
10%	2032	3035	3615	83.97%
10%	2033	3339	3651	91.45%
10%	2034	3673	3688	99.60%
10%	2035	4040	3725	108.47%
8%	2036	4363	3762	115.99%
8%	2037	4712	3799	124.03%
8%	2038	5089	3837	132.62%
6%	2039	5395	3876	139.19%
6%	2040	5718	3915	146.08%





E2W analogy model: 20m ZEV sales in 2030s

- Assumptions:
 - EV penetration may follow the trend of electric 2-wheelers that soared after the motorcycle ban in cities in 1990s
- 20m ZEV sales in 2030s
 - Possibly 50-70% of the total vehicle market







Bass model: 100% ZEVs in mid-2030s

- Assumptions:
 - Tech Diffusion model with saturation setting at 250 m ZEV and 400 m ZEV
 - Total vehicle linear growth with rate of 4% and 2%; reflecting aging and slow GDP growth
- 100% ZEV in mid-2030s
- With incentives and other supporting policies, ZEV sales are <u>already</u> higher than the Tech. Diffusion model results



Bass Tech Diffusion Model

$$\begin{split} S(t) &= m \frac{(p+q)^2}{p} \frac{\exp(-(p+q)t)}{(1+\frac{q}{p}\exp(-(p+q)t))^2} \\ \text{In which,} \\ S(t) &= \text{sales in year t} \\ m &= \text{market saturation amount} \\ p &= \text{Innovator parameter} \\ q &= \text{Imitator parameter} \end{split}$$





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2. What are the optimal e-ranges for BEVs and PHEVs in Chinese cities? (Y. Xing and 4 others)

China's PEV subsidies and credits policies (2018)

- Each manufacturer will have to generate 10% and 12% NEV credits in 2019-2020
- A 180 km BEV could accrue about 3 credits; and PHEV with 50 km may get 2 credits

Source: Notice of adjusting and improving the financial subsidy policy for the promotion and application of new energy vehicles, published by Ministry of Finance, Ministry of Industry and Information Technology, Ministry of Science of Technology on February 13, 2018

2018 Subsidies Policy

• Encourage BEVs with long electric range:

- No subsidies to BEVs with a range shorter than 150 km
- Subsidies to BEVs with 150 =< R <300 km decrease significantly
- Subsidies to BEVs with 300 =< R < 400 km increase by 2%
- Subsidies to BEVs with $R \ge 400$ km increase by by 14%

• Encourage higher battery pack density:

- No subsidy to battery pack with density less than 105 Wh/kg.
- Subsidies to battery pack with density between 105 and 120 Wh/kg decrease
- Subsidies to battery pack with density between 120 and 140 Wh/kg keep the same.
- Subsidies to battery pack with density of over 140 Wh/kg increase.

• Encourage fuel efficient or long range PHEVs: If R < 80 km,

- No subsidy in PHEV with fuel consumption in Charge Sustaining (CS) mode >65% of that of ICEVs with same vehicle curb weight.
- Half of subsidies to PHEVs with fuel consumption in CS mode between 60% and 65% of equivalent ICEVs

Full subsidies to PHEVs with fuel consumption in CS mode<60% of ICEVs

Share of approved PEV model by range in 2018

- Manufacturers responded quickly to the new subsidies policy
- Several fire incidences compel some experts to call for "safety first"

TE OF TRANSPORTATION STUDIES

Annual amount of CO2 emissions by models

(Based on the annual travel distances of the 4999 PHEV vehicles in Shanghai)

1. LCA CO2 emission factor of gasoline at national level: 2.95 kg/ L (Wang, 2017) and LCA CO2 emission factor of electricity grid in Shanghai: 0.564 kg / kWh (National Climate Change Strategy Research and International Cooperation Center , 2016).

- 2. Corporate-Average Fuel Consumption (CAFC) 2018 target: average fuel consumption of ICEs is 6 L/100 km.
- 3. 2018 Prius Hybrid: combined fuel efficiency 52 mpg (EPA), i.e. 4.55 L/100 km.

Tang 100, Song 81, Qin 65, QinPro 62 are all BYD models.

Amount of CO2 emissions by models over distance

Conclusions (BEVs)

- The energy consumption rate of a BEV needs to be smaller than 0.218 kWh/100km in Beijing and 0.238 kWh/100km in Shanghai to be cleaner than a hybrid car in CO2 emissions; based on the data from 39,854 ICE vehicles in Beijing and 4,999 PHEVs in Shanghai.
- Considering cold weather, cabin heating or cooling, extra electrical loads, hilly topography, and range anxiety as well, a BEV with the range of 350 km is enough for the majority of people in the two cities except holidays based on the real-time data*.
- * Daily VKT distribution based on real-time data

A110km-range BEV and a 210km-range BEV can meet 90% and 99% of individuals' daily travel need except holidays

- About 90% of individuals' daily travel demand in both cities is within 110 km.
- 99% of daily travel demand is within 210 km on weekdays and at weekends.

Reople who travel longer than 250km during holidays account for 2.5% of the total.

Conclusions (PHEV)

- First, the electricity consumption rate of PHEVs in Charge Depleting (CD) mode must be be smaller than the critical value of 0.218 and 0.238 kWh/100km in Beijing and Shanghai, respectively, for those PHEVs to be cleaner than a hybrid car.
- If the average energy consumption rate of the most recent PHEV fleet is used* and based on the real-time daily VKT distributions of the 90% of the trips, an electric range of, not too much more or less than, 72 km in Beijing or 61 km in Shanghai, may be required for the PHEV fleet to be cleaner than a hybrid car; and these are the optimal ranges.

* The average electricity consumption rate in CD mode of 139 most recent PHEVs in China's PEV market is 0.201 kWh/100km (s.d.=0.030) and the average gasoline consumption rate in CS mode is 5.42 l/100km (s.d.=1.094).

Thanks!

Comments & Questions

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