Supplementary Information

Anthropogenic mineral supply through a circular economy approach has potential to meet Chinese resource consumption

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Contents

Supplementary Section 1: Terminologies definition and boundary

(1) Anthropogenic mineral, nature mineral, and solid waste (Supplementary Fig. 1)

Anthropogenic mineral, or called urban mineral, belong to solid waste, is the recycled resources characterizing the product with the orderly physical structure and fixed shape under the condition of human activity. In this study, it is defined as the three group of waste products, i.e., WEEE, ELV, and WWC.

Nature mineral is the underground solid resource generated by the naturally occurring process.

Solid waste is any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, resulting from industrial, commercial, mining, and agricultural operations, and from community activities.

(2) New scrap and old scrap (Supplementary Fig. 1)

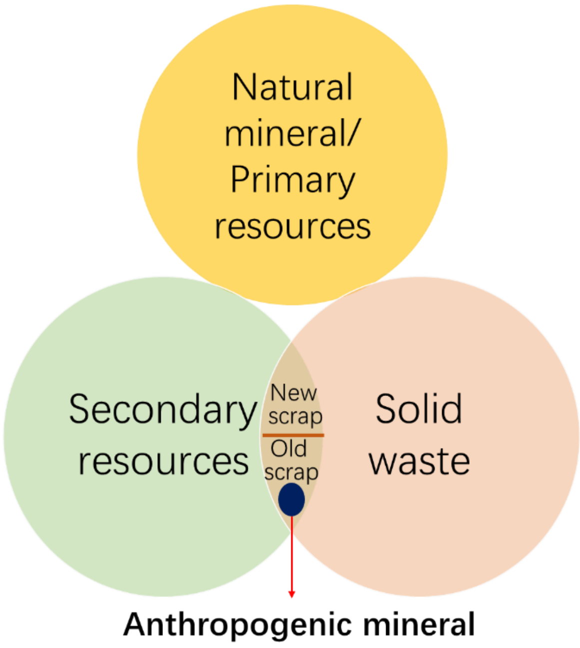
New scrap is the solid waste generated from the manufacturing process.

Old scrap is the solid waste generated from end of life product after consumption or utilization, including the anthropogenic mineral.

(3) Primary resources and secondary resources (Supplementary Fig. 1)

Primary resources called nature resources (mineral), are resources that exist without actions of humankind.

Secondary resources are the resources by anthropogenic activity, consisting of new scrap and old scrap.



Supplementary Fig. 1 Boundary of anthropogenic mineral, natural mineral, primary resources, secondary resources, solid waste, new scrap, and old scrap

(4) Product, resource, and material[1]

Product is a good consisting of a bundle of tangible and intangible attributes that satisfies consumers.

Resource stands for the useful matters, consisting of valuable material.

Material is the element, constituent, or substance of which something is composed or can be made.

(5) Urban mining and virgin mining[2]

Urban mining is the process recycling resources from anthropogenic mineral, consisting of dismantling, crushing, separation, and deep recovery using hydrometallurgy, pyrometallurgy, or biological treatment.

Virgin mining is the process to extract resources from natural mineral, consisting of crushing, separation, and deep recovery using hydrometallurgy, pyrometallurgy, or biological treatment.

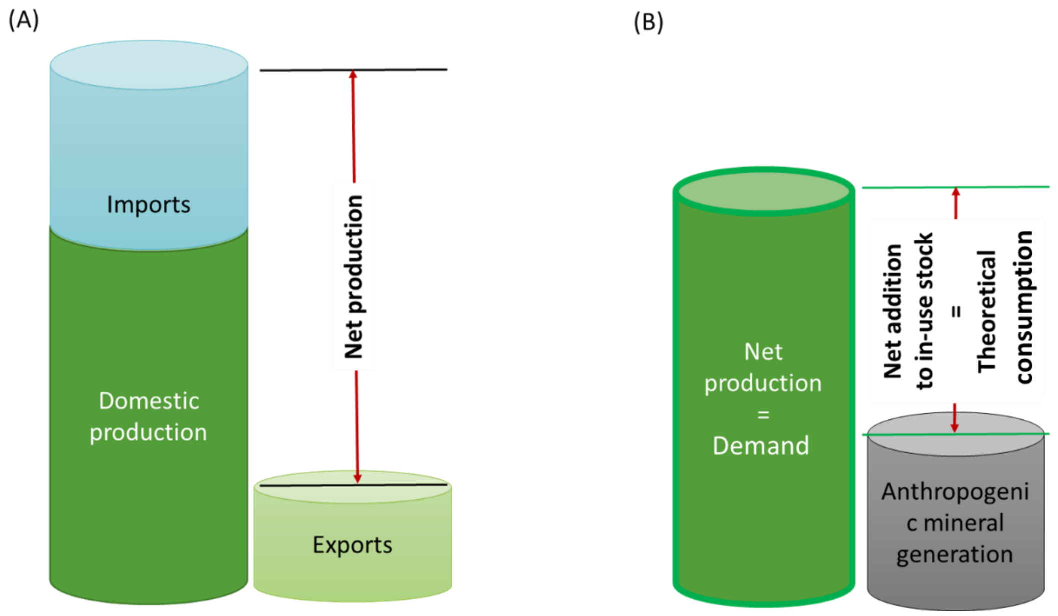
(6) Flow, stock, in-use stock, and net addition to in-use stock (Supplementary Fig. 2)[1,3]

A flow is the change of a stock over time. The yearly-generated anthropogenic mineral belongs to the flow.

A stock is the reservoir that is accumulated over time by inflows and/or depleted by outflows, which is the totally cumulative quantity.

In-use stock is the cumulative product or resource, which is used or consumed functionally.

Net addition to in-use stock in every year is the difference between the yearly demand and yearly-generated anthropogenic mineral, which is the annual theoretical consumption.

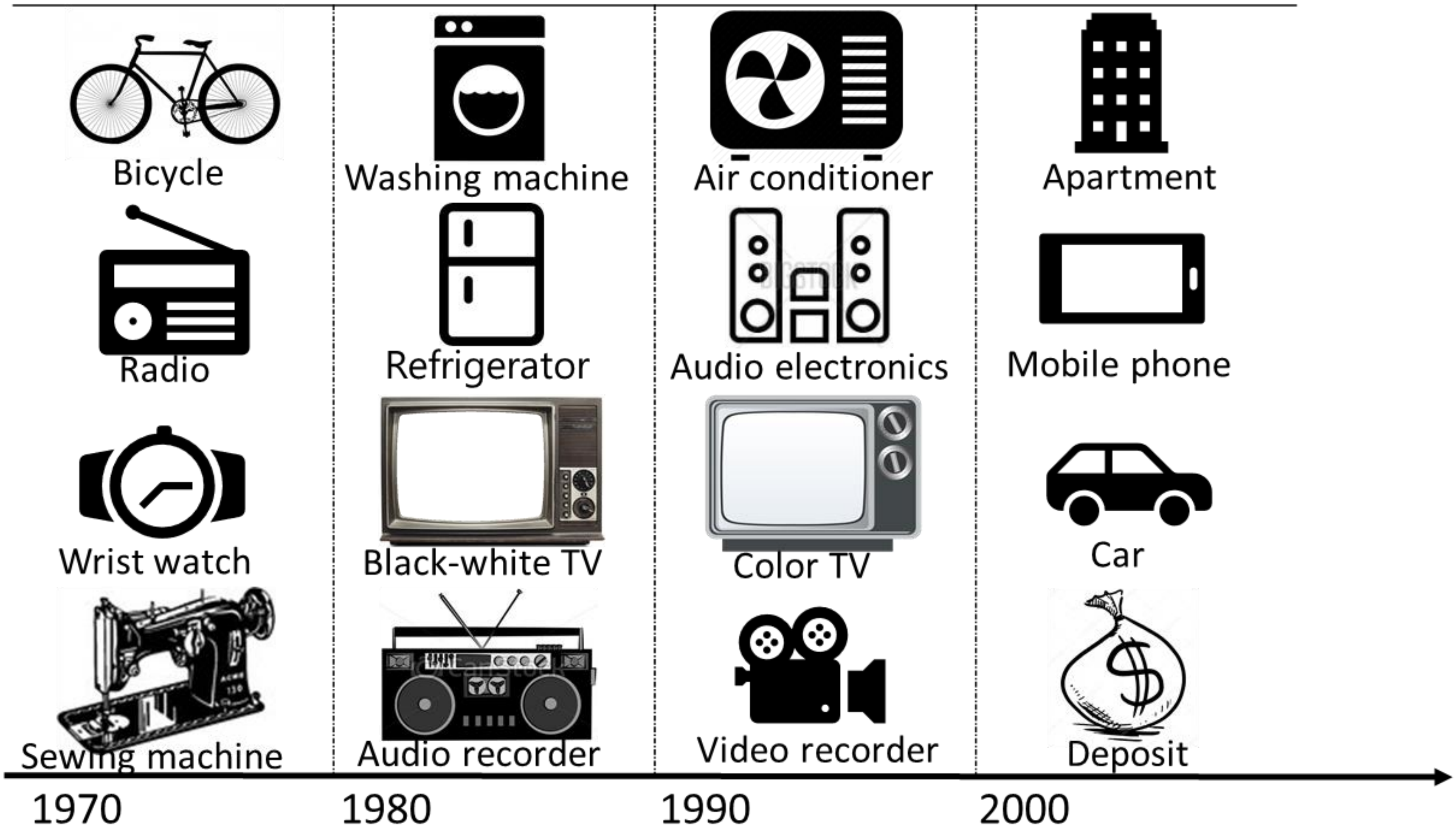


Supplementary Fig. 2 Relationship among the production, consumption, and theoretical consumption

Supplementary Section 2: Main abbreviations and acronyms

AC	air conditioner	M	million
Al	aluminum	MC	motorcycle
Ag	silver	MFA	material flow analysis
AM	anthropogenic mineral	Mg	magnesium
Au	gold	MP	mobile phone
CDF	cumulative distribution function	Mt	million ton
Co	cobalt	Nd	neodymium
CT	cargo truck	Pb	lead
Cu	copper	PC	personal computer
DPC	desktop personal computer	Pd	palladium
Dy	dysprosium	PDF	probability density function
EEE	electrical and electronic equipment	Pt	platinum
ELV	end-of-life vehicle	PV	passenger vehicle
EoL	end of line	RE	rare earth
Eq.	equation	ref.	reference
Eu	europium	RF	refrigerator
EU	European Union	Rh	rhodium
EV	electric vehicle	RH	range hood
e-waste	electrical and electronic waste	RV	refit vehicle
EWH	electric water-heater	SMT	single-machine telephone
Fe	iron	Sn	tin
Fig.	figure	TV	television
FM	fax machine	US	United States
GWH	gas water-heater	W	tungsten
ICT	information and communications technology	WEEE	waste electrical and electronic equipment
In	indium	WM	washing machine
La	lanthanum	WWC	waste wiring and cable
LPC	laptop personal computer	Y	yttrium
kg	kilogram	Zn	zinc
kt	kiloton		

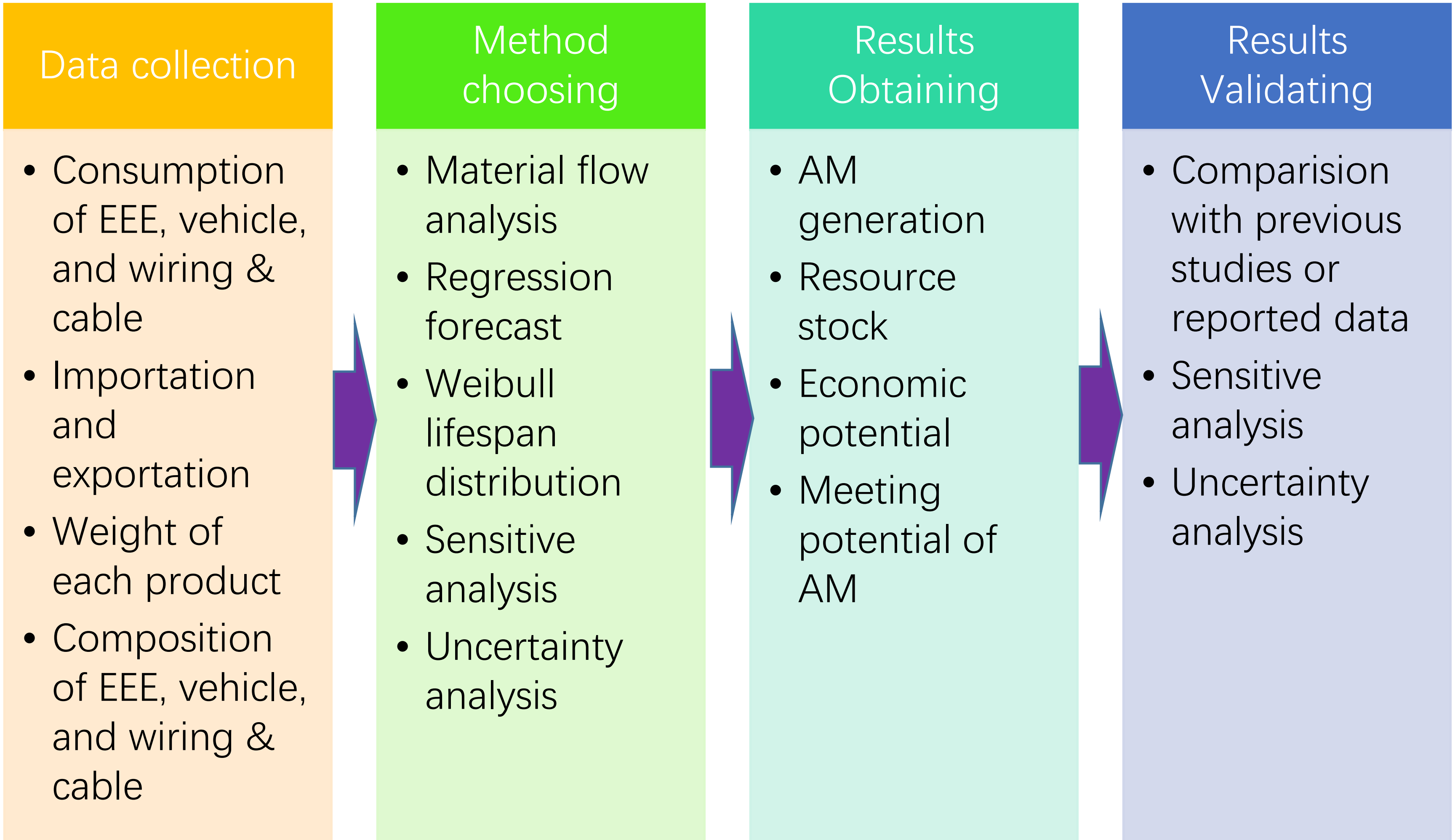
Supplementary Fig. 3 Evolution of “Four Big Items” from 1970s to 2000s



Note: The “Four Big Items” is a term originally applied to the four symbols of material success in China few decades years ago, especially while the young man has a marriage (at this time they prefer to buy the most fashionable goods almost using the whole family estate). Its evolution can indicate a progress of technology and a rise of economic income. Source from refes[4, 5, 6, 7].

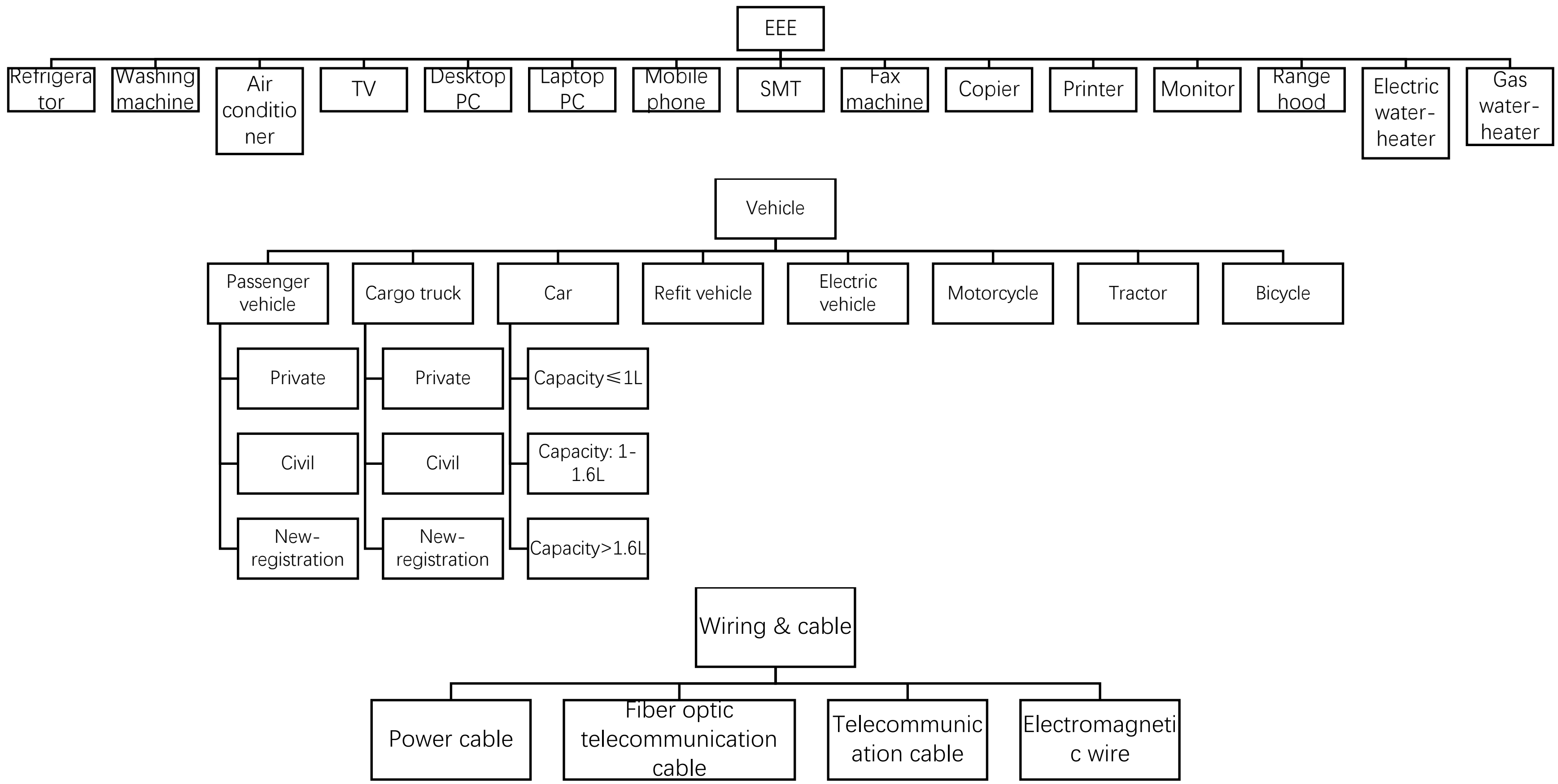
Supplementary Fig. 4 Evolution of television since 1960s

Note: The photo was taken in China GEM (http://en.gem.com.cn) by the author, illustrating the Chinese evolution of TV from black-white to color and from small to large display.



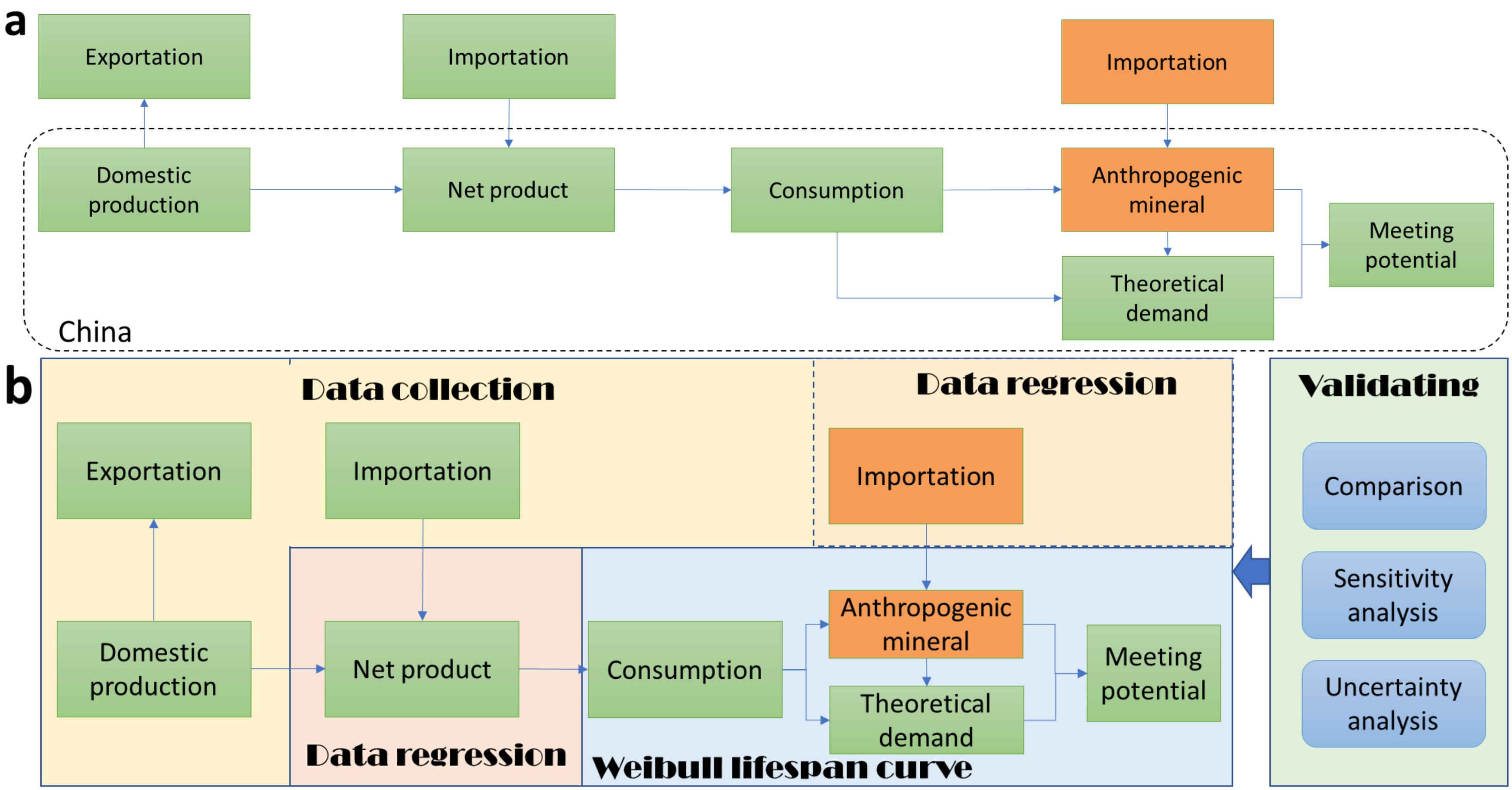
Supplementary Fig. 5 The concise diagram of research procedure for this study

Note: The choose of sensitive analysis and uncertainty analysis is relied upon the integrity of data. If only knowing the error or range of data, sensitive analysis will be used; if knowing not only the error or range, but the distribution of data, uncertainty analysis could be adopted.



Supplementary Fig. 6 Classification of EEE, vehicle, and wiring & cable in China

Note: EEE, electrical and electronic equipment; TV, television; PC, personal computer; SMT, single-machine telephone.



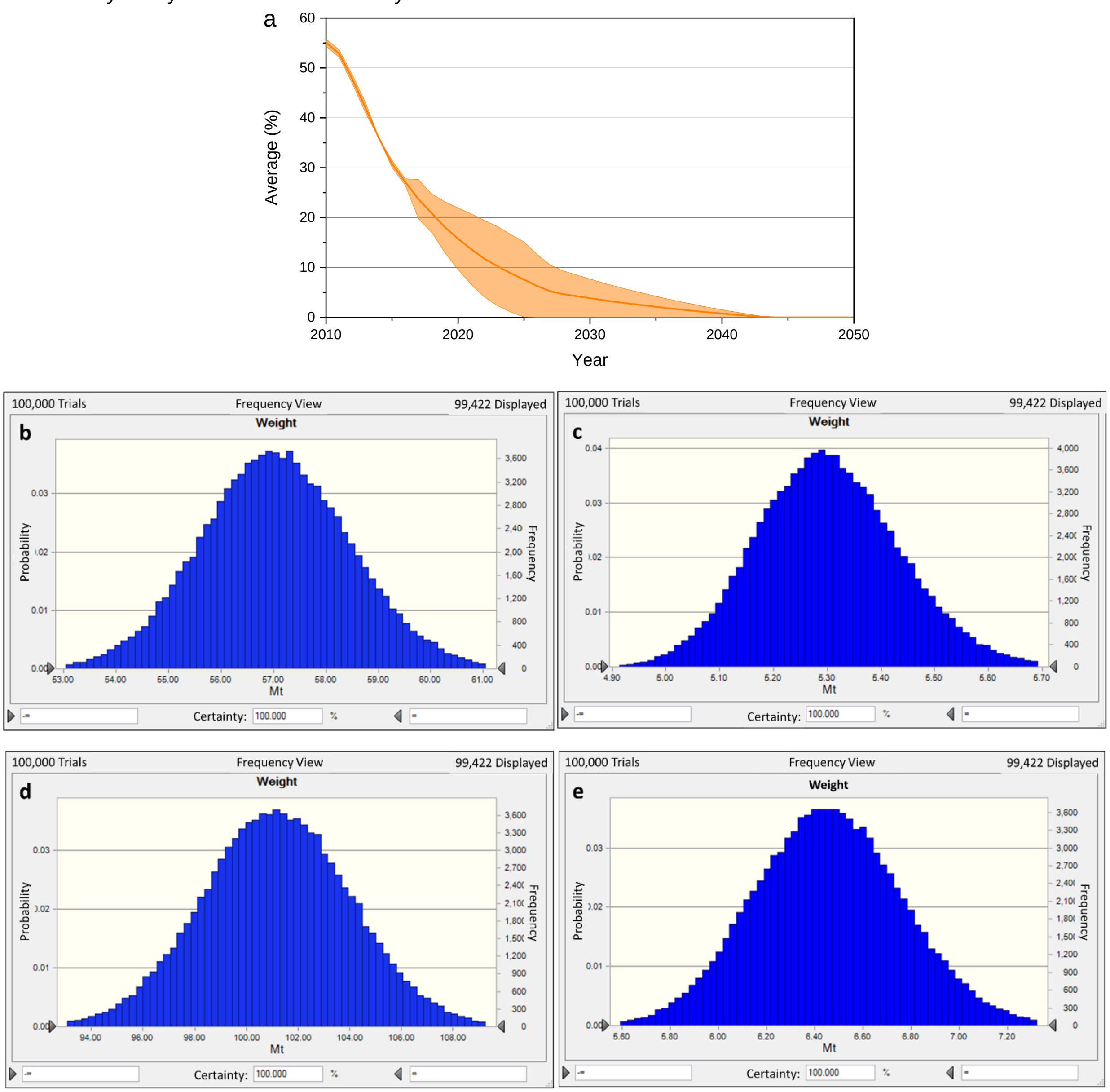
Supplementary Fig. 7 The designed framework of research methods

(a) Material flow analysis framework for anthropogenic mineral generation and its boundary in this study; Note: green color for product, and orange color for anthropogenic mineral, and dash line indicates the boundary for this study.

(b) Four extract approaches of data collection, data regression, Weibull lifespan curve, and validating methods.

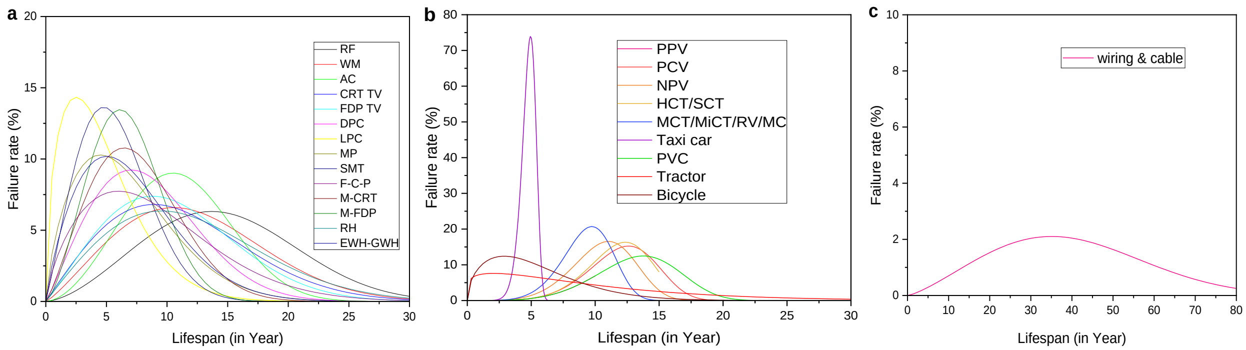
Supplementary Fig. 8 Sensitivity analysis and uncertainty analysis with 95% confidence intervals

(a) share of importation on total AM, obtained from the indefinite importation dividing total AM; (b) total weight of AM in 2017 affected by each weight and parameters; (c) Cu weight of yearly-generated AM in 2017 affected by resources content and each WEEE weight; (d) total weight of AM in 2030 affected by each weight and parameters; (e) Al weight of yearly-generated AM in 2030 affected by resources content and each WEEE weight. Note: Min, Average, and Max indicate the minimum importation, average (or estimation) importation, and maximum importation, respectively. Monte Carlo simulation (10^5 iterations) was used to perform the uncertainty analysis with the Oracle Crystal Ball software.



Supplementary Section 3: Available data pre-mining for estimation

Regarding all the related products, we identified the scale and shape parameters in the Weibull distribution function, depicted in detail in Supplementary Table 15. Their annual failure rates with probability density function are shown in Supplementary Fig. 9. The two zones of in-use and waste are located above and below the function curve, respectively. It can be utilized to determine the yearly obsolete amount and stocked resources of various WEEE, ELV, and WWC.



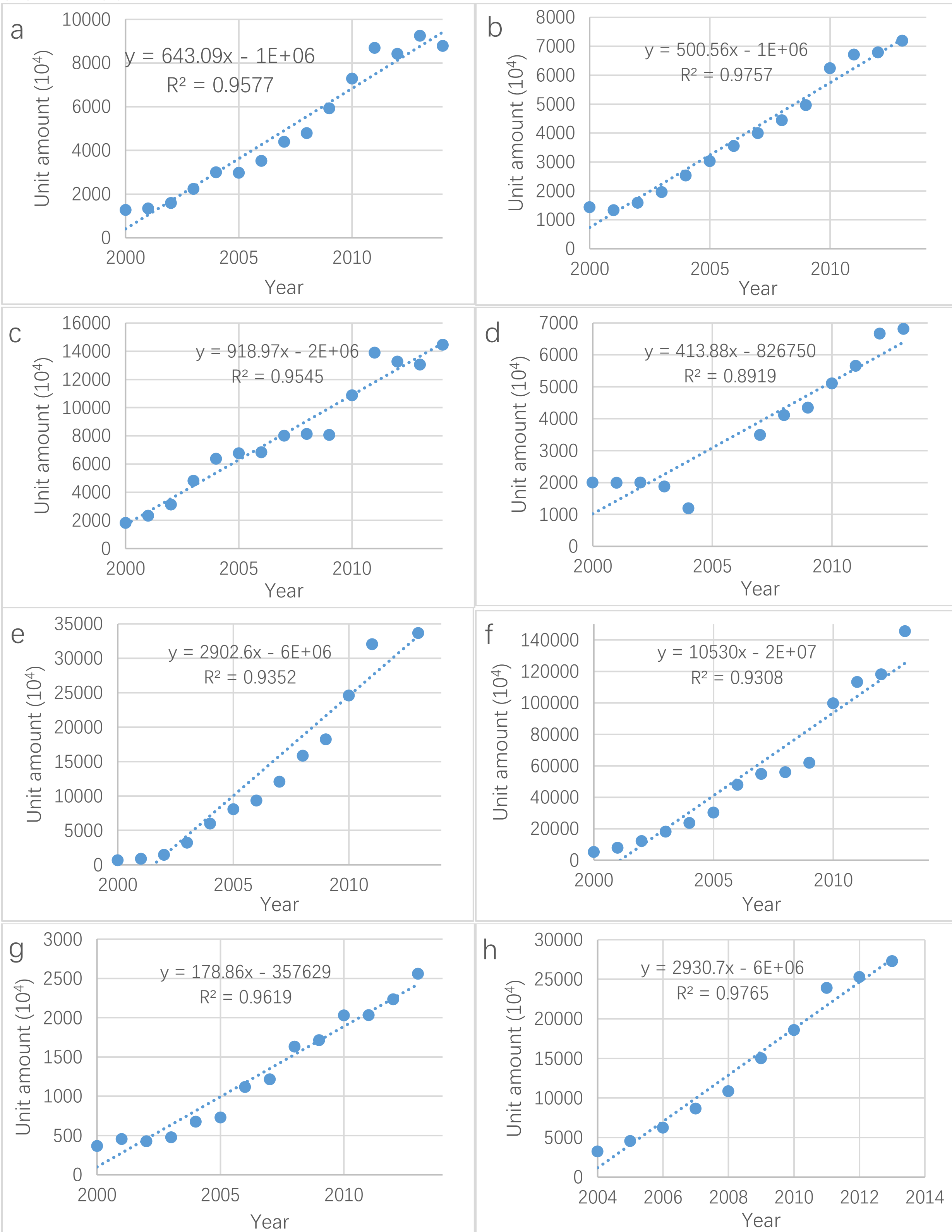
Supplementary Fig. 9 Probability density function of Weibull distribution

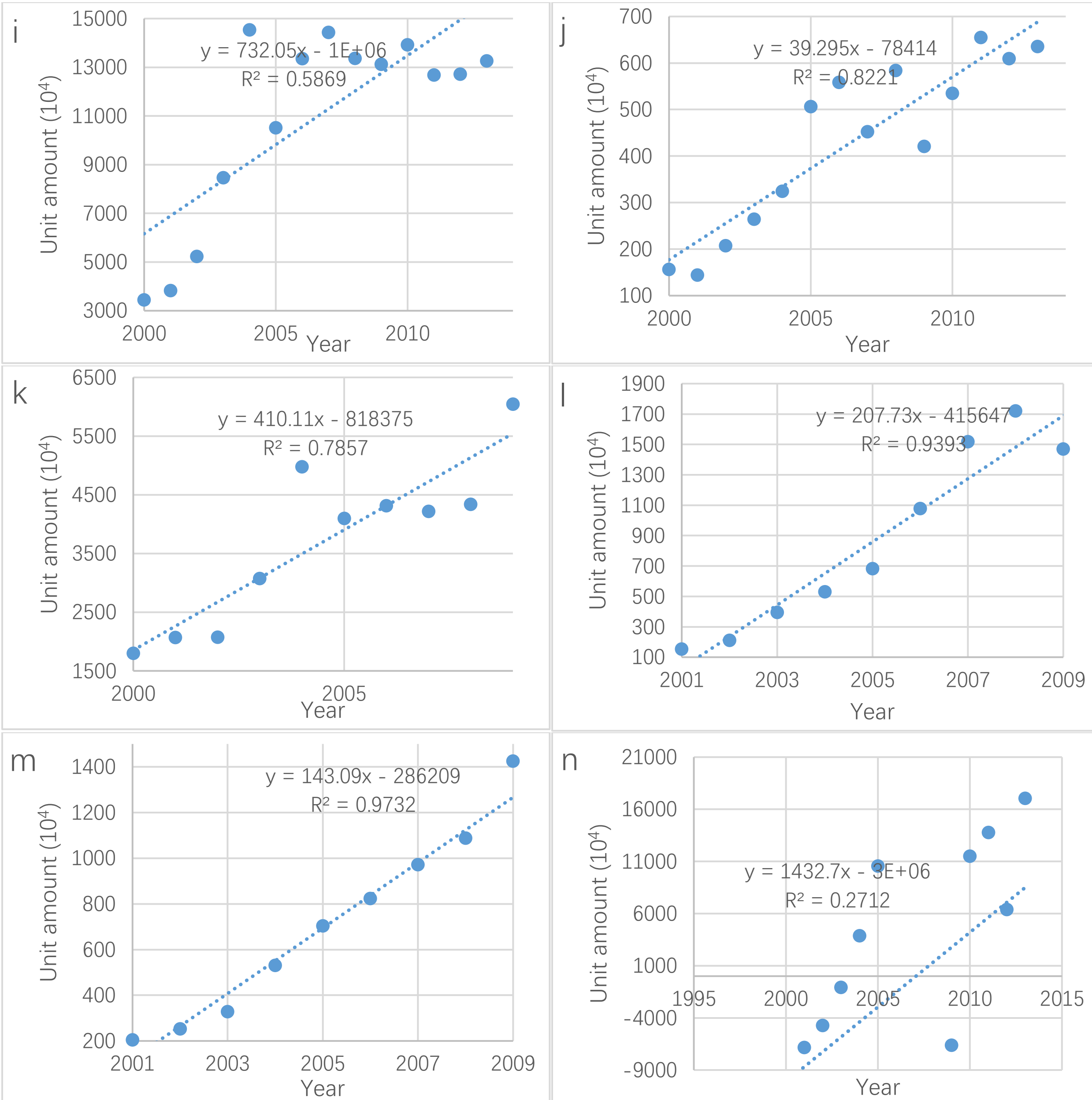
(a) EEEs[8]; (b) vehicle & bicycle; (c) wiring & cable. Note: RF: refrigerator; WM: washing machine; AC: air conditioner; CRT-TV: TV with cathode-ray tube (CRT); FDP-TV: flat display panel TV; DPC: desktop personal computer; LPC: laptop personal computer; MP: mobile phone; SMT: single-machine telephone; F-C-P: fax machine, copier, and printer; M-CRT: CRT monitor used for mainframe; M-FDP: FDP monitor used for mainframe; RH: range hood; EWH: electric water-heater; GWH: gas water-heater; PPV: Private passenger vehicle; PCV: Passenger civil vehicle; NPV: New-registration passenger vehicle; HCT: heavy cargo truck; SCT: small cargo truck; MCT: medium cargo truck; MiCT: mini cargo truck; RV: refit vehicle; MC: motorcycle; PVC: Private vehicle car.

According to the net production (demand) of various products, obtained from Supplementary Tables 1 and 2, regressions for the recent years indicate that the growth of most net production maintains an excellent linear regression, with a correlation rate of over 0.90 (Supplementary Figs. 10-12). Since there has been a distinct fluctuation in the net production of SMT, FM, printer, passenger vehicle, cargo truck, and bicycle, the fixed values of 120-, 1.61-, 59.73-, 0.4-, 4-, and 70- million were assumed for future annual production, respectively. The total estimated consumption of products from 1990s to 2050 is given in Supplementary excel table.

Supplementary Fig. 10 Data regression of net production of EEEs for *P*(x)

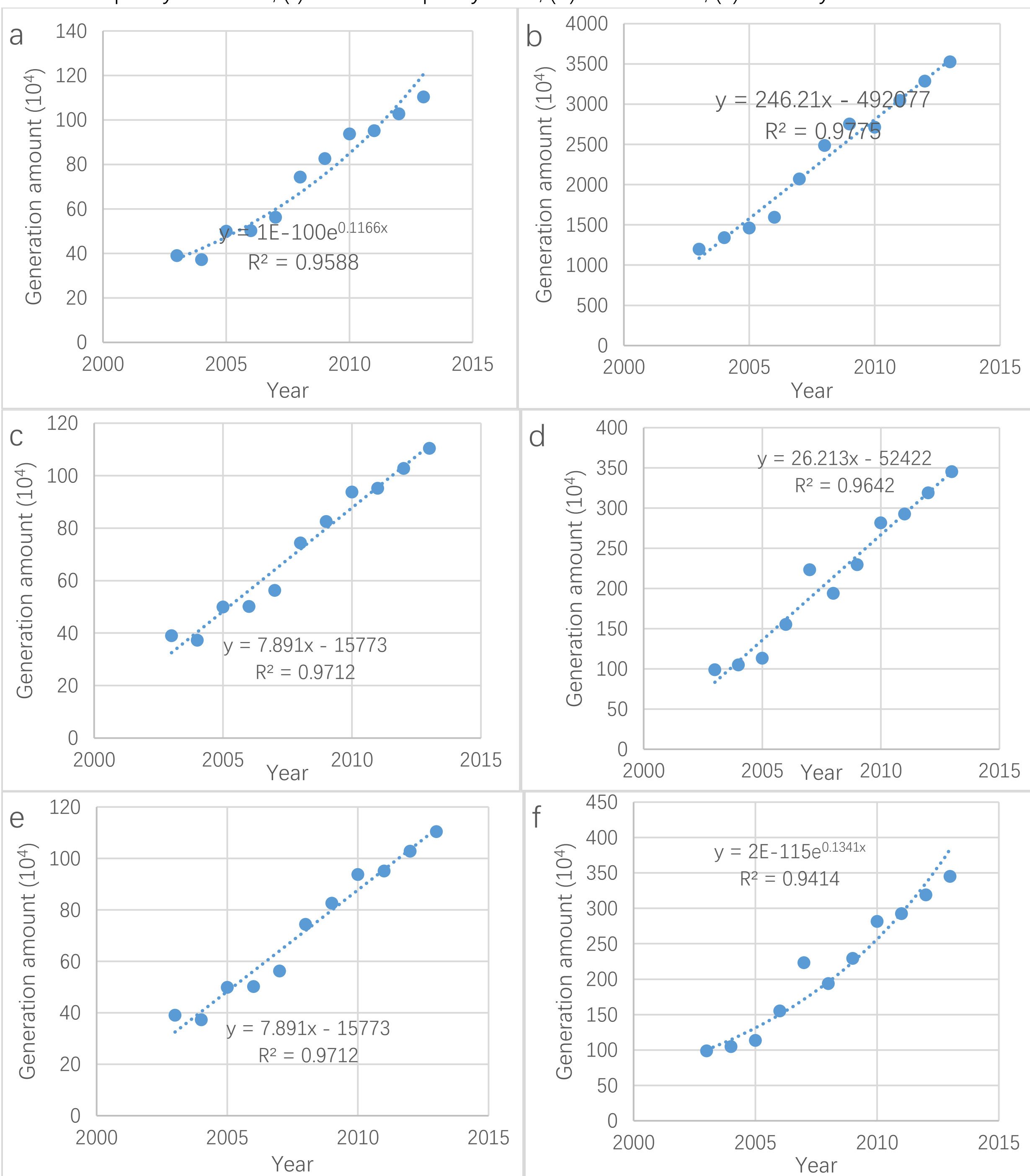
(a) RF; (b) WM; (c) AC; (d) TV; (e) DPC; (f) MP; (g) RH; (h) LPC; (i) Monitor; (j) Copier; (k) Printer; (l) EWH; (m) GWH; (n) SMT.

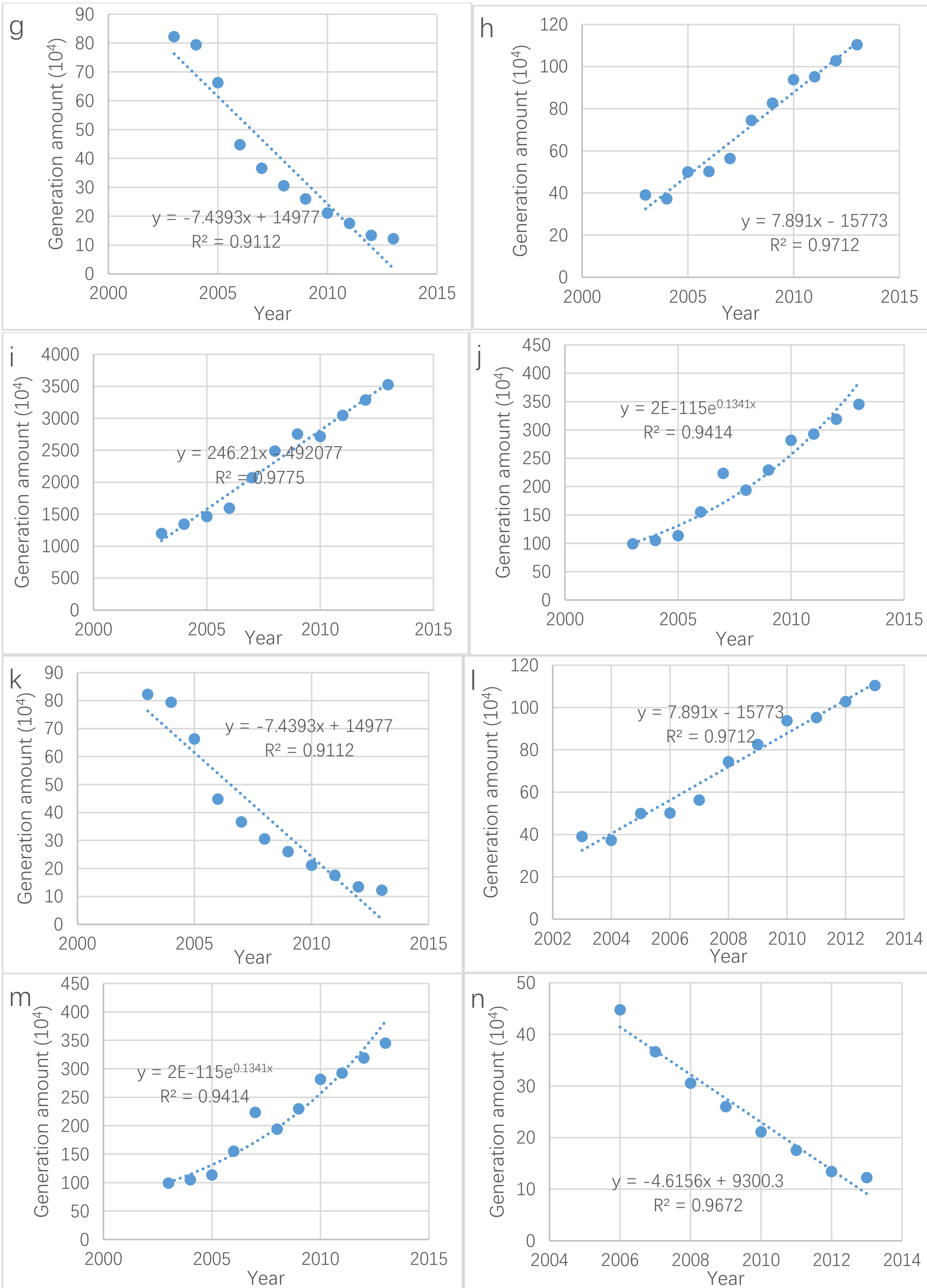


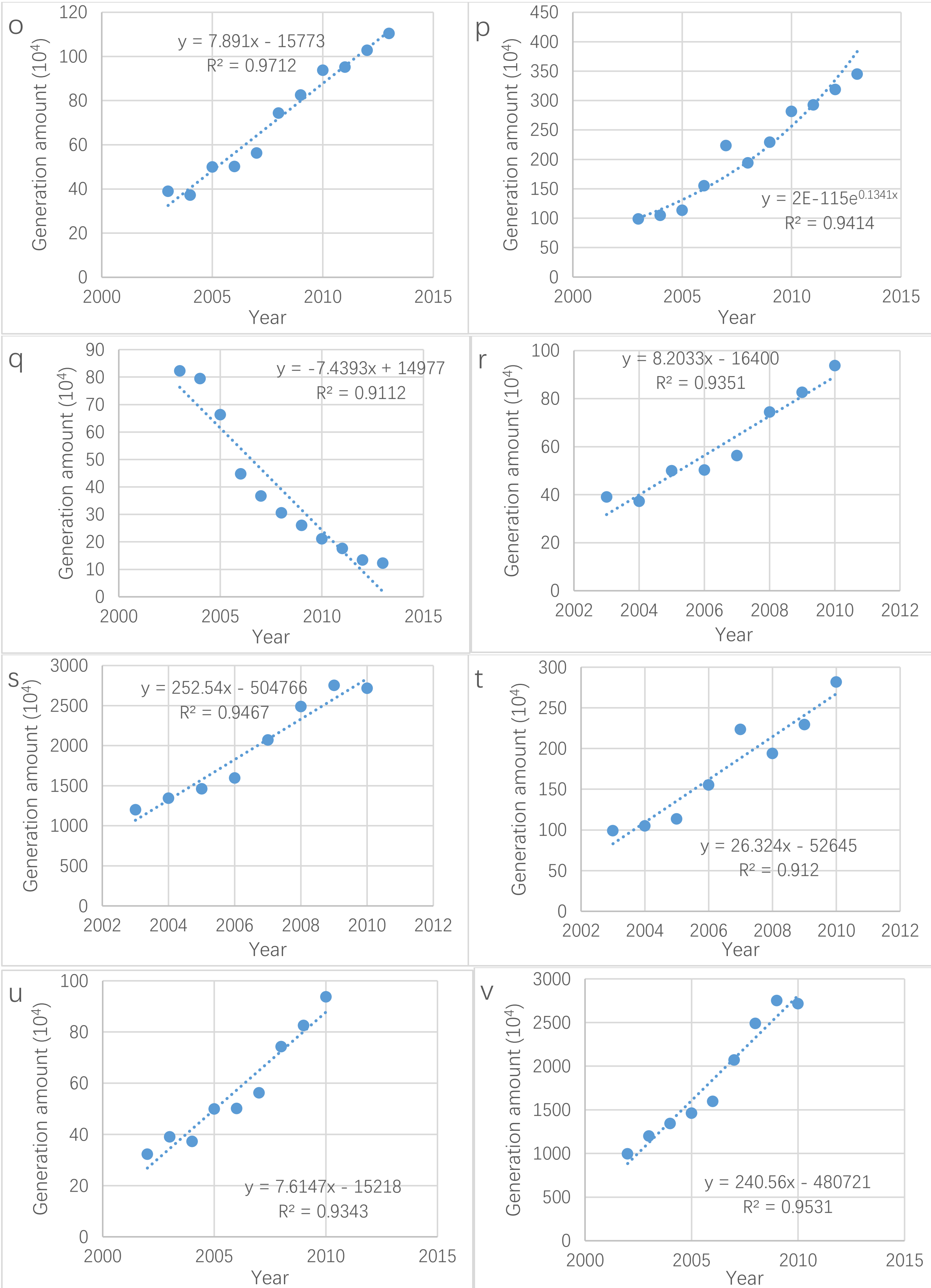

i
Unit amount (10⁴)
15000
13000
11000
9000
7000
5000
3000
2000
2005
2010
Year
y = 732.05x - 1E+06
R² = 0.5869
j
Unit amount (10⁴)
700
600
500
400
300
200
100
2000
2005
2010
Year
y = 39.295x - 78414
R² = 0.8221
k
Unit amount (10⁴)
6500
5500
4500
3500
2500
1500
2000
2005
Year
y = 410.11x - 818375
R² = 0.7857
l
Unit amount (10⁴)
1900
1700
1500
1300
1100
900
700
500
300
100
2001
2003
2005
2007
2009
Year
y = 207.73x - 415647
R² = 0.9393
m
Unit amount (10⁴)
1400
1200
1000
800
600
400
200
2001
2003
2005
2007
2009
Year
y = 143.09x - 286209
R² = 0.9732
n
Unit amount (10⁴)
21000
16000
11000
6000
1000
-4000
-9000
1995
2000
2005
2010
2015
Year
y = 1432.7x - 3E+06
R² = 0.2712

Supplementary Fig. 11 Data regression of net production of vehicle for $P(x)$

(a) Small passenger vehicle; (b) Mini passenger vehicle; (c) New-registration civil & large passenger vehicle; (d) New-registration civil & small passenger vehicle; (e) Civil & large passenger vehicle; (f) Civil & small passenger vehicle; (g) Civil & mini passenger vehicle; (h) Heavy & private cargo truck; (i) Medium & private cargo truck; (j) Small & private cargo truck; (k) Mini & private cargo truck; (l) Heavy & new-registration cargo truck; (m) Small & new-registration cargo truck; (n) Mini & new-registration cargo truck; (o) Heavy & civil cargo truck; (p) Small & civil cargo truck; (q) Mini & civil cargo truck; (r) Car with capacity≤1L; (s) Car with capacity of 1-1.6L; (t) Car with capacity>1.6L; (u) Refit vehicle; (v) Motorcycle.

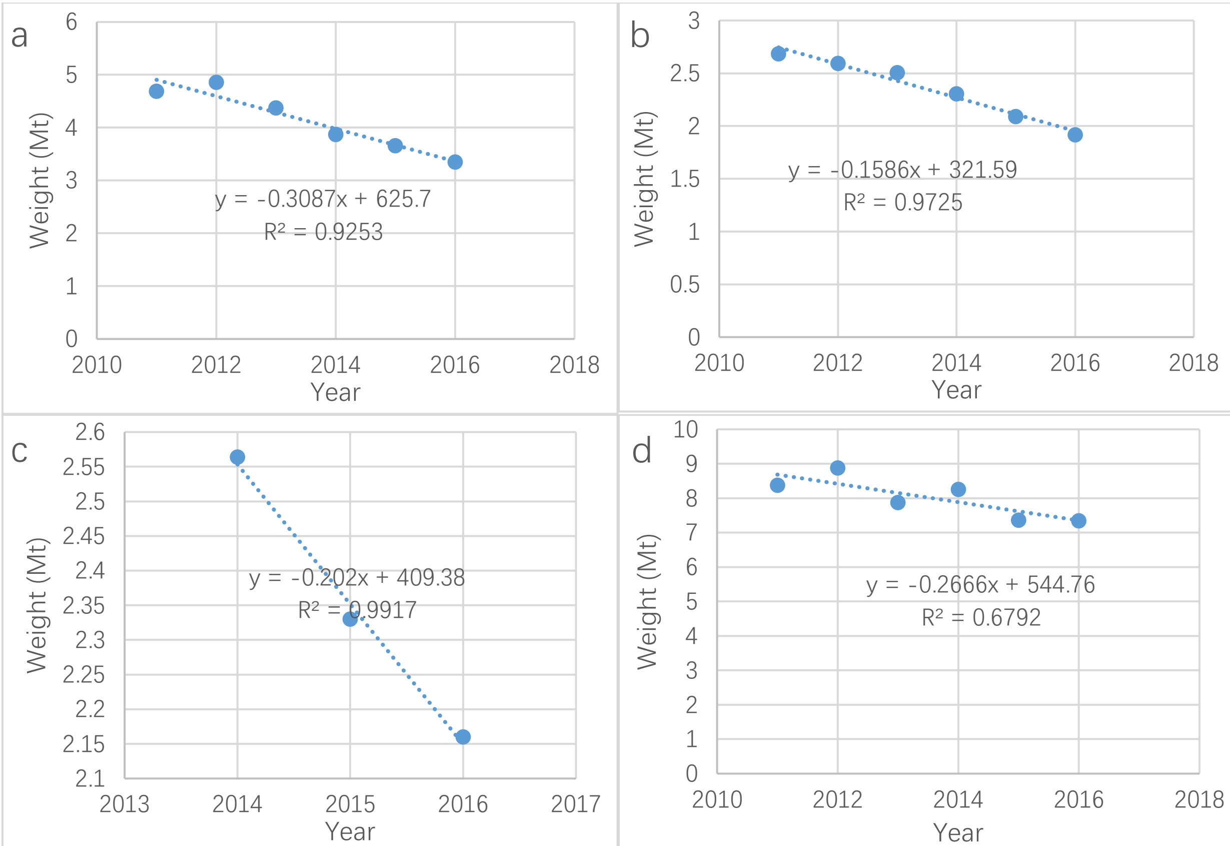



g
Generation amount (10^4)
Year
y = -7.4393x + 14977
R² = 0.9112
h
Generation amount (10^4)
Year
y = 7.891x - 15773
R² = 0.9712
i
Generation amount (10^4)
Year
y = 246.21x - 492077
R² = 0.9775
j
Generation amount (10^4)
Year
y = 2E-115e^0.1341x
R² = 0.9414
k
Generation amount (10^4)
Year
y = -7.4393x + 14977
R² = 0.9112
l
Generation amount (10^4)
Year
y = 7.891x - 15773
R² = 0.9712
m
Generation amount (10^4)
Year
y = 2E-115e^0.1341x
R² = 0.9414
n
Generation amount (10^4)
Year
y = -4.6156x + 9300.3
R² = 0.9672


o
y = 7.891x - 15773
R² = 0.9712
Generation amount (10⁴)
Year
p
y = 2E-115e^0.1341x
R² = 0.9414
Generation amount (10⁴)
Year
q
y = -7.4393x + 14977
R² = 0.9112
Generation amount (10⁴)
Year
r
y = 8.2033x - 16400
R² = 0.9351
Generation amount (10⁴)
Year
s
y = 252.54x - 504766
R² = 0.9467
Generation amount (10⁴)
Year
t
y = 26.324x - 52645
R² = 0.912
Generation amount (10⁴)
Year
u
y = 7.6147x - 15218
R² = 0.9343
Generation amount (10⁴)
Year
v
y = 240.56x - 480721
R² = 0.9531
Generation amount (10⁴)
Year

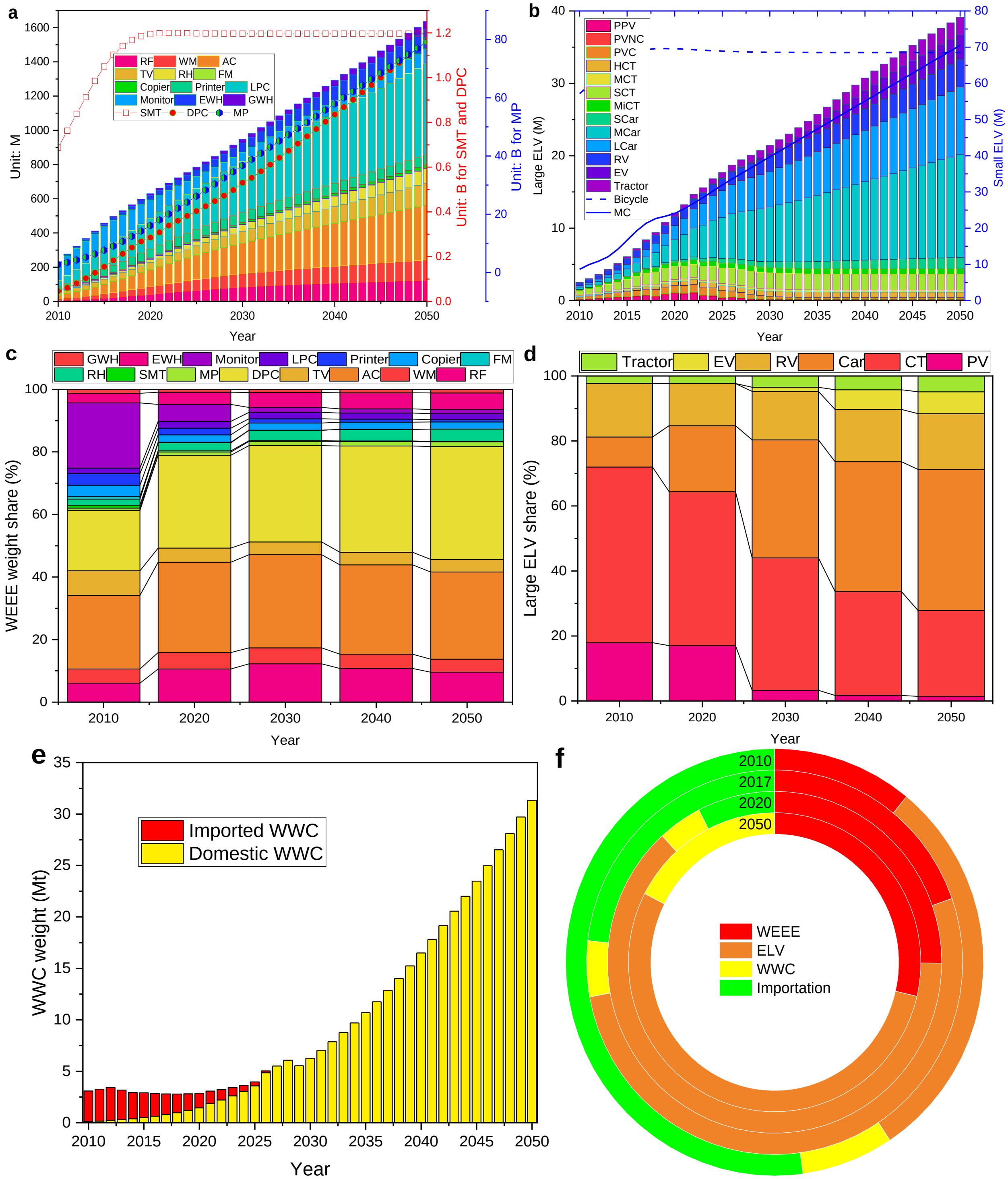
Supplementary Fig. 12 Linear regression of imported scraps for I'(x)

(a) Copper scrap; (b) Aluminum scrap; (c) Iron scrap; (d) Plastics scrap

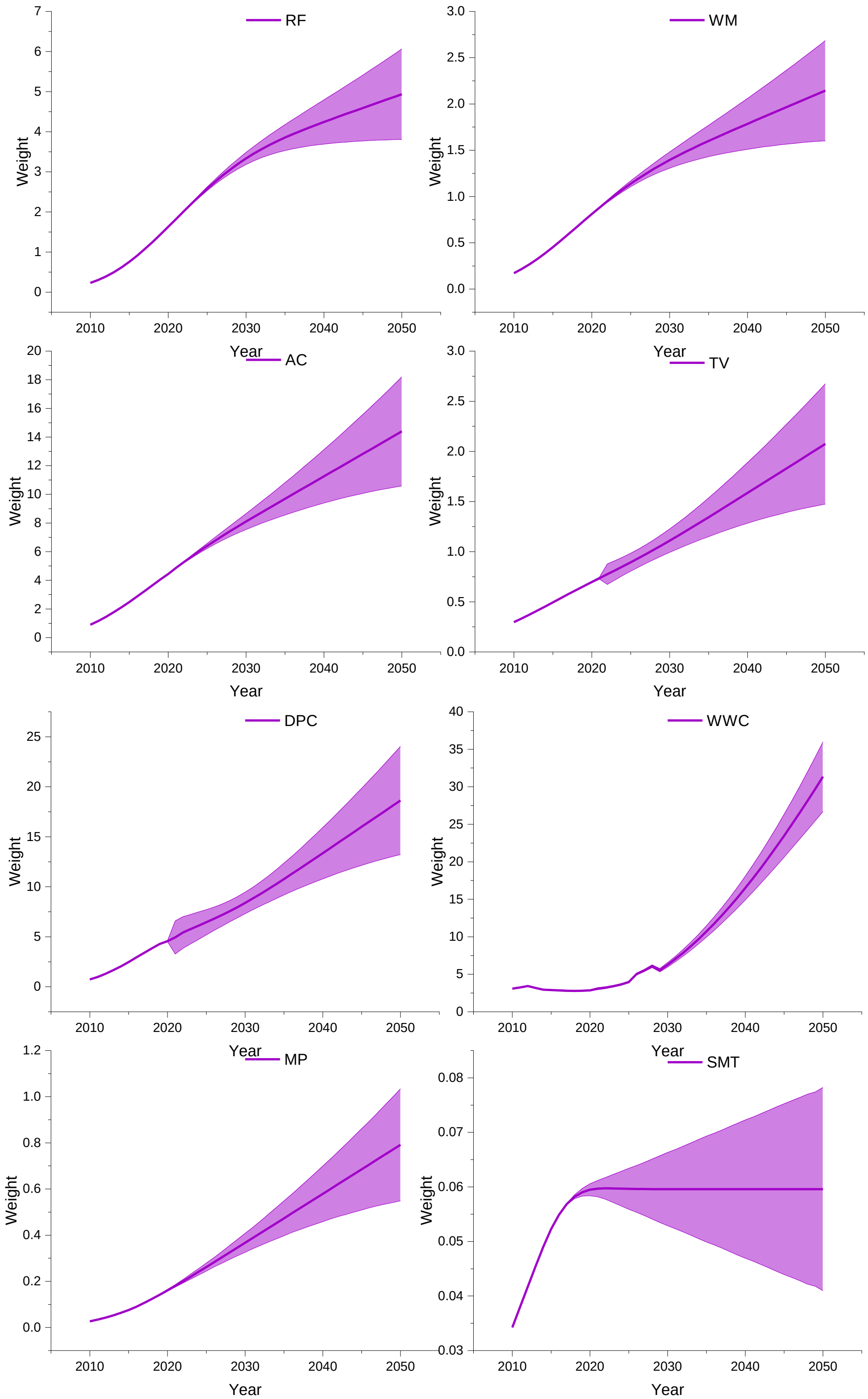


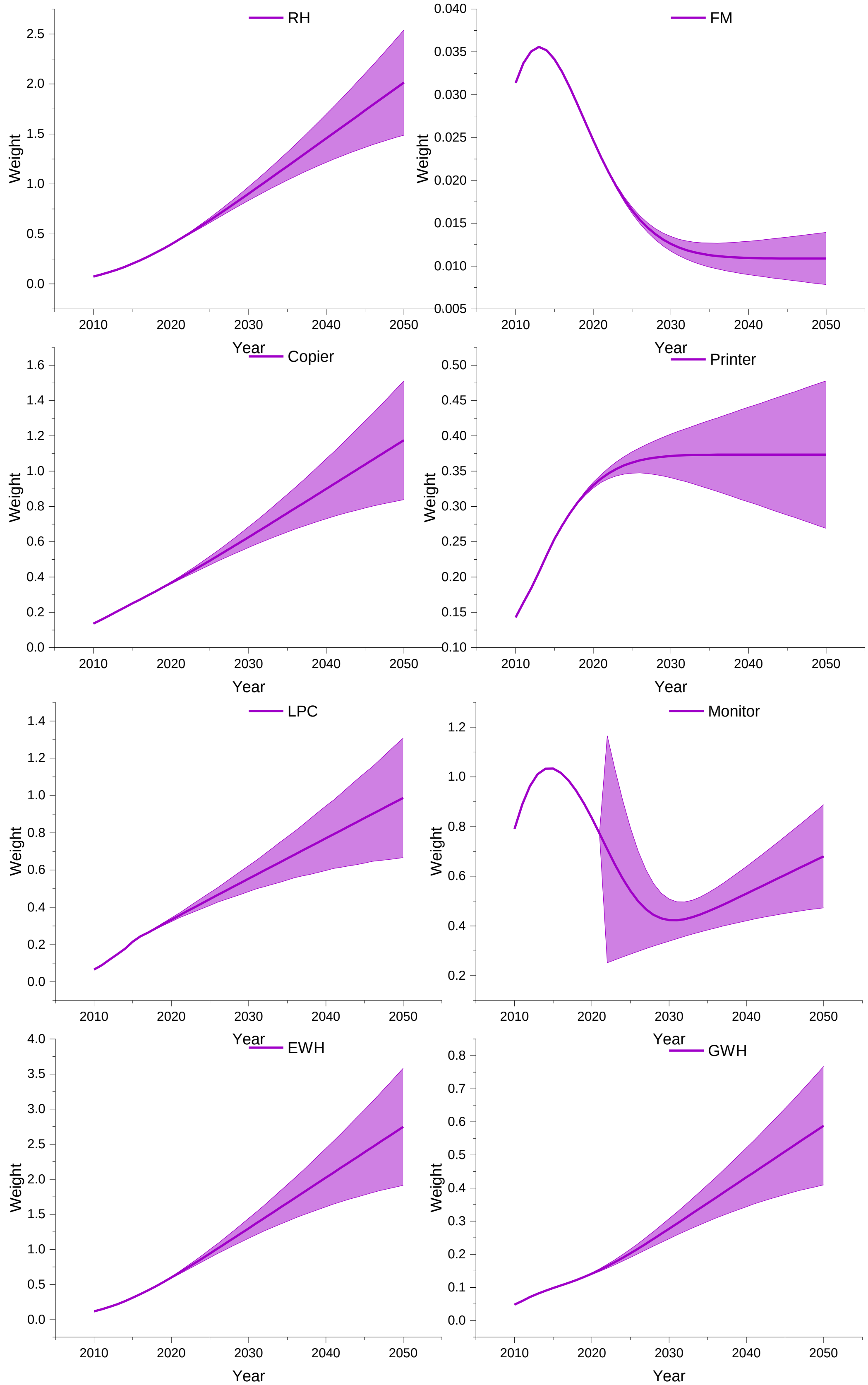
Supplementary Fig. 13A Estimation of China's AM from 2010 to 2050: Average value for *D*(*x*)

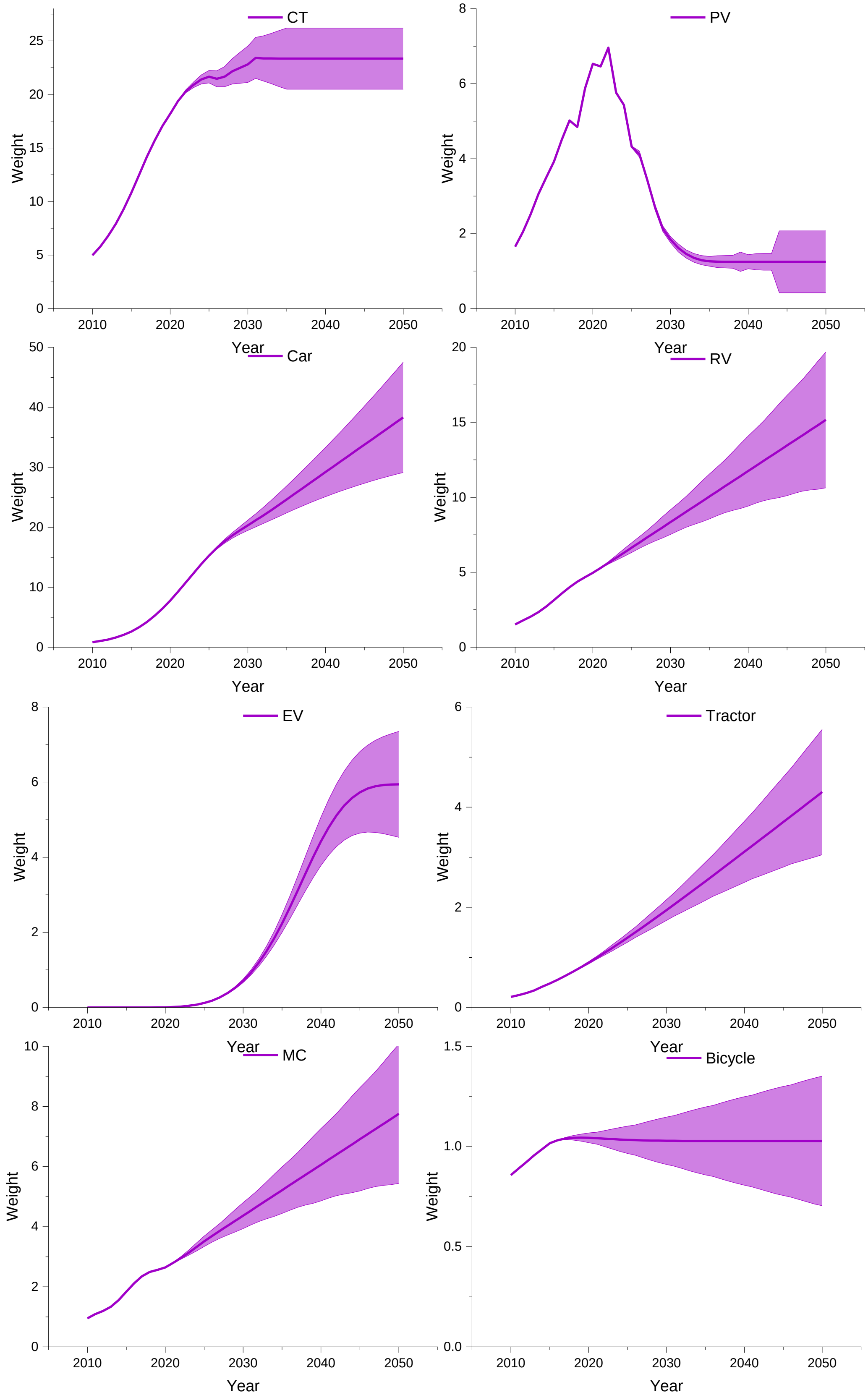
(a) WEEE quantity; (b) ELV quantity; (c) WEEE weight share; (d) ELV weight share; (e) WWC weight; (f) total weight share. Note: Large ELV consists of PPV, PVNC, PVC, HCT, MCT, SCT, MiCT, SCar, LCar, LCar, RV, EV, and tractor. Bicycle and MC are classified as small ELV.



Supplementary Fig. 13B Estimation of China's AM from 2010 to 2050: Range for $D(x)$ (Mt)



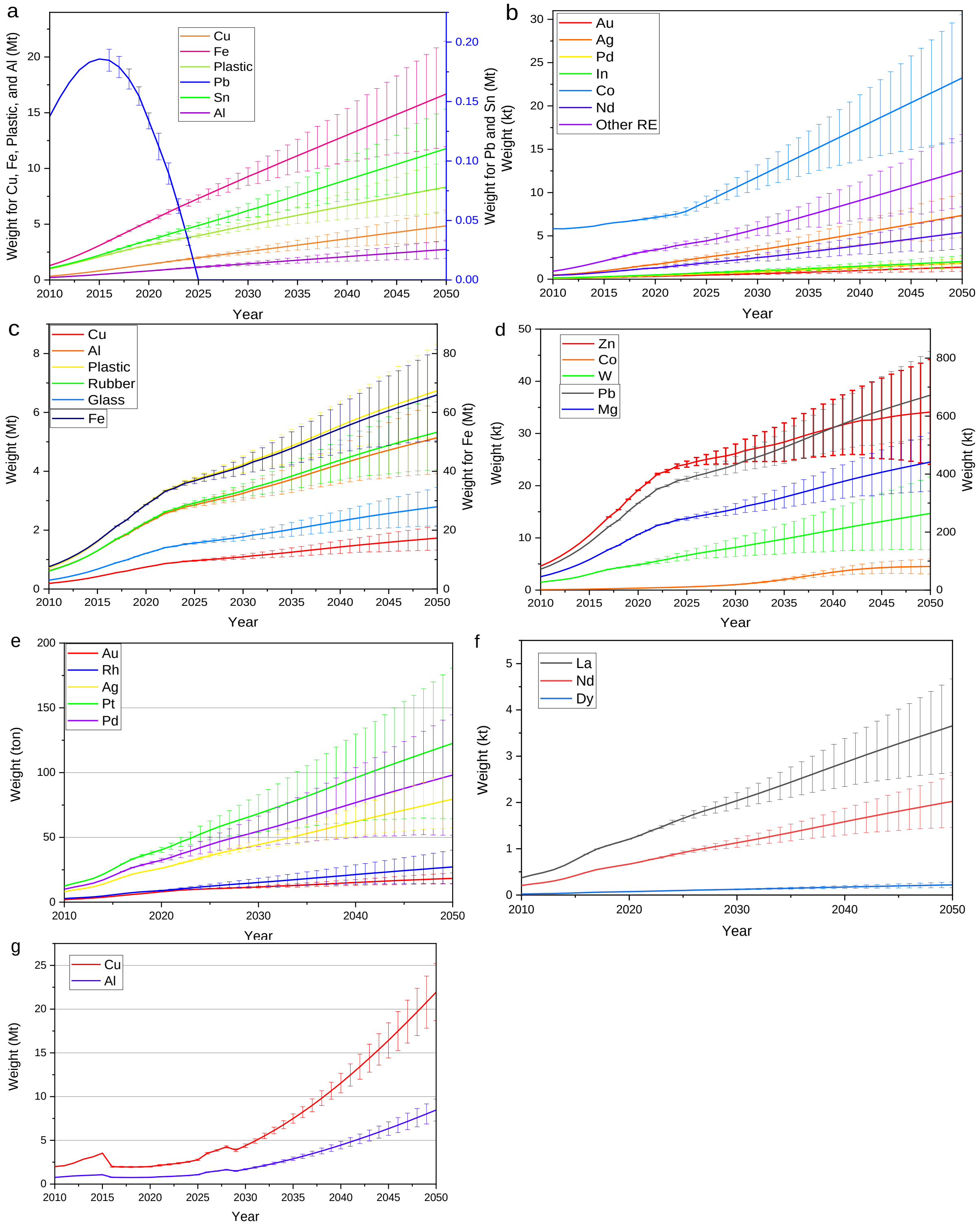

RH
Weight
0.0
0.5
1.0
1.5
2.0
2.5
Year
2010
2020
2030
2040
2050
FM
Weight
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
Year
Copier
Weight
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Year
Printer
Weight
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
Year
LPC
Weight
1.4
Year
Monitor
Weight
Year
EWH
Weight
3.0
3.5
4.0
Year
GWH
Weight
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Year



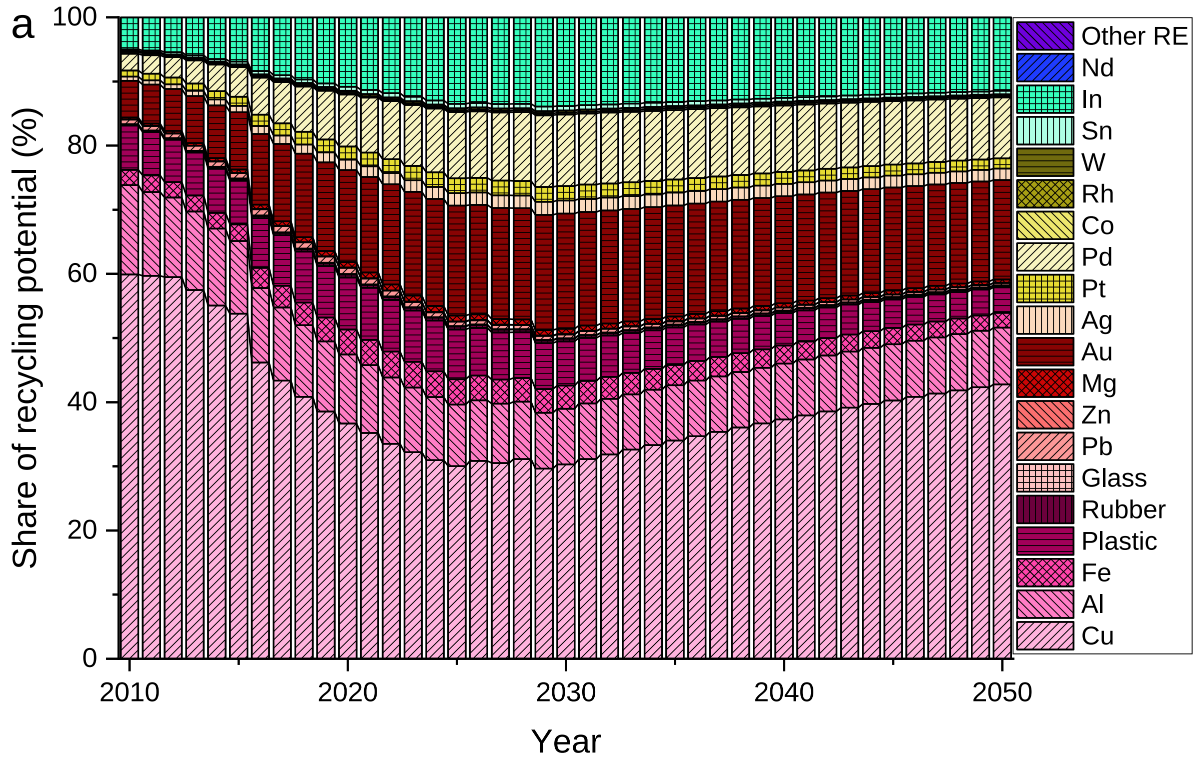
CT
Weight
Year
PV
Car
RV
EV
Tractor
MC
Bicycle

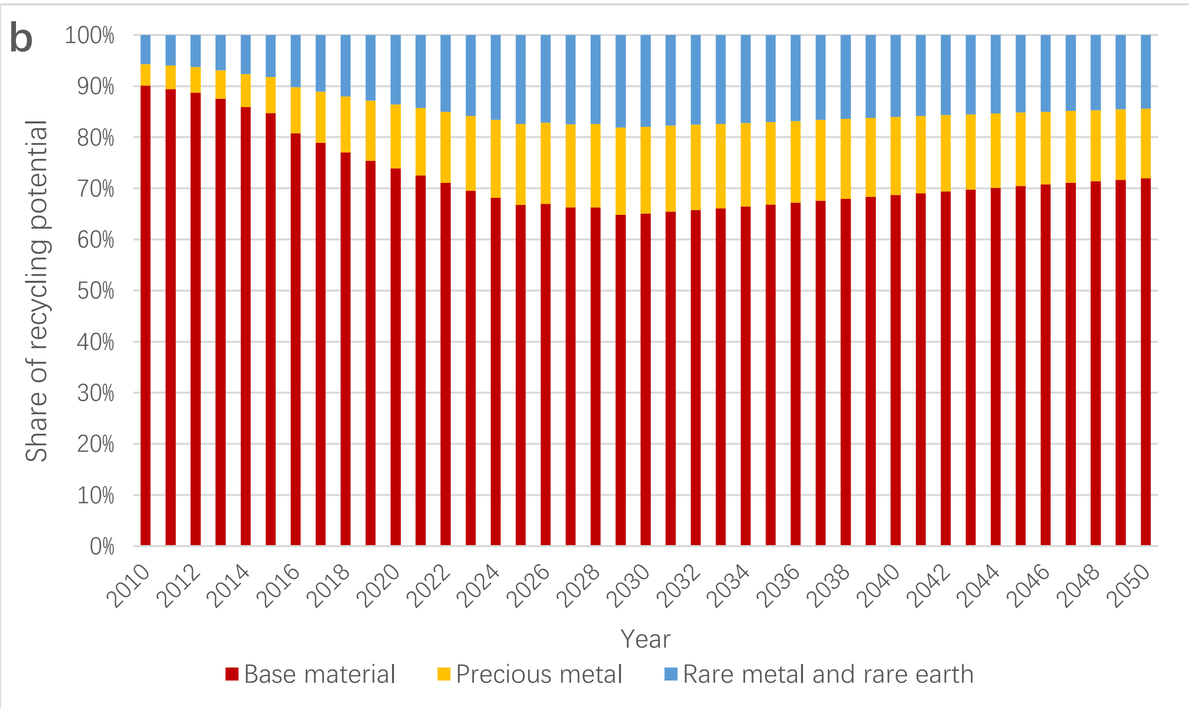
Supplementary Fig. 14 Resources weight in yearly-generated three AMs for $D_{m,j}$

(a) base materials in WEEE; (b) precious metals, rare metals, and rare earth in WEEE; (c) base materials in ELV; (d) Zn, Co, W, Pb, and Mg in ELV; (e) precious metals in ELV; (f) base materials in WWC.



Supplementary Fig. 15 Relative economic shares of materials in total AM





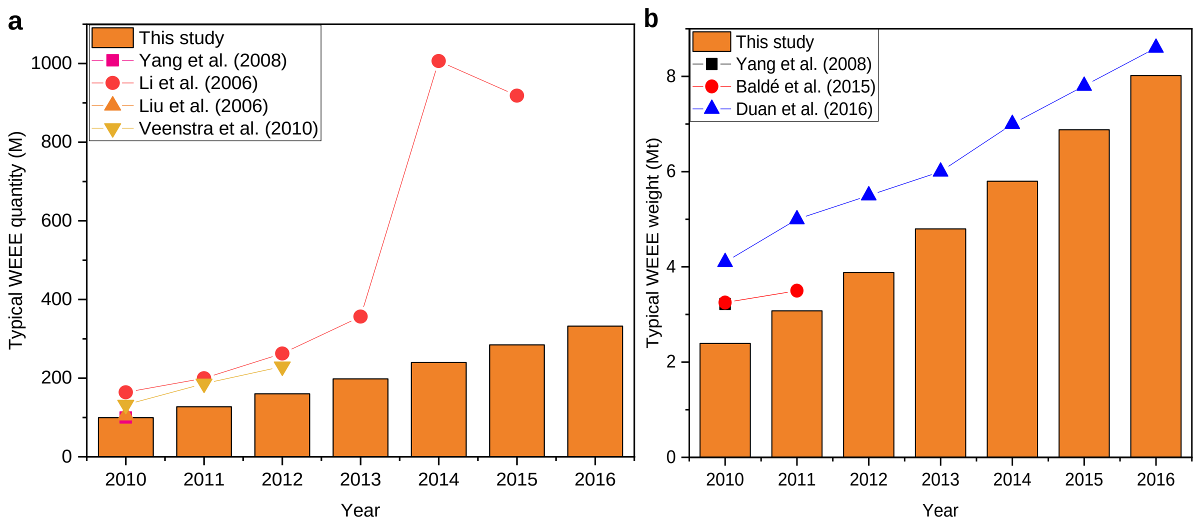
Note: Base material: Cu, Al, Fe, Plastic, Rubber, Glass, Pb, Zn, Mg, Co, and Sn; Precious metal: Au, Ag, Pt, Pd, and Rh; Rare metal and rare earth (RE): W, In, Nd, Dy, La, and other RE.

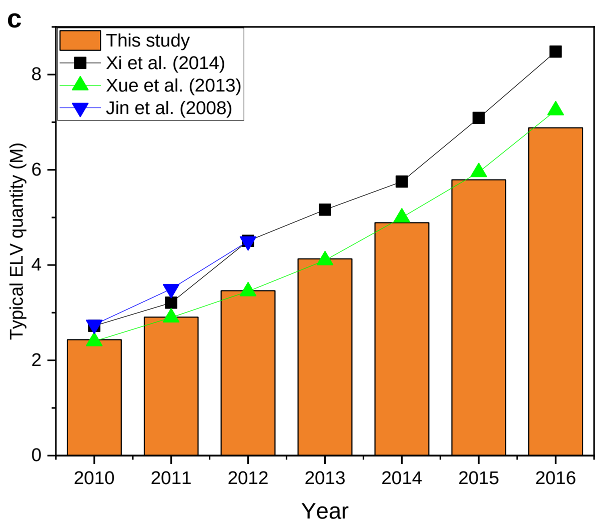
Supplementary Section 4: Comparison of this study to other studies

Regarding five typical types of WEEE (e.g., RF, WM, AC, TV, and PC), their quantity in the year of 2010-2016 without importation in this study is lower than the values from others previous studies (Supplementary Fig. 17). The difference can be attributed to two points of the previous works: old used data sources before 2010 and different forecasting methods. Moreover, in weight, the gaps among these studies are not significant. The bigger gap is from the result indicated by Duan et al. (2016), which is higher than this study because more types of WEEW were considered in Duan et al. (2016). Regarding typical ELV quantity, some previous works indicate no distinct difference to this study. The biggest difference is given from Xi et al. (2014) only using the simple linear regression (Supplementary Fig. 16). Additionally, the registered vehicle has been estimated in this study for further comparison with real value. They demonstrate the almost value without significant difference (Supplementary Fig. 17). All the discussions can verify and validate the above results of this study, and further consolidate the relevant results.

Supplementary Fig. 16 The comparison of typical AM estimation

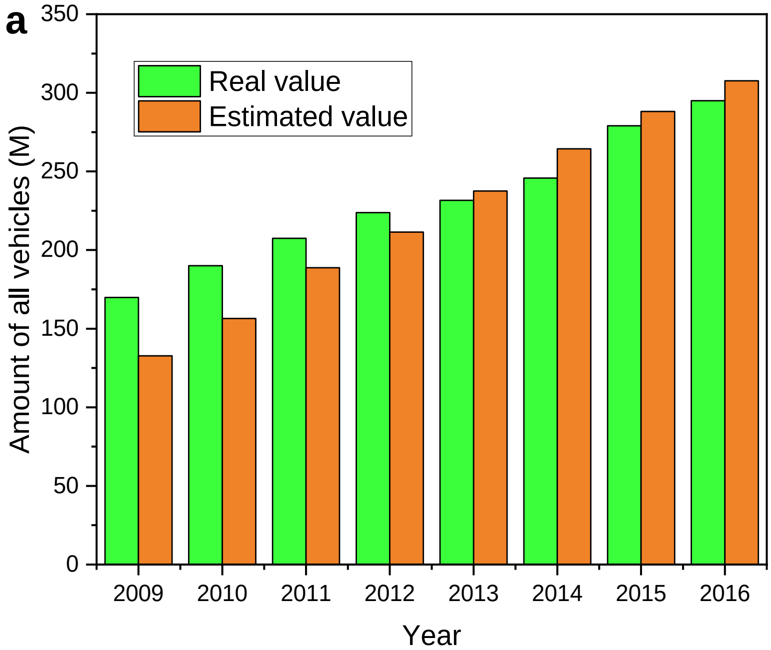
(a) Typical WEEE quantity; (b) Typical WEEE weight; (c) Typical ELV quantity. Note: Typical WEEE covered RF, WM, TV, PC, and AC; typical ELV covered passenger vehicle, cargo truck, car, and refit vehicle. Yang et al. (2008) [9], Li et al. (2006) [10], Liu et al. (2006) [11], Veenstra et al. (2010) [12], Baldé et al. (2015 & 2017) [13, 14], Duan et al. (2016) [15], Xi et al. (2014)[16], Xue et al (2013)[17], and Jin et al. (2008)[18].





Supplementary Fig. 17 Validation for all the registered vehicles quantity

(a) Comparison of estimated value in this study to real value; (b) significance test for real value and estimated value.



b	*t* Statistic	Degrees of freedom	Prob>|*t*|
Equal Variance Assumed	0.26019	14	0.79851
Equal Variance NOT Assumed (Welch Correction)	0.26019	12.3478	0.79901

Note: At 0.05 level, when equal variance is assumed, Mean 1 (real value) – Mean 2 (estimated value) is NOT significantly different from 0. And at 0.05 level, when variance is not assumed, Mean 1 (real value) – Mean 2 (estimated value) is NOT significantly different from 0.

Supplementary Table 1 *P*(*x*): Statistics of domestic production for EEE, vehicle, and wiring & cable in China

(a) EEE for the year of 1990-2016 (million unit, M)

Year	Refrigerator	Washing machine	Air conditioner	TV	Desktop PC	Laptop PC	Mobile phone	Camera	Digital camera	SMT	Fax machine	Copier	Printer	Monitor	Range hood	Electric water-heater	Gas water-heater
1990	4.6306	6.6268	0.2407	10.3304	0.0821	0	0	0	0	0	0	0	0	0	0	0	0
1991	4.6994	6.8717	0.6303	12.0506	0.1625	0	0	0	0	0	0	0	0	0	0	0	0
1992	4.8576	7.0793	1.5803	13.3308	0.1262	0	0	0	0	0	0	0	0	0	0	0	0
1993	5.9666	8.9585	3.4641	14.3576	0.1466	0	0	0	0	0	0	0	0	0	0	0	0
1994	7.6812	10.9424	3.9342	16.8915	0.2457	0	0	0	0	0	0	0	0	0	0	0	0
1995	9.1854	9.4841	6.8256	20.5774	0.8357	0	0	0	0	0	1.361	0	0	0	0	0	0
1996	9.7965	10.7472	7.8621	25.376	1.3883	0	0	0	0	0	1.379	0	0	0	0	0	0
1997	10.4443	12.5448	9.7401	27.1133	2.0655	0	0	0	0	0	1.625	0	0	0	0	0	0
1998	10.6	12.0731	11.5687	34.97	2.914	0	22.152	55.2187	0	0	1.287	0	0	0	0	0	0
1999	12.1	13.4217	13.3764	42.62	4.05	0	32.03	48.3229	0	0	1.6	0	0	0	0	0	0
2000	12.79	14.4298	18.2667	39.36	6.72	0	52.479	55.1452	0	39.36	1.9629	1.5663	17.991091	34.5092	3.6615	0	0
2001	13.5126	13.4161	23.3364	40.937	8.7765	0	80.317	59.6209	0	40.937	3.1819	1.4412	20.639945	38.2779	4.5628	1.533117	2.046028
2002	15.9887	15.9576	31.3511	51.55	14.6351	0	121.4635	53.0961	0	51.55	2.9729	2.0739	20.710473	52.2556	4.2646	2.091307	2.517558
2003	22.4256	19.6446	48.2086	65.414	32.167	14.352	182.3137	61.9814	0	65.414	7.4658	2.6417	30.68809	84.6903	4.7725	3.936664	3.273062
2004	30.0759	25.3341	63.9033	74.318	59.749	32.3838	237.5158	78.914	42.0759	74.318	8.5116	3.2457	49.769881	145.3358	6.7744	5.30086	5.302679
2005	29.8706	30.3552	67.6457	82.8322	80.8489	45.6499	303.5421	81.99	55.2297	82.8322	10.6815	4.0356	40.929867	105.1967	7.301	6.8243791	7.028524
2006	35.3089	35.605	68.4942	83.754	93.3644	62.4937	480.1379	85.5151	66.9511	83.754	11.8863	4.678	46.4027	133.5998	11.1807	10.765845	8.235657
2007	43.9713	40.051	80.1428	84.7801	120.7338	86.7143	548.5786	86.896	74.9346	84.7801	8.8853	4.5236	42.3469	144.3812	12.1688	15.175366	9.712175
2008	47.9995	44.47	81.474	91.871	158.5365	108.5868	559.451	89	81.8826	91.871	7.6991	5.8419	43.3398	133.6457	16.3315	17.196775	10.87103
2009	59.3045	49.7363	80.7825	98.9879	182.1507	150.0947	619.2447	84.5781	80.2632	98.9879	6.8351	4.2102	36.4082	131.2347	17.1448	14.682645	14.246062
2010	72.9572	62.4773	108.8747	118.3003	245.8446	185.8412	998.2736	93.277	91.285	118.3003	1.8109	5.3482	60.6876	139.2699	20.2833	18.728117	13.332711
2011	86.992	67.1594	139.125	122.3134	320.3693	238.9741	1132.5771	82.4134	80.5125	122.3134	2.6813	6.5505	55.1833	126.8054	20.3206	24.178	15.688
2012	84.27	67.9112	132.811	128.235	354.110	252.893	1181.545	88.0171	70.0707	128.235	2.6357	6.096	70.59	127.132	22.353	25.1263	11.2126

				2	2	7	7			2		9	21	7	7		
2013	92.6102	72.019	130.572	127.7605	336.61	272.7885	1455.61	46.9089	36.2014	127.7605	1.7208	6.354	73.7914	132.57	25.594	34.9255	12.023
2014	87.961		144.633	141.289	312.32	367.89	1712.6	31.23	24.675	122.8678	1.488	7.1286	66.011		30.8225	34.2968	14.7666
2015	79.9275	72.745	153.582	144.7573	389.02	312.59	1969.59	28.454	19.227	116.647	1.652	7.342	55.44		30.4639	36.355	15
2016	92.383	76.209	160.493	174.834	331.443	290.085	2261.087	23.0677	15.2727		1.763						17.7885

Source: http://data.stats.gov.cn/workspace/index?m=hgnd; http://mcin.macrochina.com.cn/index.shtml?ny=1.

(b) Vehicle for the year of 1991-2015 (M)

Year	Car			Passenger vehicle				Cargo truck				Refit vehicle	Motorcycle	Tractor	Bicycle	Electric vehicle
	Capacity≤ 1L	Capacity: 1-1.6L	Capacity>1.6L	Heavy	Middle	Small	Mini	Heavy	Middle	Small	Mini					
1991				0.00301	0.021417	0.131501	0.019814	0.019026	0.203951	0.179327	0.049719					0
1992				0.004407	0.033013	0.193899	0.041263	0.025391	0.259795	0.278526	0.062702					0
1993				0.00473	0.024367	0.191194	0.071922	0.033782	0.334656	0.330685	0.075745					0
1994				0.004062	0.019503	0.189272	0.104322	0.037173	0.313308	0.334706	0.100689					0
1995				0.003863	0.02274	0.22531	0.153541	0.030854	0.247982	0.331517	0.111469			0.063		0
1996				0.003632	0.018624	0.197549	0.175387	0.031655	0.211789	0.303422	0.141748			0.084		0
1997				0.004663	0.01593	0.189723	0.225299	0.030904	0.185726	0.297091	0.145597			0.082		0
1998				0.004215	0.011858	0.125502	0.179525	0.034829	0.183617	0.297351	0.145904			0.0678	23.1249	0
1999				0.006438	0.024562	0.154223	0.239677	0.047127	0.184738	0.386841	0.137606			0.0654	23.9757	0
2000				0.0064	0.029509	0.207579	0.334411	0.082146	0.146028	0.388831	0.134694			0.041	29.0679	0
2001				0.010028	0.046143	0.24032	0.424697	0.157405	0.151929	0.363234	0.130508	0.323372	9.959837	0.0382	29.0226	0
2002				0.014536	0.054294	0.279391	0.549422	0.255406	0.163902	0.525208	0.14803	0.390214	11.9857	0.0454	39.5752	0
2003	0.075697	1.005963	0.98914	0.019136	0.052128	0.435149	0.644553	0.261688	0.136218	0.687877	0.142374	0.372528	13.42259	0.0488	54.517	0
2004	0.159447	1.067311	1.049542	0.025435	0.0515	0.394235	0.744379	0.379713	0.161888	0.806607	0.166661	0.499501	14.61822	0.1138	79.0622	0
2005	0.197953	1.437731	1.134416	0.025617	0.056377	0.4775	0.736226	0.225951	0.198657	0.850102	0.235183	0.501938	15.95509	0.1633	69.0064	0
2006	0.199744	2.117571	1.552085	0.02908	0.059822	0.595112	0.844746	0.303592	0.201821	0.949368	0.298192	0.562731	20.69447	0.1993	78.8663	0
2007	0.225143	2.338379	2.234278	0.037447	0.071215	0.734243	0.906284	0.489883	0.23455	1.123163	0.309739	0.7435335	24.87791	0.2031	74.752	0
2008	0.27216	2.826435	1.939505	0.025993	0.047493	0.525344	0.650244	0.53604	0.206349	1.169278	0.35854	0.825816	27.51964	0.2844	63.7487	0
2009	0.516735	4.673203	2.294862	0.030239	0.051774	0.721923	1.272018	0.639885	0.269601	1.622068	0.517616	0.9375682	27.14695	0.3713	57.5765	0
2010	0.761608	5.998239	2.816053	0.036573	0.048826	0.150934	2.28352	1.058635	0.268982	1.972937	0.619809	1.119563	27.12393	0.3368	68.1948	0
2011				0.034522	0.042773	0.149679	2.044927	0.822696	0.294448	1.843632	0.490196		27.355	0.4019	71.6911	0.008368
2012				0.040923	0.046391	0.174186	2.456	0.59106	0.288719	1.827667	0.534284		26.0302	0.5273	76.1285	0.012552
2013				0.02026	0.022604	0.096539	1.481497	0.760581	0.285461	1.894993	0.527466		25.271	0.6656	75.4525	0.017533
2014				0.016468	0.015543	0.087754	1.467236	0.747451	0.247899	1.661643	0.538908		26.917	0.6437	79.1014	0.078499
2015				0.006819	0.00524	0.029915	0.762226	0.37055	0.114381	1.467718	0.538688		25.028	0.6882	68.8224	0.340471

(c) Wiring & cable for the year of 1996-2014 (M)

Year	Power cable (ton)	Aluminum cable copper reinforced (ton)	Optical communication cable (ton)	Telecommunication cable (ton)	Electromagnetic wire (ton)	Power cable (km)
1996	0.4					
1997	0.5					
1998	0.6					
1999	0.7					
2000	0.9					
2001	1.1074	0.5525				
2002	1.27355	0.663				
2003	1.51225	0.5729				
2004	2.34345	0.595				
2005	4.0621	0.7934				
2006	6.13955	0.926	3.799035	0.546176		
2007	6.8651	1.0776	5.738175	0.7015808		
2008	9.8214835	0.7092479	7.279485	0.6829728		
2009	10.693349	0.7379015	12.64163	0.4667144	1.15	
2010	13.6568295		14.13519	0.4153856	1.26	
2011	15.39685		20.69558	0.4354152	1.2843	27.0548
2012	20.00985		27.76274	0.3694528	1.3543	30.7937
2013	20.97332		34.08989	0.3460592	1.45	40.0197
2014	27.8518435		45.55677	0.3941632	1.55	55.7037

Supplementary Table 2 $I(x)$ and $E(x)$: Statistics of importation and exportation in China

(a) Product (M)

Year	EEE								Vehicle					Wiring & cable
	TV		SMT		Mobile phone		Camera	Copier	Truck	Automobile		Car	Bicycle	
	Importation	Exportation	Importation	Exportation	Importation	Exportation	Exportation	Importation	Importation	Importation	Exportation	Importation	Exportation	Exportation (ton)
1990	0.67						4.19							
1991	0.33						8.26		0.018578	0.098454		0.054409	7.29	
1992	0.23						29.23		0.041521	0.209992		0.027558	10.24	
1993	0.77						38.82		0.07257	0.310096		0.071125	10.32	
1994	0.75	10.79		72.6			43.21		0.067631	0.281425		0.034643	13.42	0.163
1995	1.16	11.51		76.12			61.5		0.011728	0.158115		0.023802	12.62	0.1985
1996	0.42	10.32		85.71			61.8		0.005916	0.07536	0.015	0.057942	12.17	0.2296
1997	0.43	9.06		100.11			65.59		0.006855	0.048441	0.0148	0.031944	14.39	0.3034
1998	0.31	10.21		106.86			67.33		0.004372	0.039711	0.0115	0.018046	17.61	0.3634
1999	0.26	12.98		134.22			59.51		0.002682	0.034906	0.008	0.019952	22.7	0.4382
2000	0.1	19.44		160.3	0.023712	160.3	90.73		0.003085	0.042371	0.0228	0.021614	32.86	0.5341
2001	0.09	21.03		148.97	0.037397	148.97	86.93		0.003138	0.072047	0.0248	0.046632	34.94	0.5447
2002	0.17	31.64		168.81	0.037674	168.8	91.56		0.006692	0.127367	0.0435	0.070326	45.56	0.6901
2003	1.01	47.62		193.27	0.033154	193.27	61.21		0.009769	0.172339	0.1322	0.103017	50.44	0.848
2004	0.78	63.09		199.02	0.027458	199	56.31		0.007989	0.175914	0.4014	0.116085	51.75	1.0771
2005	0.71	85.92		198.06	0.035923	198.06	45.93	1.025185	0.002928	0.16302	1.0809	0.076542	53.85	1.2341
2006	1.42	95.29	62.748928	693.2	0.036281	693.2	35.1	0.905703	0.00545	0.226922	0.3462	0.11178	55.99	1.4092
2007	1.21	51.03	18.734975	677.49	18.734975	677.49	21.25		0.007659	0.312085	0.61	0.139867	59.23	1.6172
2008	0.64	51.38	20.071491	700.23	20.071491	700.23	123.64		0.008719	0.40753	0.64	0.154521	56.59	1.69
2009	0.15	55.64	26.431385	712.11	26.431385	712.11	117.78		0.007143	0.418867	0.35	0.164837	46.11	1.43
2010	0.03	67.23	20.698023	903.95	20.698023	903.95	128.5		0.01335	0.810085	0.54	0.343653	58.16	1.74
2011	0.02	65.7	11.443807	1006.27	11.443807	1006.27	113.98		0.018034	1.035557	0.82	0.41027	55.72	1.8
2012	0.03	61.57	11.6741	1129.51	11.6741	1129.51	100.93		0.017998	1.129731	0.99	0.446783	57.15	1.86
2013	0.05	59.62	10.016117	1295.22	10.016117	1295.22	68.41		0.009418	1.192179	0.92	0.423399	56.95	1.95
2014	0.0606	74.0336	11.880918	1421.2255		1334	56.7588		0.009589	1.422717	0.8971	0.469617	62.655	2.1732
2015	0.0585	71.8342	18.492645	1445.5739			51.5947		0.004883	1.097418	0.7228	0.352461	57.8133	2.1675
2016							38.05							

Source: http://cndata.datesdata.com.cn/index.aspx;
http://data.stats.gov.cn/workspace/index;jsessionid=8506E2D79578DAE2FC42D18AE7790A9A?m=hgnd .

(b) Imported AM

Year	WEEE (kt) [8]		Copper scrap (Mt)	Aluminum scrap (Mt)	Steel scrap (Mt)	Plastics scrap (Mt)
	Estimation	Range*	Value	Value	Value	Value
2005			4.82	1.69		
2006			4.94	1.77		
2007			5.58	2.09	3.394	7
2008			5.58	2.15	5.589	7.07
2009			4	2.63	13.69	7.33
2010	877	[600-1500]	4.36	2.85	5.848	8.01
2011	808	[600-1500]	4.69	2.69	6.766	8.38
2012	738	[600-1500]	4.86	2.59	4.974	8.88
2013	669	[600-1500]	4.37	2.50	4.465	7.88
2014	600	600	3.87	2.31	2.564	8.26
2015	531	[0-600]	3.66	2.09	2.33	7.36
2016	462	[0-600]	3.35	1.92	2.16	7.35

Note: data of copper, aluminum, steel, and plastics scrap from National Statistics (http://data.stats.gov.cn/english/)

Supplementary Table 3 w_i: Weights of each product and those data distributions used for Monte Carlo simulation

(a) EEE (kg) [8]

Type	Mean	Stand. Dev.	Prob. Dist.	Type	Mean	Stand. Dev.	Prob. Dist.
CRT-TV	27.81	12.01	Beta	MP	0.100	0.023	Beta
CRT-BTV	10.274	1.752	Beta	SMT	0.498	0.114	Beta
RF	40.09	8.79	Beta	RH	23.57	4.21	Beta
MF	9.006	2.681	Beta	FM	6.785	2.437	Beta
LPC	1.858	0.681	Beta	Copier	60.80	37.77	Beta
WM	18.00	3.53	Beta	Printer	6.284	3.448	Beta
CRT-M	13.45	2.58	Beta	EWH	24.36	4.48	Beta
LCD-M	4.885	2.113	Beta	GWH	12.42	2.68	Beta
AC	44.90	20.40	Beta				

Note: LCD-TV: TV with liquid crystal display (LCD); CRT-CTV: color TV with cathode-ray tube (CRT); CRT-BTV: black TV with CRT; RF: refrigerator; MF: mainframe; LPC: laptop personal computer; WM: washing machine; CRT-M: CRT monitor used for mainframe; LCD-M: LCD monitor used for mainframe; AC: air conditioner; DPC: desktop personal computer; MP: mobile phone; SMT: single-machine telephone; RH: range hood; FM: fax machine; EWH: electric water-heater; GWH: gas water-heater.

(b) Vehicle [19]**(ton)**

Type	Mean	Range	Prob. Dist.	Type	Mean	Range	Prob. Dist.
LPV	14	[11-16]	Beta	Scar	0.5	[0-1]	Beta
MPV	8	[4-11]	Beta	Mcar	1.2	[1-1.4]	Beta
SPV	3	[2-4]	Beta	Lcar	2.2	[1.4-3]	Beta
MiPV	1	[0-2]	Beta	RV	4	[3-5]	Beta
HCT	16	[14-18]	Beta	EV	1.5	[1-2]	Beta
MCT	10	[6-14]	Beta	MC	0.11	[0.1-0.12]	Beta
SCT	3.4	[1.8-6]	Beta	Tractor	1.6	[1.2-1.9]	Beta
MiCT	0.9	[0-1.8]	Beta	Bicycle	0.015	[0.012-0.018]	Beta

Note: LPV: large passenger vehicle; MPV: medium passenger vehicle; SPV: small passenger vehicle; MiPV: mini passenger vehicle; HCT: heavy cargo truck; MCT: medium cargo truck; SCT: small cargo truck; MiCT: mini cargo truck; Scar: car with capacity≤1L; Mcar: car with capacity of 1-1.6L; Lcar: car with capacity>1.6L; RV: refit vehicle; MC: motorcycle; EV: electric vehicle.

Supplementary Table 4 c_{ij}: Average content of resources contained in various products

(a) WEEE [20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35]

Type	Valuable metals (%)			Precious metals (10^{-6})			Rare metals (10^{-6})		Rare earths (10^{-6})			Plastic	Glass
	Cu	Al	Fe	Au	Ag	Pd	In	Co	Nd	Y	Eu	(%)	(%)$^{\#}$
RF	3.4	1.1	50	0	0	0	0	0	0	0	0	43.3	2
WM	4	3	53	0	0	0	0	0	0	0	0	26	1
AC	18.5	7	45.9	0	0	0	0	0	0	0	0	17.5	0
CRT-TV	3	2	10	1.4	19.6	0.7	0	0	0	67.51*	5.47*	23	45
LCD-TV	1	4	30	0	0	0	102	0	0	0	0	40	18[36]
CRT-Desktop PC	6.5	2	26	46	207	18.4	0	0	170	4.40E-05*	3.56E-6*	23	40
LCD-Desktop PC	7.2	3.6	18	60	300	25	40	0	270	0	0	4.3	12
LPC	5.7	1.5	20	32	190	19	140	10700	360	0	0	16	20
MP	10.7	2.6	15	25	883	2.6	1102	3738	4500	39	42	25.6	10.6[37]
SMT	2	2	1	2.2	30.8	1.1	10000	0	0	0	0	69	0
FM	4	15	30	0	0	0	0	0	0	0	0	30	0
Copier	3.5	20	16	0	0	0	0	0	0	0	0	35.53	3
Printer	0.5	18	32	0	0	0	0	0	0	0	0	40	0
RH	10	8	30	0	0	0	0	0	0	0	0	5	2
EWH	5	10	35	0	0	0	0	0	0	0	0	5	2
GWH	8	10	30	0	0	0	0	0	0	0	0	5	2

Note: All the data is the average of all collected references; *Data source from Supplementary Table 5. All the data is assumed to fit for normal distribution. Tin composition of in e-waste; $^{\#}$Glass: 45% for CRT-TV was determined by China's recycler of e-waste recycling, and other data from personal estimation.

(b) WEEE: Tin content in the typical WEEE

Year	Country	WEEE	RF	WM	AC	TV	MP	Desktop PC	Laptop PC	Hardcopy peripherals	Tin solder weight (ton)	Tin weight in one-ton e-waste (kg)
		Each weight (kg)	40	18	44.9	27	0.1	20.45	1.875	40		
2015	China	Unit (M)	79.93	72.75	153.58	72.98	1969.59	467.14	312.59	62.78	84,952*	3.24
		Weight (Mt)	3.197	1.310	6.896	1.970	0.197	9.553	0.586	2.511		
2016	The U.S.	Unit (M)	10.9	16.41	6.87	39.68	226.17	17.87	45.22	26	3,812	1.05
		Weight (Mt)	0.436	0.295	0.308	1.071	0.023	0.365	0.085	1.040		
Average												2.14

Note: The data of each EEE weigh from Zeng et al. (2016)[3]; China's data for EEEs production amount from China Statistics; China's data for EEEs ship amount from China Statistics from www.statista.com; *361.9kt×48.6%×48.3%=84,952 ton[38]; 3,812 from USGS.

(c) WEEE: Content of other rare earths (Y and Eu) in CRT monitor (w.t. %)

Rare earth	Fluorescent powder							CRT**		
	Collected data						Average	CTV	BTV	PC
Y	12.35*	12.56*	13.53*	13.74[39]	19.83[40]	19.11[41]	15.19	0.006751111	8.10133E-06	4.40E-09
Eu	1.145*	1.13*	1.06*	1.374[40]	1.42[41]	-	1.23	0.000546667	0.000000656	3.56E-10

Note: *Data determined by Dr Quanyin Tan at Tsinghua University. **Data determined with the following information: each CRT contains 10-12g fluorescent powder [41] in around 27kg, 10kg, and 13.5kg for CRT-CTV, CRT-BTV, and CRT-M, respectively.

(d) Vehicle: collected data (w.t. %)[19, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52]

Resource	Collected data											Mean	Minimum	Maximum
Fe	71	69	64.3	65.4	68	60.6	70.4	68.3	68.76	65.4	67.7	60.6	67.2	71
Al	4	5	8	7.3	8	5.7	7.0	8.9				8	6.3	4

Cu	1.2	1										1	1.1	1.2
Pb	0.8											0.8	0.8	0.8
Zn	1	1										1	1	1
Plastics	6	7	9.3	9	12.1	10.8	9.1	8.17	9.3	7.8		6	8.86	12.1
Tire & rubber	4	4	5.6	5	5.1	3.42	5.6	4.2				3.42	4.62	5.6
Glass	3	3	2.7	3	2.9	3.1	2.9	2.8				2.7	2.93	3.1

Note: All the data is assumed to fit for normal distribution. The average weight of power battery was 275kg, 235kg, 550kg, and 1900kg for each plug-in passenger vehicle, plug-in commercial vehicle, pure electric passenger vehicle, and pure electric commercial vehicle, respectively (http://auto.gasgoo.com/News/2017/07/040628202820700169964C501.shtml).

(e) Vehicle: composition in various vehicle (%)

Resource	Cu	Al	Fe	Au	Pb	Plastic	Zn	Mg	Rubber	Glass	Co*
PV	1.8	5	69	0.00002	0.8	7	0.05	0.5	5.1	3	-
CT	1.8	5	68	0.00002	0.8	7	0.05	0.5	5.1	3	-
Car	1.8	5	69	0.00002	0.8	7	0.05	0.5	5.1	3	-
RV	1.8	5	68	0.00002	0.8	7	0.05	0.5	5.1	3	-
EV	2	5	68	0.00002	0.8	7	0.05	0.5	5.1	3	0.102
Tractor	1.2	5	68	0	0	7	0.05	0.5	6.6	1	-
MC	2	8	60	0.00002	0	7	0	0	9	3	-
Bicycle	1	10	82	0	0	1	0	0	6	0	-

Note: Data from Supplementary Table 4d and personal estimation. *Since cobalt is used in power battery for EV, its composition in EV will be 0.92%×60%×(275+235+550+1900)/(4×4000)= 0.102% [0.92% is the composition of cobalt in MnNiCo cathode material (http://wemedia.ifeng.com/10681129/wemedia.shtml); 60% is the cathode material composition in EV battery)[24]; (275+235+550+1900)/(4×4000) is the average battery weight share in each EV]; Cobalt content in other vehicle is given in Table 4g.

(f) Vehicle: Mass content of W, Pt, Pd, and Rh in each vehicle (g/car)

Material	Year	Region	Total consumption quantity	Vehicle share	Vehicle production quantity	Consumption quantity in each vehicle (g)

			(ton)	(%)	(k)*	
W	2000	The U.S.	14,890[53]	4.8[53]	12,774	56
	2016	World	86,400[54]	23[54]	94,031	211.3
	Average					134
Pt	2013	World	97.2 ton		86,953	1.118
Pd			77.8 ton			0.895
Rh			21.6 ton			0.248

Note: *data source from https://www.bts.gov/archive/publications/national_transportation_statistics/table_01_23; In 2013, around 97.2 ton, 77.8 ton, and 21.6 ton were globally utilized for Pt, Pd, and Rh, respectively in vehicle industry (http://www.hysec.com/f/tsnr/[D2014]/2014-12/TSNR100/23/RR_3003029292.pdf), which is used as catalyst to emission controlling. Because the world production quantity was 86,953,000 unit, each vehicle will consume 1.118g Pt, 0.895g Pd, and 0.248g Rh.

(g) Vehicle: Mass content of other critical metals in an average ELV (g/car)

Metal	min	average	max	**Metal**	min	average	max	**Metal**	min	average	max
Dy	1.443256	2.013372	3.23657	**Nd**	14.06395	18.4593	24.49419	**Ag**	0.477907	0.725	1.136047
La	24.44767	33.33721	45.83721	**Co**	23.67442	31.93023	44.88372	**Sn (%)**	0.0015	0.0019	0.0023

Note: personal calculation based on the data[55].

(h) Copper and aluminum consumption in wiring & cable (kt) [56, 57]

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Cu	700	780	840	950	1140	1230	1300	1430	1500	1720	2000	2100	2400	2850	3120	3540
Al	220	220	240	250	270	280	320	350	430	580	760	850	930	980	1020	1070

Supplementary Table 6 Resource market prices in recent years (US$/ton)

Resource	Min	Max	Mean	Error
Ag	0.5×10^{6}	1.55×10^{6}	1.03×10^{6}	$\pm0.53\times10^{6}$
Al	1.3×10^{3}	3.3×10^{3}	2.3×10^{3}	$\pm1\times10^{3}$
Au	34×10^{6}	60×10^{6}	47×10^{6}	$\pm13\times10^{6}$
Co	2.3×10^{4}	5.2×10^{4}	3.75×10^{4}	$\pm1.45\times10^{4}$
Cu	2.8×10^{3}	1×10^{4}	6.4×10^{3}	$\pm3.6\times10^{3}$
Dy	2.62×10^{5}	2.92×10^{5}	2.77×10^{5}	$\pm3\times10^{4}$
Fe	51	188	120	±68
Glass	26	46	36	±10
In	13×10^{6}	35×10^{6}	24×10^{6}	$\pm11\times10^{6}$
La	4.6×10^{3}	5.4×10^{3}	6.1×10^{3}	$\pm1.4\times10^{3}$
Mg	4×10^{3}	6×10^{3}	5×10^{3}	$\pm1\times10^{3}$
Nd	6×10^{4}	1.05×10^{5}	1.5×10^{5}	$\pm9\times10^{4}$
Pb	882	3.6×10^{3}	2.21×10^{3}	$\pm1.36\times10^{3}$
Pd	14×10^{6}	28×10^{6}	21×10^{6}	$\pm7\times10^{6}$
Plastics*	750	1.03×10^{3}	890	±140
Pt	1.9×10^{6}	5.1×10^{6}	3.5×10^{6}	$\pm1.6\times10^{6}$
Sn	14×10^{3}	25×10^{3}	20×10^{3}	$\pm5.5\times10^{3}$
Rh	1.3×10^{6}	3×10^{6}	2.2×10^{6}	$\pm0.9\times10^{6}$
Rubber	160	260	210	±50
W	6×10^{3}	1.4×10^{4}	1×10^{4}	$\pm4\times10^{3}$
Y/Eu	190	210	200	±10
Zn	1.5×10^{3}	2.8×10^{3}	2.2×10^{3}	±650

Note: Mean is the average of Min and Max. Error = (Max - Min)/2. Data source from London Metal Exchange (http://www.lme.com), and InvestmentMine (http://www.infomine.com); * Source from six-month operation of a recycling plant in China.

Supplementary Table 7 Previous applications of various methods for predicting AM generation

Method	Utilizations
Market supply method	Fluorescent lamp [58]; Refrigerator [59]
Market supply method A	Mobile phone [60]; liquid crystal display [61]
Stanford method	Computer [62]; printer [63]
Consumption and use approach	Mobile phone [60]
Time-step method	Computer [59]; Lithium battery [64]
Stock-based model	Household appliances [65]
Material flow analysis method	WEEE/E-waste [66]

Supplementary Table 8 Data demand's comparison of various methods for AM prediction [60]

	Other designation	Sales (production, import and export)	Lifetime distribution	Possession	Historical collected/ generation amount	Saturation factor	Substitution effect	Influential factors	Econometric indicators
Market supply method	Classic market supply method/sales/simple delay	√	√						
Market supply A method	Distribution delay	√	√						
Stanford method		√	√						
Carnegie Mellon method		√	√						
Consumption and use approach	Approximation/ estimate formula/batch leaching		√	√					
Time-step method		√		√	√				
MFA method		√		√					
ICER model		√				√			
Use-phase analysis			√	√			√		
Time-series model	Projection				√				
Factor model					√			√	
Econometric analysis									√
Direct waste analysis	Waste facility record compilation/disposal related analysis				√				

Supplementary Table 9 w_i: Estimation of average PC weight

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CRT (%)	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0	0
LCD (%)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	100
PC weight (kg)	**20.1**	**19.8**	**19.5**	**19.1**	**18.8**	**18.5**	**18.2**	**17.8**	**17.5**	**17.2**	**16.8**	**16.5**	**16.2**	**15.9**	**15.5**	**15.2**	**14.9**	**14.5**	**14.2**	**13.9**	**13.9**

Note: The market share of CRT used in PC is gradually shrinking, and CRT will not be utilized for PC in 2019.

Supplementary Table 10 w_i: Estimation of average TV weight

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CRT (%)	95	90	80	70	60	50	40	30	20	10	0
LCD (%)	5	10	20	30	40	50	60	70	80	90	100
TV weight (kg)	**27.3**	**26.8**	**25.8**	**24.9**	**23.9**	**22.9**	**21.9**	**20.9**	**20.0**	**19.0**	**18.0**

Note: The market share of CRT used in TV is also gradually shrinking, and CRT will not be utilized for TV in 2010.

Supplementary Table 11 Prohibitive imported directory of solid waste and their implemented time

NO	Solid waste catalog	Implemented time	NO	Solid waste catalog	Implemented time	NO	Solid waste catalog	Implemented time
Ⅰ. Waste plant and animal products			51	Waste acid lotion and waste oil	Dec., 31, 2017	99	Cr scrap	Dec., 31, 2017
1	Waste hair of people	Dec., 31, 2017	52	Organic-containing chemical waste	Dec., 31, 2017	100	Be scrap	Dec., 31, 2017
2	Pig hair scrap	Dec., 31, 2017	53	Other chemical waste	Dec., 31, 2017	101	Cr scrap	Dec., 31, 2017
3	Animal hair scrap	Dec., 31, 2017	54	Other unlisted chemical waste	Dec., 31, 2017	102	Tl scrap	Dec., 31, 2017
4	Feather scrap	Dec., 31, 2017	55	Sludge	Dec., 31, 2017	103	In scrap	Dec., 31, 2017
5	Bone scrap containing ingredients of cattle and sheep	Dec., 31, 2017	56	Medical waste	Dec., 31, 2017	104	Wooden scrap	Dec., 31, 2019
6	Other bone scrap	Dec., 31, 2017	VI. Plastic scrap and heels			105	Soft wood scrap	Dec., 31, 2019
7	Animal tooth scrap	Dec., 31, 2017	57	Ethylene polymer plastic scrap and heels	Dec., 31, 2018	106	Stainless steel scrap	Dec., 31, 2019
8	Waste horse hair	Dec., 31, 2017	58	Aluminum-plastic composite membrane	Dec., 31, 2018	107	W scrap	Dec., 31, 2019
9	Oil tanning reclaimed grease	Dec., 31, 2017	59	Butyl acrylate-methacrylic acid-styrene polymer plastic scrap and heels	Dec., 31, 2018	108	Mg scrap	Dec., 31, 2019
10	Cane Molasses	Dec., 31, 2017	60	Vanadium-containing (20% ≥ V_2O_5>10%) slag ore, ash, and residue	Dec., 31, 2018	109	Bi scrap	Dec., 31, 2019
11	Other molasses	Dec., 31, 2017	61	PET scrap and heels	Dec., 31, 2018	110	Ti scrap	Dec., 31, 2019
II. Slag ore, ash, and residue			62	Waste PET bottle	Dec., 31, 2018	111	Zr scrap	Dec., 31, 2019

12	Slag ore	Dec., 31, 2017	63	Other plastic scrap and heels	Dec., 31, 2018	112	Ge scrap	Dec., 31, 2019
13	Bitumen crushed stone	Dec., 31, 2017	64	Discarded CD-ROM breakage	Dec., 31, 2018	113	V scrap	Dec., 31, 2019
14	Mica scrap	Dec., 31, 2017	VII. Waste rubber and leather			114	Nb scrap	Dec., 31, 2019
15	Waste Mg brick	Dec., 31, 2017	65	Waste tire and cutting material	Dec., 31, 2017	115	Hf scrap	Dec., 31, 2019
16	Mn-containing slag from iron and steel smelting	Dec., 31, 2017	66	Waste vulcanized rubber	Dec., 31, 2017	116	Ga & Re scrap	Dec., 31, 2019
17	Other slag from iron and steel smelting	Dec., 31, 2017	67	Un-vulcanized rubber scrap and heel	Dec., 31, 2017	117	Granular or powdered tungsten carbide scrap	Dec., 31, 2019
18	Vanadium-containing slag (V_2O_5>20%) from iron and steel smelting	Dec., 31, 2017	68	Waste hard rubber	Dec., 31, 2017	118	Other tungsten carbide scrap	Dec., 31, 2019
19	Other vanadium slag from iron and steel smelting	Dec., 31, 2017	69	Waste leather residue, ash, sludge and powder	Dec., 31, 2017	119	Scrap car press	Dec., 31, 2018
20	Other slag ore, ash, and residue from iron and steel smelting	Dec., 31, 2017	70	Leather heel	Dec., 31, 2017	120	Recycling of scrap metal and electrical appliances mainly to recover iron and steel scrap hardware and electrical appliances	Dec., 31, 2018
21	Hard zinc-containing slag ore, ash, and residue	Dec., 31, 2017	VIII. Waste paper and cardboard			121	Waste motor based on recovery of Cu	Dec., 31, 2018
22	Other zinc-containing slag ore, ash, and residue	Dec., 31, 2017	71	Waste wall paper, wax coated paper, paraffin paper, carbon paper	Dec., 31, 2017	122	Waste wiring based on recovery of Al	Dec., 31, 2018
23	Lead silt containing slag	Dec., 31, 2017	72	Other waste paper	Dec., 31, 2017	123	Hulk	Dec., 31, 2018

24	Other lead-containing slag ore, ash, and residue	Dec., 31, 2017	IX. Waste textile raw materials and products			XII. Waste battery		
25	Copper-containing slag ore, ash, and residue	Dec., 31, 2017	73	The falling hair of other animals	Dec., 31, 2017	124	Scrap battery and waste battery	Dec., 31, 2017
26	Al-containing slag ore, ash, and residue	Dec., 31, 2017	74	Other animal fine wool waste	Dec., 31, 2017	X III. WEEE and its components & parts		
27	As/Hg/Tl-containing slag ore, ash, and residue	Dec., 31, 2017	75	Other animal coarse wool waste	Dec., 31, 2017	125	Waste computer and office WEEE	Feb., 1, 2000
28	Sb/Be/Cd/Cr-containing slag ore, ash, and residue	Dec., 31, 2017	76	Recovered fiber from animal fine/coarse wool	Dec., 31, 2017	126	Home WEEE	Feb., 1, 2000
29	Other W-containing slag ore, ash, and residue	Dec., 31, 2017	77	Waste cotton yarn	Dec., 31, 2017	127	Waste communication equipment	Feb., 1, 2000
30	Vanadium-containing (V_2O_5>20%) slag ore, ash, and residue	Dec., 31, 2017	78	Cotton recovered fiber	Dec., 31, 2017	128	Waste audio-visual products and radio and television equipment and signaling devices	Feb., 1, 2000
31	Cu-containing (>10%) residue from Cu smelting	Dec., 31, 2017	79	Other waste cotton	Dec., 31, 2017	129	Discarded game machine	Feb., 1, 2000
32	Other metals or compound slag ore, ash, and residue	Dec., 31, 2017	80	Synthetic fiber waste	Dec., 31, 2017	130	Discarded lighting equipment	Feb., 1, 2000
33	Ash and residue from MSW incineration	Dec., 31, 2017	81	Man-made fiber waste	Dec., 31, 2017	131	Discarded electronics components	Feb., 1, 2000
34	Seaweed ash or other ash	Dec., 31, 2017	82	Used cloth	Dec., 31, 2017	132	Discarded medical equipment and radiographic application equipment	Feb., 1, 2000
35	Other slag ore and ash	Dec., 31, 2017	83	Woven fabric made of broken fabrics	Dec., 31, 2017	133	Other WEEE	Feb., 1, 2000

36	PCB and PBB-containing waste oil	Dec., 31, 2017	84	Other waste fabrics	Dec., 31, 2017	X IV. Others		
37	Other waste oil	Dec., 31, 2017	85	Other woven fabrics made of textile materials	Dec., 31, 2017	134	Waste gypsum	Dec., 31, 2017
38	Residue of other mineral oil	Dec., 31, 2017	86	Other waste fabrics	Dec., 31, 2017	135	Asbestos	Dec., 31, 2017
39	Granular slag produced by smelting iron and steel (Mn>25%)	Dec., 31, 2018	X. Waste glass			136	Waste ceramic fiber similar to the physical and chemical properties of asbestos	Dec., 31, 2017
40	Oxide skin produced by rolling steel	Dec., 31, 2018	87	Scrap glass	Dec., 31, 2017	137	Used plastic bags, membranes, nets, and used plastic plastic films and used agricultural plastic hoses collected from home or from domestic waste	Dec., 31, 2017
41	Granular slag produced by smelting iron and steel (Fe>80%)	Dec., 31, 2018	XI. Waste of metal and metal compounds			138	Waste fishing net	Dec., 31, 2017
42	Polysilicon scrap (SI>99.9999999%)	Dec., 31, 2017	88	Ash containing silver or silver compounds	Dec., 31, 2017	139	Waste woven bags and waste sacks	Dec., 31, 2017
43	Other silicon scrap (SI≥99.99%)	Dec., 31, 2017	89	Ash containing other precious metals or its compounds	Dec., 31, 2017	140	Waste paint and waste paint	Dec., 31, 2017
IV. Waste drug			90	Scrap containing Au or Au compounds	Dec., 31, 2017	141	Bamboo fiber waste and leftover	Dec., 31, 2017
44	Waste drug	Dec., 31, 2017	91	Scrap containing Ag or Ag compounds	Dec., 31, 2017	142	Finished waste silicon wafer	Dec., 31, 2017

V. Mixed chemical waste			92	Scrap containing other precious metals or their compounds	Dec., 31, 2017	143	Chorionic waste	Dec., 31, 2017
45	Residual alkali solution of wood pulp	Dec., 31, 2017	93	Sedimentary copper	Dec., 31, 2017	144	Sulphur silt	Dec., 31, 2017
46	MSW	Dec., 31, 2017	94	Lead scrap	Dec., 31, 2017	145	Waste phosphor	Dec., 31, 2017
47	Sludge	Dec., 31, 2017	95	Molybdenum scrap	Dec., 31, 2017	146	Nickel-containing slag, ash and residue	Dec., 31, 2017
48	Medical waste	Dec., 31, 2017	96	Cobalt matte scrap	Dec., 31, 2017	147	Vanadium-containing waste catalyst	Dec., 31, 2017
49	Waste organic solvent	Dec., 31, 2017	97	Cd scrap	Dec., 31, 2017	148	Discarded sleepers	Dec., 31, 2017
50	Other waste organic solvent	Dec., 31, 2017	98	Sb scrap	Dec., 31, 2017	149	Other listed waste	Dec., 31, 2017

Note: Data source from MEE (2017, 2018) [67, 68].

Supplementary Table 12 *I*(*x*): Estimation and range of imported AM in 2010-2050

(a) WEEE (kt) [8]

Year	Estimation	Range*	Year	Estimation	Range	Year	Estimation	Range	Year	Estimation	Range
2010	877	[600-1500]	**2021**	115	[0-600]	**2031**	0	[0-600]	**2041**	0	[0-600]
2011	808	[600-1500]	**2022**	46	[0-600]	**2032**	0	[0-600]	**2042**	0	[0-600]
2012	738	[600-1500]	**2023**	0	[0-600]	**2033**	0	[0-600]	**2043**	0	[0-600]
2013	669	[600-1500]	**2024**	0	[0-600]	**2034**	0	[0-600]	**2044**	0	[0-600]
2014	600	600	**2025**	0	[0-600]	**2035**	0	[0-600]	**2045**	0	[0-600]
2015	531	[0-600]	**2026**	0	[0-600]	**2036**	0	[0-600]	**2046**	0	[0-600]
2016	462	[0-600]	**2027**	0	[0-600]	**2037**	0	[0-600]	**2047**	0	[0-600]
2017	392	[0-600]	**2028**	0	[0-600]	**2038**	0	[0-600]	**2048**	0	[0-600]
2018	323	[0-600]	**2029**	0	[0-600]	**2039**	0	[0-600]	**2049**	0	[0-600]
2019	254	[0-600]	**2030**	0	[0-600]	**2040**	0	[0-600]	**2050**	0	[0-600]
2020	185	[0-600]									

Note: *600 kt was determined from the latest survey in 2015, and 1500 kt was imported WEEE weight in 2001[8].

(c) Copper scrap (Mt)

Year	Estimation	Range*	Year	Estimation	Range	Year	Estimation	Range	Year	Estimation	Range
2005	4.82	4.82	**2017**	3.05	[2.74-3.36]	**2029**	0	[0-0.27]	**2040**	0	[0-0.27]
2006	4.94	4.94	**2018**	2.74	[2.19-3.29]	**2030**	0	[0-0.27]	**2041**	0	[0-0.27]
2007	5.58	5.58	**2019**	2.43	[1.70-3.16]	**2031**	0	[0-0.27]	**2042**	0	[0-0.27]
2008	5.58	5.58	**2020**	2.13	[1.28-2.98]	**2032**	0	[0-0.27]	**2043**	0	[0-0.27]
2009	4	4	**2021**	1.82	[0.91-2.73]	**2033**	0	[0-0.27]	**2044**	0	[0-0.27]
2010	4.36	4.36	**2022**	1.51	[0.60-2.42]	**2034**	0	[0-0.27]	**2045**	0	[0-0.27]
2011	4.69	4.69	**2023**	1.20	[0.36-2.04]	**2035**	0	[0-0.27]	**2046**	0	[0-0.27]
2012	4.86	4.86	**2024**	0.89	[0.18-1.60]	**2036**	0	[0-0.27]	**2047**	0	[0-0.27]
2013	4.37	4.37	**2025**	0.58	[0.06-1.10]	**2037**	0	[0-0.27]	**2048**	0	[0-0.27]
2014	3.87	3.87	**2026**	0.27	[0-0.54]	**2038**	0	[0-0.27]	**2049**	0	[0-0.27]
2015	3.66	3.66	**2027**	0	[0-0.27]	**2039**	0	[0-0.27]	**2050**	0	[0-0.27]
2016	3.35	3.35	**2028**	0	[0-0.27]						

Note: *Value for 2010-2016 is real data. Range for 2017 is assumed with 10% of estimation for 2017. This rate is given 10% increase owing to growing uncertainty.

Thus, the error rate in 2026 will be 100% so that its range is 0-0.54.

(c) Aluminum scrap (Mt)

Year	Estimation	Range*	Year	Estimation	Range	Year	Estimation	Range	Year	Estimation	Range
2005	1.69	1.69	**2017**	1.79	[1.61-1.99]	**2029**	0	[0-0.37]	**2040**	0	[0-0.37]
2006	1.77	1.77	**2018**	1.64	[1.31-1.97]	**2030**	0	[0-0.37]	**2041**	0	[0-0.37]
2007	2.09	2.09	**2019**	1.48	[1.04-1.92]	**2031**	0	[0-0.37]	**2042**	0	[0-0.37]
2008	2.15	2.15	**2020**	1.32	[0.79-1.85]	**2032**	0	[0-0.37]	**2043**	0	[0-0.37]
2009	2.63	2.63	**2021**	1.16	[0.65-1.72]	**2033**	0	[0-0.37]	**2044**	0	[0-0.37]
2010	2.85	2.85	**2022**	1.00	[0.40-1.60]	**2034**	0	[0-0.37]	**2045**	0	[0-0.37]
2011	2.69	2.69	**2023**	0.84	[0.25-1.43]	**2035**	0	[0-0.37]	**2046**	0	[0-0.37]
2012	2.59	2.59	**2024**	0.68	[0.13-1.23]	**2036**	0	[0-0.37]	**2047**	0	[0-0.37]
2013	2.50	2.50	**2025**	0.53	[0.06-1.00]	**2037**	0	[0-0.37]	**2048**	0	[0-0.37]
2014	2.31	2.31	**2026**	0.37	[0-0.74]	**2038**	0	[0-0.37]	**2049**	0	[0-0.37]
2015	2.09	2.09	**2027**	0.21	[0-0.58]	**2039**	0	[0-0.37]	**2050**	0	[0-0.37]
2016	1.92	1.92	**2028**	0.05	[0-0.42]						

Note: *Value for 2010-2016 is real data. Range for 2017 is assumed with 10% of estimation for 2017. This rate is given 10% increase owing to growing uncertainty. Thus, the error rate in 2026 will be 100% so that its range is 0-0.74.

(d) Steel scrap (Mt)

Year	Estimation	Range*	Year	Estimation	Range	Year	Estimation	Range	Year	Estimation	Range
2007	3.39	3.39	**2018**	1.74	[1.39-2.09]	**2029**	0	[0-0.13]	**2040**	0	[0-0.13]
2008	5.85	5.85	**2019**	1.54	[1.08-2.00]	**2030**	0	[0-0.13]	**2041**	0	[0-0.13]
2009	13.69	13.69	**2020**	1.34	[0.80-1.88]	**2031**	0	[0-0.13]	**2042**	0	[0-0.13]
2010	5.85	5.85	**2021**	1.14	[0.57-1.71]	**2032**	0	[0-0.13]	**2043**	0	[0-0.13]
2011	6.77	6.77	**2022**	0.94	[0.28-1.50]	**2033**	0	[0-0.13]	**2044**	0	[0-0.13]
2012	4.97	4.97	**2023**	0.73	[0.22-1.24]	**2034**	0	[0-0.13]	**2045**	0	[0-0.13]
2013	4.47	4.47	**2024**	0.53	[0.10-0.96]	**2035**	0	[0-0.13]	**2046**	0	[0-0.13]
2014	2.56	2.56	**2025**	0.33	[0.03-0.63]	**2036**	0	[0-0.13]	**2047**	0	[0-0.13]
2015	2.33	2.33	**2026**	0.13	[0-0.26]	**2037**	0	[0-0.13]	**2048**	0	[0-0.13]
2016	2.16	2.16	**2027**	0	[0-0.13]	**2038**	0	[0-0.13]	**2049**	0	[0-0.13]
2017	1.95	[1.76-2.14]	**2028**	0	[0-0.13]	**2039**	0	[0-0.13]	**2050**	0	[0-0.13]

Note: *Value for 2010-2016 is real data. Range for 2017 is assumed with 10% of estimation for 2017. This rate is given 10% increase owing to growing uncertainty.

Thus, the error rate in 2026 will be 100% so that its range is 0-0.26.

(e) Plastics scrap (Mt)

Year	Estimation	Range*	**Year**	Estimation	Range	**Year**	Estimation	Range	**Year**	Estimation	Range
2010	8.01	8.01	**2021**	6.02	[3.01-9.03]	**2031**	3.36	[0-8.05]	**2041**	0.69	[0-5.38]
2011	8.38	8.38	**2022**	5.76	[2.31-9.21]	**2032**	3.09	[0-7.78]	**2042**	0.42	[0-5.11]
2012	8.88	8.88	**2023**	5.49	[1.65-9.22]	**2033**	2.82	[0-7.51]	**2043**	0.16	[0-4.85]
2013	7.88	7.88	**2024**	5.22	[1.04-9.40]	**2034**	2.56	[0-7.25]	**2044**	0	[0-4.69]
2014	8.26	8.26	**2025**	4.96	[0.50-9.42]	**2035**	2.29	[0-6.98]	**2045**	0	[0-4.69]
2015	7.36	7.36	**2026**	4.69	[0-9.38]	**2036**	2.02	[0-6.71]	**2046**	0	[0-4.69]
2016	7.35	7.35	**2027**	4.42	[0-9.11]	**2037**	1.76	[0-6.45]	**2047**	0	[0-4.69]
2017	7.09	[6.28-7.80]	**2028**	4.16	[0-8.85]	**2038**	1.49	[0-6.18]	**2048**	0	[0-4.69]
2018	6.82	[5.46-8.18]	**2029**	3.89	[0-8.55]	**2039**	1.22	[0-5.91]	**2049**	0	[0-4.69]
2019	6.56	[4.59-8.53]	**2030**	3.62	[0-8.31]	**2040**	0.96	[0-5.65]	**2050**	0	[0-4.69]
2020	6.29	[3.77-8.81]									

Note: *Value for 2010-2016 is real data. Range for 2017 is assumed with 10% of estimation for 2017. This rate is given 10% increase owing to growing uncertainty. Thus, the error rate in 2026 will be 100% so that its range is 0-9.38.

Supplementary Table 13 η, β, and L: Parameters of Weibull lifespan distribution and the regulated maximum lifetime

(a) EEE [65, 69, 70]

Parameter	Refrigerator	Washing machine	Air conditioner	TV	Desktop PC	Laptop PC	Mobile phone	SMT	Fax machine	Copier	Printer	Monitor	Range hood	Electric water-heater	Gas water-heater
η (scale)	16.5	13.9	12.3	CRT: 12.6 FDP: 12	9.6	5.2	7.6	6.5	10.1	10.1	10.1	CRT: 8.5 FDP: 7.5	13.5	7.9	7.9
β (shape)	2.6	2.2	2.8	CRT: 2 FDP: 2.1	2.1	1.5	1.7	2.1	1.7	1.7	1.7	CRT: 2.2 FDP: 2.5	2	1.8	1.8

(b) Vehicle, bicycle, and cable [71, 72]

Type		**η (scale)**	**β (shape)**	**Regulated maximum lifetime for compulsory recycling (y)** [73, 74]
Passenger vehicle	Private passenger vehicle	14.46	4.79	10
	Civil vehicle	13.11	5.33	20
	New-registration civil vehicle	11.53	5.08	20
Cargo truck	Heavy duty truck	12.8	5.58	15
	Middle duty truck	10.09	5.58	15
	Small duty truck	8.02	5.58	15
	Mini duty truck	8.02	5.58	12
Car	Taxi	5		8
	Private vehicle	14.46	4.79	None
Refit vehicle		8.02	5.58	15
Motorcycle		8.02	5.58	12
Tractor		10 [75]	1.18 [76]	None
Bicycle		6	1.5	None
Cable [77, 78]		45	2.298	25*

Note: *In 1992-2014, the regulated maximum lifetime for home wiring & cable was 25 years, and since 2015, it was adjusted for over 70 years. The data of η and β is assumed to fit for normal distribution.

Supplementary Table 14 *f*(*x*): Lifetime distribution function of all the relevant products

(a) EEEs

EEE	***η* (scale)**	***β* (shape)**	*f(x)=* $\frac{\beta}{\eta}(\frac{x}{\eta})^{\beta-1}e^{-(x/\eta)^{\beta}}$
RF	16.5	2.6	$\frac{2.6}{16.5}(\frac{x}{16.5})^{1.6}e^{-(x/16.5)2.6}$
WM	13.9	2.2	$\frac{2.2}{13.9}(\frac{x}{13.9})^{1.2}e^{-(x/13.9)2.2}$
AC	12.3	2.8	$\frac{2.8}{12.3}(\frac{x}{12.3})^{1.8}e^{-(x/12.3)^{2.8}}$
TV-CRT	12.6	2	$\frac{\beta}{12.6}\frac{x}{12.6}e^{-(x/12.6)^{2}}$
TV-FDP	12	2.1	$\frac{2.1}{12}(\frac{x}{12})^{1.1}e^{-(x/12)^{2.1}}$
DPC	9.6	2.1	$\frac{2.1}{9.6}(\frac{x}{9.6})^{1.1}e^{-(x/9.6)^{2.1}}$
LPC	5.2	1.5	$\frac{1.5}{5.2}(\frac{x}{5.2})^{0.5}e^{-(x/5.2)^{1.5}}$
MP	7.6	1.7	$\frac{1.7}{7.6}(\frac{x}{7.6})^{0.7}e^{-(x/7.6)^{1.7}}$
SMT	6.5	2.1	$\frac{2.1}{6.5}(\frac{x}{6.5})^{1.1}e^{-(x/6.5)^{2.1}}$
FM	10.1	1.7	$\frac{1.7}{10.1}(\frac{x}{10.1})^{0.7}e^{-(x/10.1)^{1.7}}$
Copier	10.1	1.7	$\frac{1.7}{10.1}(\frac{x}{10.1})^{0.7}e^{-(x/10.1)^{1.7}}$
Printer	10.1	1.7	$\frac{1.7}{10.1}(\frac{x}{10.1})^{0.7}e^{-(x/10.1)^{1.7}}$
Monitor-CRT	8.5	2.2	$\frac{2.2}{8.5}(\frac{x}{8.5})^{1.2}e^{-(x/8.5)^{2.2}}$
Monitor-FDP	7.5	2.5	$\frac{2.5}{7.5}(\frac{x}{7.5})^{1.5}e^{-(x/7.5)^{2.5}}$
RH	13.5	2	$\frac{2}{13.5}\frac{x}{13.5}e^{-(x/13.5)^{2}}$
EWH	7.9	1.8	$\frac{1.8}{7.9}(\frac{x}{7.9})^{0.8}e^{-(x/\eta)^{1.8}}$
GWH	7.9	1.8	$\frac{1.8}{7.9}(\frac{x}{7.9})^{0.8}e^{-(x/\eta)^{1.8}}$

(b) Vehicles

Type of vehicle	*η* (y)	*β*	Regulated maximization lifetime (y) [73]	Lifetime distribution function

Passenger vehicle	Private passenger vehicle	14.46	4.79	10	$f(x)=\begin{cases}0 & x>10\\ e^{-(x/14.46)^{4.79}} & x=10\\ \frac{4.79}{14.46}(\frac{x}{14.46})^{3.79}e^{-(x/14.46)^{4.79}} & 0\le x<10\\ 0 & x<0\end{cases}$
	Civil vehicle	13.11	5.33	20	$f(x)=\begin{cases}0 & x>20\\ e^{-(x/13.11)^{5.33}} & x=20\\ \frac{5.33}{13.11}(\frac{x}{13.11})^{4.33}e^{-(x/13.11)^{5.33}} & 0\le x<20\\ 0 & x<0\end{cases}$
	New-registration civil vehicle	11.53	5.08	20	$f(x)=\begin{cases}0 & x>20\\ e^{-(x/11.53)^{5.08}} & x=20\\ \frac{5.08}{11.53}(\frac{x}{11.53})^{4.08}e^{-(x/11.53)^{5.08}} & 0\le x<20\\ 0 & x<0\end{cases}$
Cargo truck	Heavy cargo truck	12.8	5.58	15	$f(x)=\begin{cases}0 & x>15\\ e^{-(x/12.8)^{5.58}} & x=15\\ \frac{5.58}{12.8}(\frac{x}{12.8})^{4.58}e^{-(x/12.8)^{5.58}} & 0\le x<15\\ 0 & x<0\end{cases}$
	Medium cargo truck	10.09	5.58	15	$f(x)=\begin{cases}0 & x>15\\ e^{-(x/10.09)^{5.58}} & x=15\\ \frac{5.58}{10.09}(\frac{x}{10.09})^{4.58}e^{-(x/10.09)^{5.58}} & 0\le x<15\\ 0 & x<0\end{cases}$
	Small cargo truck	8.02	5.58	15	$f(x)=\begin{cases}0 & x>15\\ e^{-(x/8.02)^{5.58}} & x=15\\ \frac{5.58}{8.02}(\frac{x}{8.02})^{4.58}e^{-(x/8.02)^{5.58}} & 0\le x<15\\ 0 & x<0\end{cases}$
	Mini cargo truck	8.02	5.58	12	$f(x)=\begin{cases}0 & x>12\\ e^{-(x/8.02)^{5.58}} & x=12\\ \frac{5.58}{8.02}(\frac{x}{8.02})^{4.58}e^{-(x/8.02)^{5.58}} & 0\le x<12\\ 0 & x<0\end{cases}$
Car	Taxi	5	10	8	$f(x)=\begin{cases}0 & x>8\\ e^{-(x/5)^{10}} & x=8\\ \frac{10}{5}(\frac{x}{5})^{9}e^{-(x/5)^{10}} & 0\le x<8\\ 0 & x<0\end{cases}$

	Private vehicle	14.46	4.79	None	$f(x)=\begin{cases}\frac{4.79}{14.46}(\frac{x}{14.46})^{3.79}e^{-(x/14.46)^{4.79}} & x\ge 0\\ 0 & x<0\end{cases}$
Refit vehicle		8.02	5.58	15	$f(x)=\begin{cases}0 & x>15\\ e^{-(x/8.02)^{5.58}} & x=15\\ \frac{5.58}{8.02}(\frac{x}{8.02})^{4.58}e^{-(x/8.02)^{5.58}} & 0\le x<15\\ 0 & x<0\end{cases}$
Motorcycle		8.02	5.58	12	$f(x)=\begin{cases}0 & x>12\\ e^{-(x/8.02)^{5.58}} & x=12\\ \frac{5.58}{8.02}(\frac{x}{8.02})^{4.58}e^{-(x/8.02)^{5.58}} & 0\le x<12\\ 0 & x<0\end{cases}$
Tractor		10[75]	1.18[76]	none	$f(x)=\begin{cases}\frac{1.18}{10}(\frac{x}{10})^{0.18}e^{-(x/10)^{1.18}} & x\ge 0\\ 0 & x<0\end{cases}$

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