Supplementary Materials

Table SM1: GCAM-China-v8 Model Overview (Reference Card)

The tables below provide a concise, high-level overview of GCAM-China, summarizing key model structures, assumptions, and implementation details. For clarity and ease of reference, the tables are organized into six thematic sections.

- Table SM1A: Model scope and methods
- Table SM1B: Socio-economic drivers and macro-economy
- Table SM1C: Energy Supply and Transformation
- Table SM1D: Energy end-use
- Table SM1E: Land use
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Table SM1A: Model scope and methods

Dimension	Sub-Dimension	Endogenous	Exogenous	Not Included	Details
Model type					global multisector model
Geographical scope					global
Objective					GCAM-China is a comprehensive integrated assessment model designed to represent coupled human–Earth system dynamics within a unified global framework. It combines economic activity with energy, water, and land system representations in a cross-sectorally consistent manner, while remaining computationally lightweight enough for execution on personal computers and for extensive exploration of alternative scenarios and uncertainties. Although grounded in economic theory, the model is formulated in physical units—such as energy, water volumes, and land area—and its individual components employ process-based formulations informed by current scientific understanding, with an intentional level of aggregation that favors system-wide integration over fine sectoral detail.
Solution concept					Partial equilibrium (price elastic demand)
Solution horizon					Recursive dynamic (myopic)

Anticipation					GCAM-China is implemented using a recursive dynamic framework, in which the model advances sequentially through time. At each simulation step, system responses are determined by information available at that point—such as current market signals, policy settings, and resource availability—without incorporating expectations about future outcomes. The resulting state of the system is then carried forward, with accumulated investments, resource use, and land allocation forming the starting conditions for subsequent steps, thereby governing the model's long-term evolution.
Spatial Dimension					GCAM-China is a China-focused version of GCAM that disaggregates the energy-economic system of the China region into 31 province-level sub-regions and six electricity grid regions that are also embedded in the global GCAM model. Electricity generation and end-use energy demand (buildings, transportation, and industry) are modeled at the provincial level in GCAM-China, and the model allows for electricity trade within grid regions. Renewable energy resources (hydro, solar, and wind) and carbon storage resources are also provincial-specific. Primary production of fossil resources including oil, gas, and coal, as well as other energy transformation sectors (hydrogen, gas, and refined liquids production) are still modeled at the aggregate national level. Agricultural and land use activities, including the supply of biomass energy feedstocks (residues and dedicated energy crops) are modeled at the level of 22 water basins in China.
Policies	Emission tax	x			
	Emission pricing	x			
	Cap and trade	x			
	Fuel taxes	x			
	Fuel subsidies	x			
	Feed-in-tariff	x			
	Portfolio standard	x			
	Capacity targets	x			
	Emission standards	x			
	Energy efficiency standards	x			
	Agricultural producer subsidies	x			
	Agricultural consumer subsidies	x			
	Land protection	x			

	Pricing carbon stocks	x			

Table SM1B: Socio-economic drivers and macro-economy

Dimension	Sub-Dimension	Endogenous	Exogenous	Not Included	Details
Population			x		
Population age structure				x	
Education level				x	
Urbanization rate				x	
GDP			x		
Income distribution				x	Can be included; not included by default
Employment rate			x		
Labor productivity			x		
Total factor productivity			x		
Economic sectors					Energy, industry, transportation, residential, commercial, agriculture, forestry
Trade	Coal	x			Heckscher-Ohlin (H-O) / Armington hybrid
	Oil	x			Heckscher-Ohlin (H-O) / Armington hybrid
	Gas	x			Heckscher-Ohlin (H-O) / Armington hybrid
	Uranium	x			Heckscher-Ohlin (H-O)
	Electricity	x		x	Electricity generation and end-use energy demand (buildings, transportation, and industry) are modeled at the provincial level in GCAM-China, and the model allows for electricity trade within grid regions.
	Bioenergy crops	x			
	Food crops	x			
	Emissions	x			Emissions markets can be set up to permit or restrict trading.
Institutional and political factors	Early retirement of capital allowed	x			
	Interest rates differentiated by		x		Homogenous by default but can be differentiated.

	country/region				
	Regional risk factors included		x		Homogenous by default but can be differentiated.
	Technology costs differentiated by country/region		x		Homogenous by default but can be differentiated.
	Technological change differentiated by country/region		x		Homogenous by default but can be differentiated.
	Behavioral change differentiated by country/region		x		Varies by sector. By default, technology preferences evolve homogenously across regions for some sectors/technologies and are differentiated for others (e.g., nuclear power). Technology preferences and behavioral change can be differentiated.
Resource use	Coal	x			
	Conventional oil	x			
	Unconventional oil	x			
	Conventional gas	x			
	Unconventional gas	x			
	Uranium	x			
	Bioenergy	x			
	Water	x			
	Raw materials	x			Limestone for cement production
	Land	x			
Technological change	Energy conversion technologies		x		
	Energy End-use		x		
	Material Use		x		
	Agriculture		x		

Table SM1C: Energy Supply and Transformation

Dimension	Sub-Dimension	Endogenous	Exogenous	Not Included	Details
Energy technology substitution	Energy technology choice				Logit choice model
	Energy technology substitutability				Mixed high and low substitutability
Electricity technologies	Coal w/o CCS	x			conventional and integrated gasification combined cycle (IGCC)
	Coal w/ CCS	x			conventional and IGCC
	Gas w/o CCS	x			combined cycle (CC), steam turbine (ST), and combustion turbine (CT)
	Gas w/ CCS	x			CC
	Oil w/o CCS	x			combined cycle (CC) and steam/CT
	Oil w/ CCS	x			CC
	Bioenergy w/o CCS	x			conventional and IGCC
	Bioenergy w/ CCS	x			conventional and IGCC
	Geothermal power		x		geothermal is not available in all provinces; deployment is endogenous in regions outside the China
	Nuclear power	x			generation II (historic) and III (next gen)
	Solar power	x			central PV, distributed PV, CSP
	Wind power	x			onshore, offshore
	Hydroelectric power		x		
	Ocean power			x	
Hydrogen production	Coal to hydrogen w/o CCS	x			
	Coal to hydrogen w/ CCS	x			
	Natural gas to hydrogen w/o CCS	x			
	Natural gas to hydrogen w/ CCS	x			
	Oil to hydrogen w/o			x	

	CCS				
	Oil to hydrogen w/ CCS			x	
	Biomass to hydrogen w/o CCS	x			
	Biomass to hydrogen w/ CCS	x			
	Nuclear thermochemical hydrogen	x			
	Solar thermochemical hydrogen			x	
	Electrolysis	x			
Refined liquids	Coal to liquids w/o CCS	x			
	Coal to liquids w/ CCS	x			
	Gas to liquids w/o CCS	x			
	Gas to liquids w/ CCS			x	
	Bioliquids w/o CCS	x			
	Bioliquids w/ CCS	x			
	Oil refining	x			
Refined gasses	Coal to gas w/o CCS	x			
	Coal to gas w/ CCS			x	
	Oil to gas w/o CCS	x			
	Oil to gas w/ CCS			x	
	Biomass to gas w/o CCS	x			
	Biomass to gas w/ CCS			x	
Heat generation	Coal heat	x			
	Natural gas heat			x	
	Oil heat	x			
	Biomass heat	x			
	Geothermal heat			x	
	Solar thermal heat			x	
	CHP (coupled heat and	x			represented in province-level industry sectors

	power)				
Grid Infra Structure	Electricity		x		Electricity generation and end-use energy demand (buildings, transportation, and industry) are modeled at the provincial level in GCAM-China, and the model allows for electricity trade within grid regions.
	Gas			x	
	Heat			x	
	CO_2		x		Geologic carbon storage potentials and costs are represented at the grid-region level.
	Hydrogen			x	

Table SM1D: Energy end-use

Dimension	Sub-Dimension	Endogenous	Exogenous	Not Included	Details
Passenger transportation	Passenger trains	x			liquid fuels (standard and advanced), electric (standard and advanced), high speed rail (electric)
	Buses	x			
	CNG Buses	x			
	Electric Buses			x	
	Light Duty Vehicles (LDVs)	x			2 size classes (Car, Large Car and Truck)
	Gasoline LDVs	x			no distinction between gasoline and diesel internal combustion engine (ICE) vehicles
	Diesel LDVs			x	
	Hybrid LDVs	x			
	Electric LDVs	x			
	Hydrogen LDVs	x			
	Passenger aircrafts	x			
	Diesel Three-wheelers	x			
	CNG Three-wheelers			x	
	Electric Three-wheelers	x			
	LPG/CNG LDVs	x			
Freight transportation	Freight trains	x			coal, liquid fuels (standard and advanced), electric (standard and advanced)

	Heavy duty vehicles	x			3 size classes (light truck, medium truck, heavy truck); liquid fuels and LPG/CNG for each
	Freight aircrafts			x	
	Freight ships	x			
Industry	Steel production	x			
	Aluminum production			x	Included in GCAM but not currently included in GCAM-China
	Cement production	x			
	Petrochemical production			x	Included in GCAM but not currently included in GCAM-China
	Plastics production			x	
	Paper production			x	
	Pulp production			x	
Residential buildings	Space heating	x			Electric (furnace), gas (furnace, high-efficiency), liquid fuel (furnace, high-efficiency), biomass (wood furnace), coal (furnace), heat (district heat)
	Space cooling	x			Electric (standard, high-efficiency)
	Water heating and cooking	x			Gas (standard, high-efficiency), electric (resistance, resistance high-efficiency), liquid fuel (standard, high-efficiency), coal (standard), biomass (wood furnace)
	Lighting	x			Electric (standard)
	Appliances	x			Electric (standard)
Commercial buildings	Space heating	x			Electric (furnace, heat pump), gas (furnace, high-efficiency), liquid fuel (fuel furnace), biomass (wood furnace), coal (furnace), heat (district heat)
	Space cooling	x			Electric (standard, high-efficiency), gas
	Water heating and cooking	x			Gas (standard, high-efficiency), electric (resistance), liquid fuel, coal (furnace)
	Lighting	x			Electric (standard)
	Appliances	x			Electric (standard)

Table SM1E: Land use

Dimension	Sub-Dimension	Endogenous	Exogenous	Not Included	Details
Land cover	Cropland	x			
	Cropland irrigated	x			
	Cropland food crops	x			
	Cropland feed crops	x			
	Cropland energy crops	x			
	Forest	x			
	Managed forest	x			
	Natural forest	x			
	Pasture	x			
	Shrubland	x			
	Built-up area	x			
Agriculture and forestry demands	Agriculture food	x			
	Agriculture food crops	x			
	Agriculture food livestock	x			
	Agriculture feed	x			
	Agriculture feed crops	x			
	Agriculture feed livestock	x			
	Agriculture non-food	x			
	Agriculture non-food crops	x			
	Agriculture non-food livestock	x			
	Agriculture bioenergy	x			
	Agriculture residues	x			
	Forest industrial roundwood	x			
	Forest fuelwood	x			

	Forest residues	x			
Agricultural commodities	Wheat	x			
	Rice	x			
	Other coarse grains	x			
	Oilseeds	x			
	Sugar crops	x			
	Ruminant meat	x			
	Non-ruminant meat and eggs	x			
	Dairy products	x			

Table SM1F: Emissions, climate, and impacts

Dimension	Sub-Dimension	Endogenous	Exogenous	Not Included	Details
Greenhouse gases	CO_2 fossil fuels	x			
	CO_2 cement	x			
	CO_2 land use	x			
	CH_4 energy	x			
	CH_4 land use	x			
	CH_4 other	x			
	N_2O energy	x			
	N_2O land use	x			
	N_2O other	x			
	CFCs			x	Included in GCAM but not currently included in GCAM-China
	HFCs			x	Included in GCAM but not currently included in GCAM-China
	SF_6			x	Included in GCAM but not currently included in GCAM-China
	PFCs			x	Included in GCAM but not currently included in GCAM-China
Pollutants	CO energy			x	Included in GCAM but not currently included in GCAM-China
	CO land use			x	Included in GCAM but not currently included in GCAM-China
	CO other			x	Included in GCAM but not currently included in GCAM-China
	NOx energy			x	Included in GCAM but not currently included in GCAM-China
	NOx land use			x	Included in GCAM but not currently included in GCAM-China
	NOx other			x	Included in GCAM but not currently included in GCAM-China

	VOC energy			x	Included in GCAM but not currently included in GCAM-China
	VOC land use			x	Included in GCAM but not currently included in GCAM-China
	VOC other			x	Included in GCAM but not currently included in GCAM-China
	SO_2 energy			x	Included in GCAM but not currently included in GCAM-China
	SO_2 land use			x	Included in GCAM but not currently included in GCAM-China
	SO_2 other			x	Included in GCAM but not currently included in GCAM-China
	BC energy			x	Included in GCAM but not currently included in GCAM-China
	BC land use			x	Included in GCAM but not currently included in GCAM-China
	BC other			x	Included in GCAM but not currently included in GCAM-China
	OC energy			x	Included in GCAM but not currently included in GCAM-China
	OC land use			x	Included in GCAM but not currently included in GCAM-China
	OC other			x	Included in GCAM but not currently included in GCAM-China
	NH_3 energy			x	Included in GCAM but not currently included in GCAM-China
	NH_3 land use			x	Included in GCAM but not currently included in GCAM-China
	NH_3 other			x	Included in GCAM but not currently included in GCAM-China
Climate indicators	Concentration: CO_2			x	Included in GCAM but not currently included in GCAM-China
	Concentration: CH_4			x	Included in GCAM but not currently included in GCAM-China
	Concentration: N_2O			x	Included in GCAM but not currently included in GCAM-China
	Concentration: Kyoto gases			x	Included in GCAM but not currently included in GCAM-China
	Radiative forcing: CO_2			x	Included in GCAM but not currently included in GCAM-China
	Radiative forcing: CH_4			x	Included in GCAM but not currently included in GCAM-China
	Radiative forcing: N_2O			x	Included in GCAM but not currently included in GCAM-China
	Radiative forcing: F-gases			x	Included in GCAM but not currently included in GCAM-China
	Radiative forcing: Kyoto gases			x	Included in GCAM but not currently included in GCAM-China
	Radiative forcing: aerosols			x	Included in GCAM but not currently included in GCAM-China
	Radiative forcing: land albedo			x	Included in GCAM but not currently included in GCAM-China
	Radiative forcing: AN_3A			x	Included in GCAM but not currently included in GCAM-China
	Radiative forcing: total			x	Included in GCAM but not currently included in GCAM-China
	Temperature change			x	Included in GCAM but not currently included in GCAM-China

Carbon dioxide removal	Bioenergy with CCS	x			
	Reforestation	x			
	Afforestation	x			
	Soil carbon enhancement			x	
	Direct air capture			x	
	Enhanced weathering			x	
Climate change impacts	Agriculture		x		Not included by default but possible to implement
	Energy supply			x	
	Energy demand	x			Not included by default but possible to implement
	Economic output			x	
	Built capital			x	
Co-Linkages	Energy security: Fossil fuel imports & exports (region)	x			
	Energy access: Household energy consumption	x			
	Air pollution & health: Source-based aerosol emissions			x	Included in GCAM but not currently included in GCAM-China
	Air pollution & health: Health impacts of air Pollution			x	
	Food access	x			
	Water availability	x			
	Biodiversity			x	

Table SM2: GCAM-China Reference scenario Socioeconomic Assumptions

GCAM-China Reference scenario Population (million persons)

Region	2015	2021	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
AH	61.6	63.4	63.1	62.4	61.1	59.5	57.6	55.5	53.2	50.8	48.4	46.0	43.7	41.5	39.3	37.2	35.2	33.5
BJ	21.8	21.9	22.7	23.5	24.0	24.2	24.1	23.8	23.3	22.5	21.6	20.7	19.6	18.6	17.6	16.7	15.8	15.0
CQ	30.3	31.4	31.9	32.1	32.1	31.8	31.2	30.4	29.3	28.2	27.0	25.7	24.4	23.2	21.9	20.8	19.7	18.7
FJ	38.5	39.9	40.3	40.5	40.4	39.9	39.0	37.9	36.6	35.1	33.6	32.0	30.4	28.8	27.3	25.8	24.5	23.3
GS	26.1	26.4	26.2	25.9	25.3	24.6	23.8	22.9	22.0	21.0	20.0	19.0	18.1	17.1	16.2	15.3	14.5	13.8
GD	108.8	116.8	120.2	123.3	125.0	125.3	124.3	122.1	118.9	114.8	110.1	105.1	99.9	94.7	89.7	84.9	80.5	76.4
GX	48.1	49.3	48.8	47.9	46.7	45.2	43.6	41.8	40.0	38.1	36.2	34.5	32.8	31.1	29.4	27.8	26.4	25.1
GZ	35.4	36.0	35.7	35.0	34.1	33.1	31.9	30.6	29.3	27.9	26.6	25.3	24.0	22.8	21.6	20.4	19.3	18.4
HI	9.1	9.5	9.6	9.7	9.7	9.6	9.4	9.2	8.9	8.5	8.2	7.8	7.4	7.0	6.6	6.3	6.0	5.7
HE	74.5	76.2	76.9	77.2	76.7	75.7	74.0	71.8	69.3	66.5	63.5	60.5	57.5	54.6	51.6	48.9	46.3	44.0
HL	38.2	37.0	36.1	34.9	33.6	32.2	30.7	29.3	27.8	26.4	25.0	23.8	22.6	21.4	20.3	19.2	18.2	17.3
HA	95.1	95.6	94.4	92.4	89.9	86.9	83.6	80.1	76.5	72.8	69.2	65.8	62.6	59.3	56.2	53.2	50.4	47.9
HB	58.7	59.0	58.7	57.9	56.7	55.2	53.4	51.4	49.2	46.9	44.7	42.6	40.4	38.3	36.3	34.4	32.6	30.9
HN	68.0	69.4	70.1	70.4	70.0	69.0	67.5	65.6	63.2	60.7	58.0	55.2	52.5	49.8	47.1	44.6	42.3	40.2
NM	25.2	25.3	25.1	24.7	24.2	23.5	22.8	21.9	20.9	20.0	19.0	18.1	17.2	16.3	15.4	14.6	13.9	13.2
JS	80.0	80.3	79.8	78.6	76.9	74.8	72.3	69.5	66.5	63.5	60.5	57.5	54.7	51.8	49.1	46.5	44.0	41.8
JX	45.8	46.6	46.6	46.3	45.6	44.6	43.3	41.8	40.2	38.4	36.6	34.9	33.2	31.4	29.8	28.2	26.7	25.4
JL	27.6	26.5	25.9	25.0	24.0	22.9	21.9	20.8	19.7	18.7	17.7	16.8	16.0	15.2	14.4	13.6	12.9	12.3
LN	43.9	43.1	42.3	41.2	39.8	38.4	36.8	35.1	33.4	31.8	30.2	28.7	27.3	25.9	24.5	23.2	22.0	20.9
NX	6.7	7.0	7.2	7.3	7.3	7.3	7.2	7.0	6.8	6.5	6.3	6.0	5.7	5.4	5.1	4.8	4.6	4.4
QH	5.9	6.1	6.2	6.2	6.2	6.2	6.1	5.9	5.7	5.5	5.2	5.0	4.7	4.5	4.3	4.0	3.8	3.6
SN	38.0	38.6	38.5	38.0	37.3	36.3	35.2	33.9	32.4	31.0	29.5	28.1	26.7	25.3	24.0	22.7	21.5	20.4
SD	98.7	100.8	101.2	100.9	99.8	97.9	95.3	92.3	88.8	85.0	81.1	77.3	73.4	69.6	65.9	62.4	59.2	56.2
SH	24.2	24.5	24.9	25.1	25.2	24.9	24.5	23.9	23.1	22.3	21.3	20.3	19.3	18.3	17.3	16.4	15.5	14.8
SX	36.7	37.5	38.0	38.2	38.1	37.7	37.0	36.0	34.7	33.4	31.9	30.4	28.9	27.4	25.9	24.5	23.3	22.1
SC	82.3	83.2	82.4	80.8	78.8	76.4	73.6	70.7	67.5	64.4	61.2	58.3	55.4	52.5	49.7	47.0	44.6	42.4
TJ	15.5	16.2	17.4	18.7	19.7	20.5	21.0	21.2	21.0	20.6	19.9	19.1	18.1	17.2	16.3	15.4	14.6	13.9
XZ	3.2	3.6	3.7	3.9	4.0	4.1	4.1	4.1	4.0	3.9	3.7	3.6	3.4	3.2	3.0	2.9	2.7	2.6
XJ	23.7	25.7	26.7	27.7	28.4	28.7	28.7	28.3	27.7	26.9	25.8	24.7	23.4	22.2	21.0	19.9	18.9	17.9
YN	47.5	48.6	48.8	48.6	48.1	47.2	45.9	44.5	42.8	41.0	39.1	37.2	35.4	33.5	31.8	30.1	28.5	27.1
ZJ	55.5	59.0	60.2	61.1	61.3	61.0	60.1	58.7	56.9	54.8	52.5	50.0	47.5	45.1	42.7	40.4	38.3	36.4

GCAM-China Reference scenario GDP (billion 2015 USD)

Region	2015	2021	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
AH	207	317	397	489	567	637	667	716	753	786	815	840	859	876	888	897	905	912
BJ	209	302	376	457	522	574	585	608	616	616	608	594	574	553	530	506	482	459
CQ	138	202	255	316	369	415	434	465	486	504	517	526	530	533	532	530	528	524
FJ	233	360	446	541	616	679	696	729	748	759	763	762	754	743	729	713	695	678
GS	55	75	97	123	147	170	183	203	220	237	254	270	285	300	313	327	340	354
GD	621	926	1174	1463	1710	1928	2015	2151	2240	2305	2344	2360	2354	2337	2309	2273	2234	2194
GX	135	182	230	286	335	382	405	440	470	498	524	549	572	593	611	628	644	660
GZ	90	144	181	224	262	297	313	340	361	381	399	417	432	446	458	468	478	488
HI	31	46	59	74	87	100	107	116	123	130	135	140	143	147	149	151	152	154
HE	223	304	389	493	588	678	726	796	854	907	955	998	1034	1068	1096	1122	1146	1170
HL	98	116	146	181	211	239	254	276	296	315	333	352	370	387	403	418	432	447
HA	319	462	574	702	809	905	944	1010	1061	1106	1147	1183	1213	1239	1258	1274	1287	1300
HB	262	389	480	582	664	734	756	798	827	849	866	879	886	889	887	883	877	870
HN	239	342	435	544	641	731	773	838	888	933	970	1002	1026	1047	1062	1074	1084	1093
NM	118	146	182	221	254	283	293	312	325	336	345	353	358	362	364	365	365	365
JS	586	836	1010	1192	1324	1426	1430	1471	1484	1485	1476	1460	1434	1402	1364	1323	1280	1238
JX	143	212	268	334	391	444	469	507	538	565	589	611	628	644	656	666	676	684
JL	87	100	124	151	175	196	205	221	234	247	259	271	281	291	300	308	316	323
LN	176	211	261	317	364	405	420	448	469	488	504	520	532	543	551	558	563	568
NX	23	32	42	53	64	73	79	86	92	97	102	105	108	111	113	115	116	118
QH	19	26	33	42	50	58	62	68	72	77	81	84	87	90	92	94	95	97
SN	147	220	273	334	385	430	447	477	498	516	531	543	552	559	562	564	565	565
SD	456	607	760	935	1083	1214	1265	1351	1412	1462	1503	1534	1553	1566	1571	1571	1568	1564
SH	230	322	394	471	528	573	576	593	597	594	586	573	555	536	514	492	470	449
SX	101	148	190	242	289	334	359	395	425	452	476	498	517	534	548	562	574	587
SC	263	397	495	608	703	789	825	884	931	972	1009	1042	1069	1092	1110	1124	1137	1149
TJ	98	124	164	215	262	308	332	364	388	406	417	422	422	420	415	410	404	397
XZ	9	15	20	26	32	38	42	46	51	54	57	60	62	64	65	67	68	69
XJ	81	119	156	203	247	289	314	347	375	399	419	435	447	458	466	473	479	485
YN	132	200	255	320	379	433	462	503	538	569	597	622	644	664	680	695	708	722
ZJ	367	532	664	813	935	1039	1070	1128	1161	1182	1191	1190	1178	1162	1139	1114	1087	1059

Table SM3: Key technological and economic parameters for industrial sector

Supply sector		Technology	Price elasticity	Minicam input	Cost
1.agricultural energy use		biomass	-0.4	delivered biomass	18.8400
		coal	-0.4	delivered coal	5.0000
		district heat	-0.4	heat	5.0000
		electricity	-0.4	elect_td_ind	29.7672
		gas	-0.4	wholesale gas	18.8400
		hydrogen	-0.4	H2 industrial	22.6080
		liquid	-0.4	refined liquids industry	18.8400
2. chemical	**direct cost**	chemical	-0.4	chemical energy use; chemical feedstocks	25.0000
	chemical energy use	biomass	-0.4	delivered biomass	3.0000
		coal	-0.4	delivered coal	3.0000
		coal CCS	-0.4	delivered coal	3.5000
		district heat	-0.4	heat	3.0000
		electricity	-0.4	elect_td_ind	0.5447
		gas	-0.4	wholesale gas	3.0000
		gas CCS	-0.4	wholesale gas	3.5000
		hydrogen	-0.4	H2 industrial	3.0000
		liquid	-0.4	refined liquids industry	3.0000
		liquid CCS	-0.4	refined liquids industry	3.5000
	chemical feedstocks	coal	-0.4	delivered coal	3.0000
		gas	-0.4	wholesale gas	3.0000
		liquid	-0.4	refined liquids industry	3.0000
3. coke		coke	-0.4	coke	0.0046

		coke CCS	-0.4	coke	0.0084
4. construction	**direct cost**	construction	-0.4	construction energy use; construction feedstocks	3.0000
	construction energy use	biomass	-0.4	delivered biomass	55.5600
		coal	-0.4	delivered coal	5.0000
		district heat	-0.4	heat	5.0000
		electricity	-0.4	elect_td_ind	87.7848
		gas	-0.4	wholesale gas	55.5600
		hydrogen	-0.4	H2 industrial	66.6720
		liquid	-0.4	refined liquids industry	55.5600
	construction feedstocks	coal	-0.4	delivered coal	0.9951
		gas	-0.4	wholesale gas	18.8400
		liquid	-0.4	refined liquids industry	18.8400
5. iron and steel	**BLASTFUR**	Biomass-based	-0.1	delivered biomass; elect_td_ind	0.0832
		BLASTFUR	-0.1	coke; elect_td_ind; refined liquids industrial; delivered coal	0.1122
		BLASTFUR CCS	-0.1	coke; elect_td_ind; refined liquids industrial; delivered coal	0.1372
	EAF with DRI	EAF with DRI	-0.1	elect_td_ind; refined liquids industrial; wholesale gas	0.1214
		EAF with DRI CCS	-0.1	elect_td_ind; refined liquids industrial; wholesale gas	0.1224
		Hydrogen-based DRI	-0.1	elect_td_ind; refined liquids industrial; scrap	0.0978

	EAF with scrap	EAF with scrap	-0.1	H2 industrial; elect_td_ind	0.0442
6. mining energy use		biomass	-0.4	delivered biomass	37.0500
		coal	-0.4	delivered coal	5.0000
		district heat	-0.4	heat	5.0000
		electricity	-0.4	elect_td_ind	58.5390
		gas	-0.4	wholesale gas	37.0500
		hydrogen	-0.4	H2 industrial	44.4600
		liquid	-0.4	refined liquids industry	37.0500

***Note: the unit for cost is** 1975$/kg for coke and iron and steel 1975$/GJ for others*

Table SM4: Province-to-basin mappings

Basin	Province
Russia South East Coast	Heilongjiang, Jilin
Gobi Interior	Gansu, Inner Mongolia, Qinghai, Xinjiang
Amur	Heilongjiang, Jilin, Inner Mongolia
Ob	Xinjiang
Bo Hai Korean Bay North Coast	Hebei, Jilin, Liaoning, Inner Mongolia
Lake Balkash	Xinjiang
Ziya He Interior	Beijing, Henan, Hebei, Liaoning, Inner Mongolia, Shandong, Shanxi, Tianjin
China Coast	Anhui, Fujian, Guangdong, Jiangsu, Jiangxi, Shandong, Shanghai, Zhejiang
Huang He	Gansu, Henan, Inner Mongolia, Ningxia, Qinghai, Sichuan, Shandong, Shaanxi, Shanxi
Tarim Interior	Gansu, Qinghai, Xinjiang, Tibet
Indus	Xinjiang, Tibet
Plateau of Tibet Interior	Qinghai, Tibet
Yangtze	Anhui, Chongqing, Gansu, Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Qinghai, Sichuan, Shandong, Shaanxi, Tibet, Yunnan
Xun Jiang	Guangdong, Guangxi, Guizhou, Hunan, Yunnan
Hong (Red River)	Yunnan
Ganges Bramaputra	Tibet
South China Sea Coast	Guangdong, Guangxi
Hainan	Hainan
Mekong	Qinghai, Tibet, Yunan

Salween	Tibet, Yunnan
Irrawaddy	Tibet, Yunnan

Table SM5: GCAM-China Grid Regions

Province	Subregion	Province.name	GB.Code	Climate.region	Grid.region
AH	East China	Anhui	34	HSCW	East China Grid
BJ	North China	Beijing	11	C	North China Grid
CQ	Southwest	Chongqing	50	HSCW	Central China Grid
FJ	East China	Fujian	35	HSWW	East China Grid
GD	South China	Guangdong	44	HSWW	China Southern Power Grid
GS	Northwest	Gansu	62	C	Northwest China Grid
GX	South China	Guangxi	45	HSWW	China Southern Power Grid
GZ	Southwest	Guizhou	52	HSCW	China Southern Power Grid
HA	South China	Henan	41	C	Central China Grid
HB	South China	Hubei	42	HSCW	Central China Grid
HE	North China	Hebei	13	C	North China Grid
HI	South China	Hainan	46	HSWW	China Southern Power Grid
HL	Northeast	Heilongjiang	23	SC	Northeast China Grid
HN	South China	Hunan	43	HSCW	Central China Grid
JL	Northeast	Jilin	22	SC	Northeast China Grid
JS	East China	Jiangsu	32	HSCW	East China Grid
JX	East China	Jiangxi	36	HSCW	Central China Grid
LN	Northeast	Liaoning	21	SC	Northeast China Grid
NM	North China	Inner Mongolia	15	SC	North China Grid
NX	Northwest	Ningxia	64	SC	Northwest China Grid
QH	Northwest	Qinghai	63	SC	Northwest China Grid
SC	Southwest	Sichuan	51	HSCW	Central China Grid
SD	East China	Shandong	37	C	North China Grid
SH	East China	Shanghai	31	HSCW	East China Grid
SN	Northwest	Shaanxi	61	C	Northwest China Grid
SX	North China	Shanxi	14	C	North China Grid
TJ	North China	Tianjin	12	C	North China Grid
XJ	Northwest	Xinjiang	65	SC	Northwest China Grid
YN	Southwest	Yunnan	53	HSCW	China Southern Power Grid
ZJ	East China	Zhejiang	33	HSCW	East China Grid

Table SM6: Key Input Data Sources for GCAM-China Calibration

File Name	Description
A_ExoShutdownScalar.csv	Maximum proportion of vintage that can be deployed for exogenous shutdown decider.
A44.hab_land_flsp_china.csv	Provincial administrative area data for China are derived from the Second National Land Survey and previous land change surveys, as provided by the Ministry of Natural Resources' National Land Survey Database (https://gtdc.mnr.gov.cn/Share#/secondSurvey)
China_Compendium_of_Statistics.csv	Historical population data by province in China are derived from the China Compendium of Statistics (60-year statistics)
China_Statistics_Yearbook.csv	Provincial population data for China covering the period 2000–2019 are based on the Annual National Sample Survey of Population
biofuel_MT_province_F.csv	Ethanol and biodiesel production data for Chinese provinces are compiled based on the APEC Expert Group on New and Renewable Energy Technologies (EGNRET) dataset available at the project archive (http://www.egnret.ewg.apec.org/Archive/me_china.html)
CPSY_GWh_province_F_elec_out.csv	Provincial-level electricity generation by fuel in China, expressed in units of 100 GWh, is compiled based on the China Power Statistical Yearbook.
detailed_industry_output.csv	Provincial-level detailed industry output data, expressed in Mt (for steel and coke production) and EJ (for energy consumption), are compiled based on the China Statistical Yearbook and the MEIC-HR Emissions Inventory, with facility-level energy consumption data aggregated to the provincial level.
en_balance_Mtce_Yh_province.csv	Provincial energy balance data for China are reported in million tons of coal equivalent (Mtce). The data are derived from the China Statistical Yearbook, accessed via the Lawrence Berkeley National Laboratory (LBL) China Energy Databook (v9). For years prior to 2014, values follow the Databook records; 2015 values are assumed to be identical to those of 2014; 2021 values follow the China Energy Statistical Yearbook.
floorspace_m2_province_Yh.csv	Historical per capita floorspace for urban and rural households derived from provincial statistical yearbooks.
future_hydro_gen_EJ.csv	Planned hydro electricity generation. 2020,2021 values are derived from NEA; 2025 value are derived from WEO 2019 Current Policies Scenario; other value are derived

	from WEO2023 Stated Policies Scenario.
future_hydro_gen_EJ_adv.csv	2020,2021 values are derived from NEA; Other data are derived from WEO 2019 Sustainable Development Scenario.
GDP_deflator.csv	GDP deflator, taking 2015 USD as base year. https://data.worldbank.org/indicator/NY.GDP.DEFL.ZS?locations=CN
gdp_mil10usd_province.csv	Provincial GDP for China, expressed in million 2010 USD, is calculated for both historical and future periods based on provincial GDP per capita and population. Historical GDP per capita data for 2010–2019 are obtained from the National Bureau of Statistics (NBS) national data portal in current CNY, with values for 2010–2017 adjusted to reflect revisions from the Fourth National Economic Census. All historical figures are converted to 2010 CNY using China-specific GDP deflators from the World Bank World Development Indicators (2020) and subsequently converted to 2010 USD using the annual average USD–CNY exchange rate for 2010. GDP per capita for 2019–2021 is projected using growth rates from the IMF World Economic Outlook (April 2020), including adjustments for the COVID-19 shock in 2020, while long-term projections from 2022 to 2100 follow growth trajectories from the OECD ENV-Growth / IIASA SSP Database (Version 2.0, extracted July 2020).
GDP_raw.csv	Raw provincial GDP data for China in historical years are reported in units of 100 million RMB and are compiled from official national statistical sources using the CNKI data extraction platform, drawing on the China Statistical Yearbook and the China Compendium of Statistics (60-year statistics).
IMF_growth_rates.csv	IMF GDP per capita growth rates-World Economic Outlook (April 2020)
IO_detailed_industry.csv	Input-output data are calculated based on historical energy consumption sourced from the MEIC-HR emission inventory. The energy consumption data could not be used directly due to the inconsistency between IEA data(used in GCAM) and China's energy statistics so the energy consumption share was used to allocate.
irrigation_shares_0p5degree.csv	Livestock water withdrawals by China province; calibrated using historical total water use data from China’s Water Resources Bulletin; copy 2015 to 2021 due to limited data constraints.
livestock_water_withdrawals.csv	Livestock water withdrawals by China province; copy 2015 to 2021 due to limited data constraints.
MEIC2015_province_vint_gen.csv	Existing coal electricity generation data from 2015 for Chinese provinces for use in vintaging

Nuclear_incremental_fixed.csv	Electricity generation from nuclear by province
Population_Growth_Rates.csv	Regional population growth rates are calculated based on historical population data
population_thous_province.csv	Historical data (1975-2018) on national population were obtained from the 2019 China Statistics Yearbook and the China Compendium of 60-year Statistics (1949-2008) SSP growth rates were applied to project future population in China from 2020 to 2100.
province_decile_gdp_per_capita_projections.csv	Province-level projections of GDP per capita deciles under different scenarios are provided to characterize the relative income distribution across Chinese provinces. The dataset reports decile classifications only; corresponding population and GDP values are intentionally left blank, as they are not updated within this dataset. The projections are based on scenario information from the JGCRI PRIDR repository (https://github.com/JGCRI/pridr) and historical statistical context from the China Statistical Yearbook.
regional_fuel_prices_RMB.csv	Provincial fuel price data for China are compiled for refined liquid fuels, natural gas, and coal, with units reported as 2014 RMB per ton for refined liquids, 2015 RMB per thousand cubic meters for natural gas, and 2015 RMB per ton for coal. Refined liquid fuel prices are based on the LBL China Key Energy Statistics diesel price cap for 2014; natural gas prices are obtained from the National Development and Reform Commission (NDRC) price notifications; and coal prices are derived from market data compiled by Coal-link. For Tibet, the diesel price is calculated as a consumption-weighted average of prices within its corresponding grid region using 2010 diesel consumption. Natural gas prices for Fujian and Tibet are similarly computed as grid-level weighted averages based on 2010 LNG and natural gas consumption. In provinces with multiple coal markets, coal prices are represented by the midpoint between the minimum and maximum observed market prices; where provincial coal price data are unavailable, grid-level consumption-weighted averages are applied, and for Guangxi the 2014 coal import price is used.
solar_csp_pv_capacityfactor.csv	Capacity factor for centralized PV and CSP by province are derived from He and Kammen 2016.
solar_potential_province.csv	Provincial-level supply curves are generated by Shen and Yin.
unallocated_	Provincial unallocated CO2 from PNNL's research based on Dahowski et al

CStorage_province.csv	(2010,2017) and Yu et al. (2018)
urban_income_share_province.csv	Urban population fraction in China provinces from China Statistical Yearbook
urban_pop_share_province.csv	Urban population fraction in China provinces from China Statistical Yearbook 2018 Table 2-7. https://springernature.figshare.com/articles/dataset/Projected_provincial_urbanization_rate_for_China/9229841?backTo=%2Fcollections%2FProvincial_and_gridded_population_projection_for_China_under_shared_socioeconomic_pathways_from_2010_to_2100%2F4605713&file=16809551
water_km3_china_ind_Yh.csv	China water withdrawal and consumption for industry, which are calculated using historical water withdrawal data from China's Water Resources Bulletin
wind_potential_province.csv	Provincial-level supply curves are generated by Shen and Yin

Figure SM1: Resource supply curves for onshore wind by province

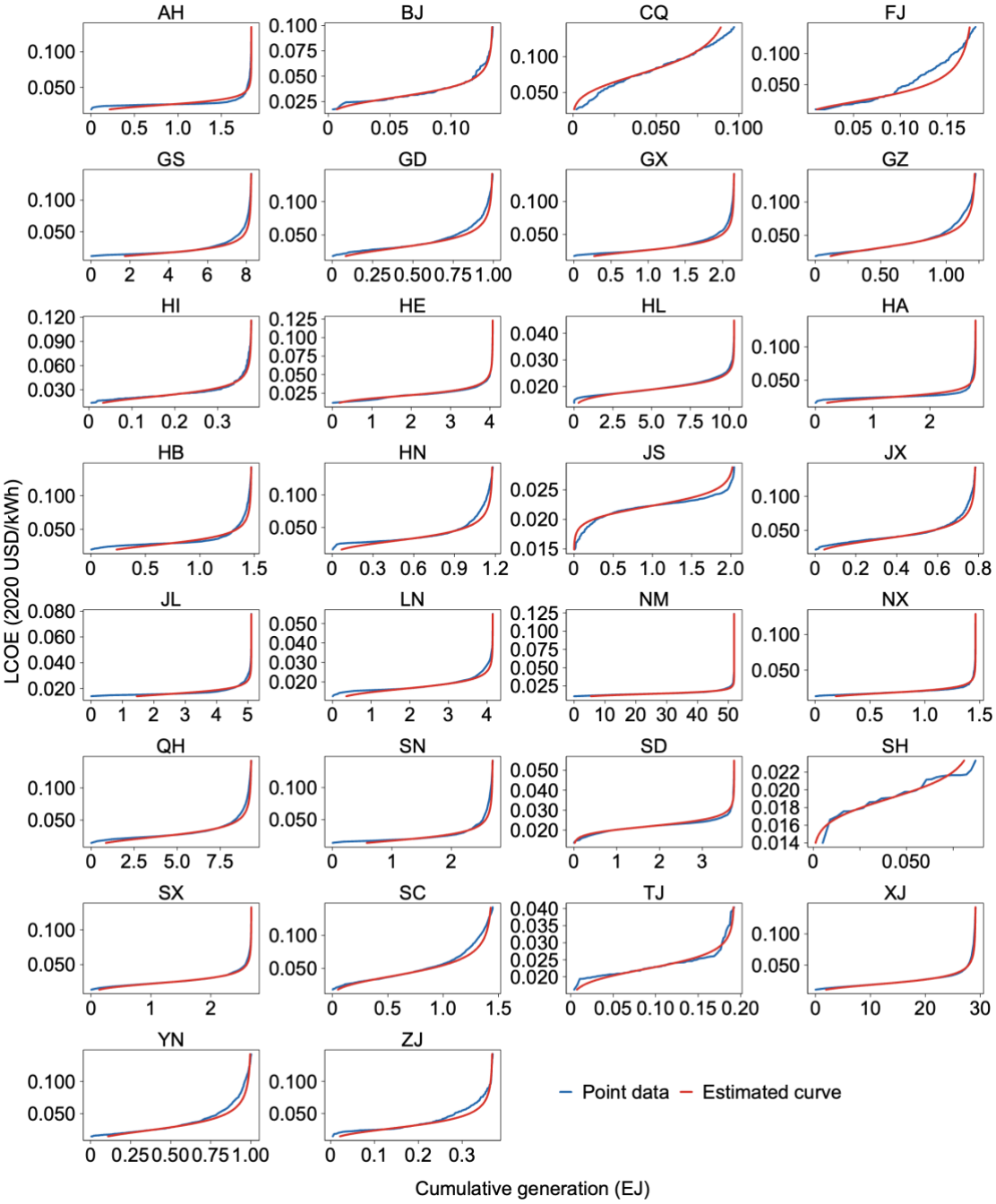

Figure SM1. Resource supply curves for onshore wind by province