Why monitoring renewables and energy efficiency needs accurate balances data?

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IEA Energy Data Centre

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IEA

Overview

- Monitoring **renewables and energy efficiency** : **Why?**
- Reminding the key elements of the **energy balance**
- Understanding **efficiency** from the energy balance
- Understanding **renewables** from the energy balance
- **Beyond energy balances**: what other relevant information to collect?

Monitoring renewables and energy efficiency: why?

How to track economic and social development indicators?

THE 13TH FIVE-YEAR PLAN

FOR ECONOMIC AND SOCIAL DEVELOPMENT OF THE PEOPLE'S REPUBLIC OF CHINA

(2016–2020)

Box 2
Main Economic and Social Development Indicators for the 13th Five-Year Plan Period

Indicator	2015	2020	5-year average [5-year cumulative total]	Type of Indicator
19. Energy consumption reduction per unit of GDP (%)	n/a	n/a	[15]	Obligatory
20. Non-fossil energy (% of primary energy consumption)	12	15	[3]	
21. CO_2 emissions reduction per unit of GDP (%)	n/a	n/a	[18]	

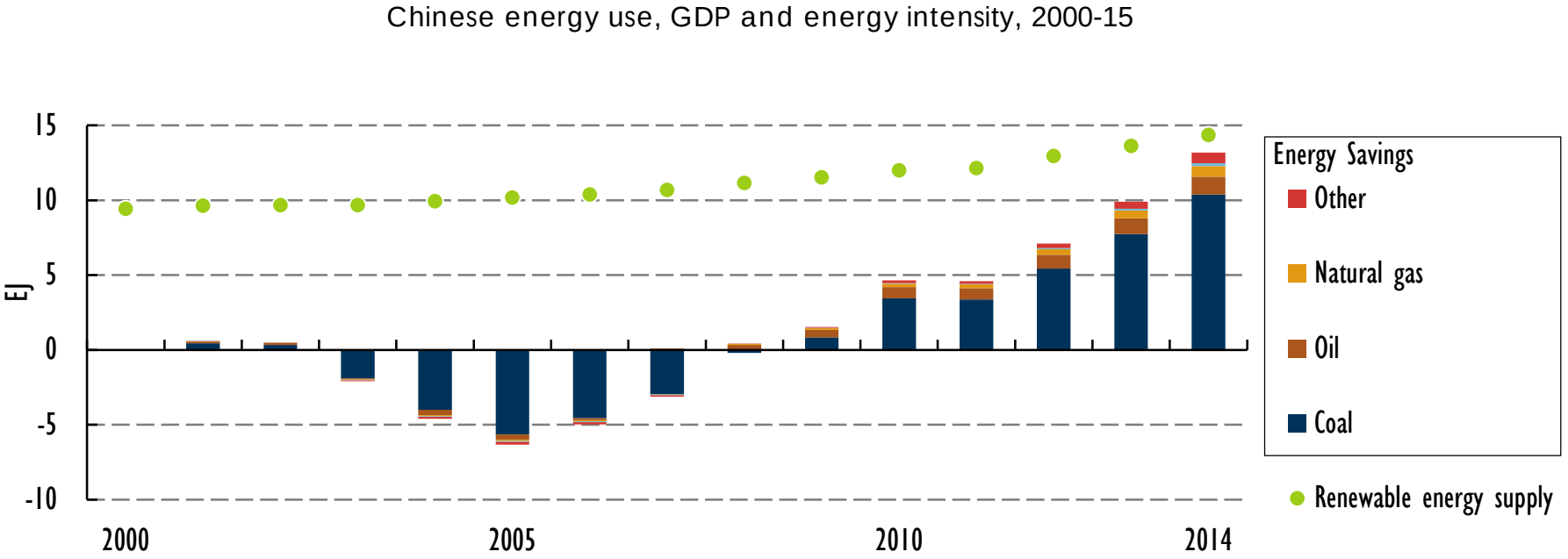
China National Determined Contribution (NDC)

Targets for 2030:

- peak CO_2 emissions by 2030 at the latest
- lower the carbon intensity of GDP by 60%–65% below 2005 levels
- increase the share of non-fossil energy in total primary energy supply to around 20%

Several important targets require indicators relying on energy data

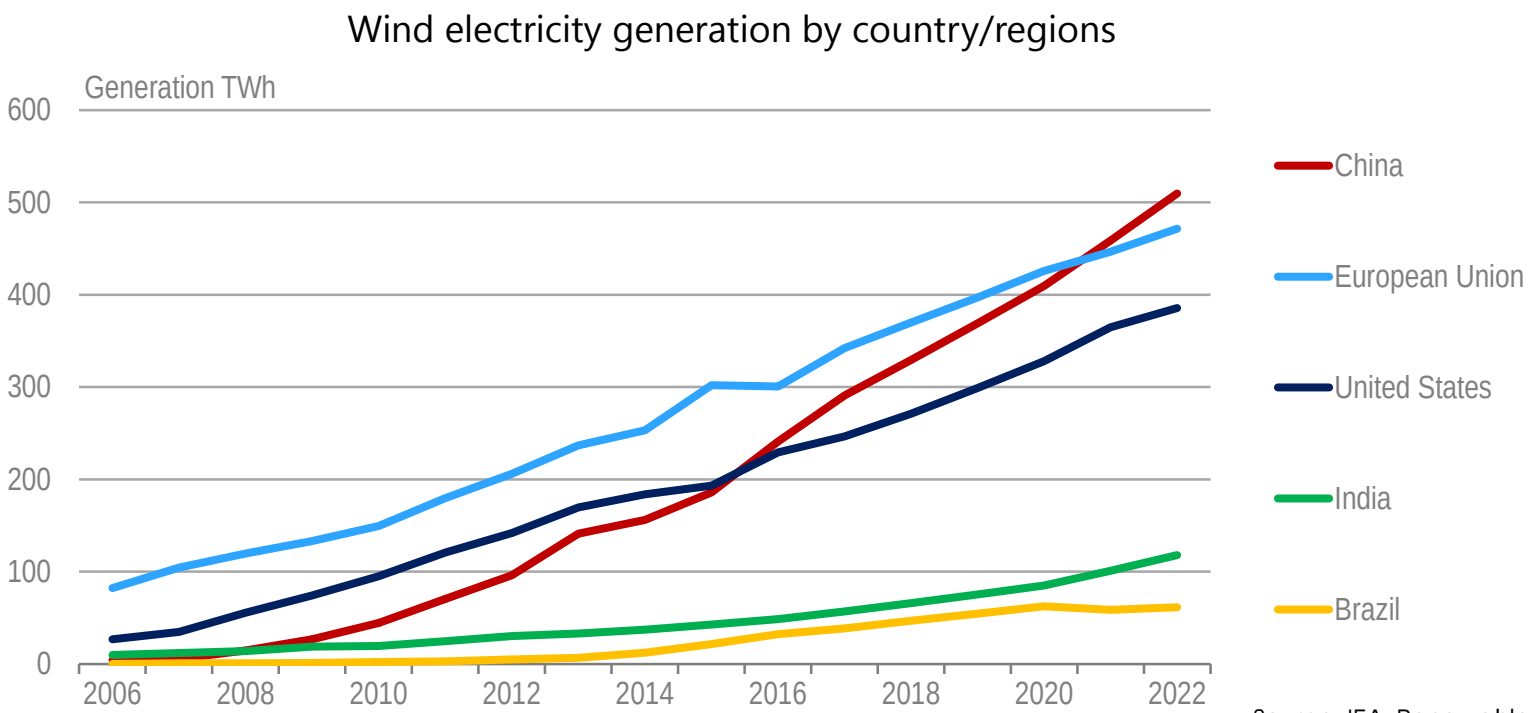
Efficiency and renewables are changing the energy system



Source: IEA Energy Efficiency Market report, 2016

Dramatic progress on energy efficiency since 2006 saved 350 million tonnes of coal in 2014. Energy savings were as large as China's renewable energy supply.

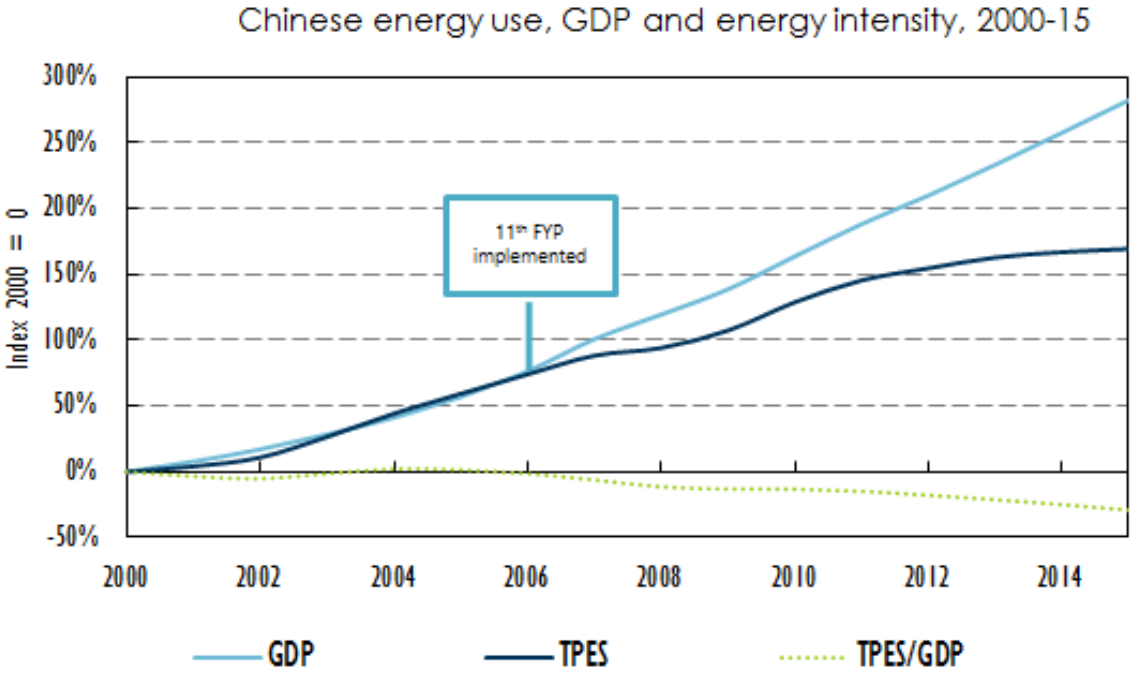
China to surpass EU to become largest wind generator



Source: IEA, Renewables 2017

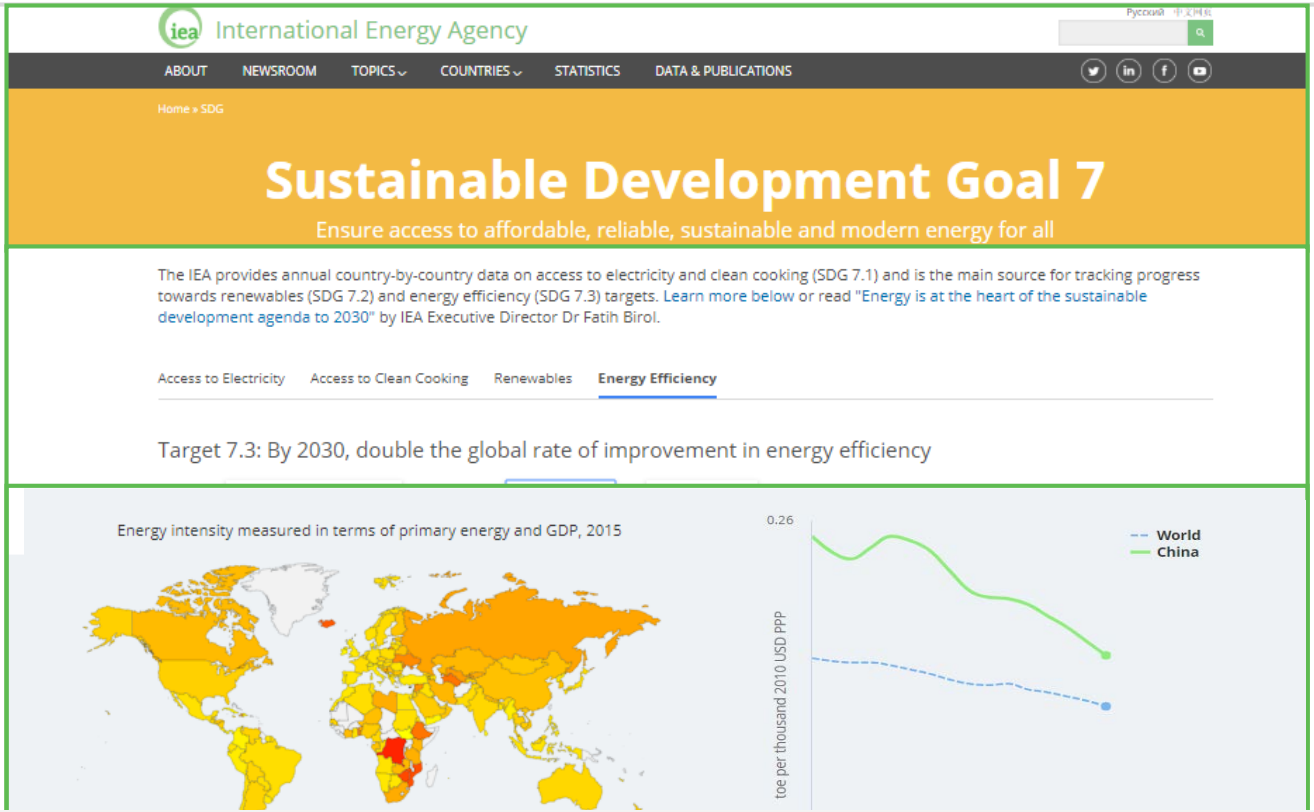
China will generate 30% of global electricity from wind by 2022 but it could generate even more if grid integration challenges are addressed quickly

Policy has been the major driver of energy efficiency in China



Efficiency policies within China's 11th, 12th and 13th five year have made a significant impact. The top 1,000 and 10,000 Programmes are substantial contributors

Renewables and efficiency: core of sustainable development goals



http://www.iea.org/sdg/

Globally, also tracking SDG7 indicators 7.2 and 7.3 also relies on good balances data

Reminding the key elements of the energy balance

The energy balance matrix

	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Production	1868159	214760	0	112618	44509	95844	46236	113508	0	0	2495635
Imports	108753	335483	53573	48640	0	0	0	0	534	0	546982
Exports	-9602	-2866	-41220	-2715	0	0	0	0	-1604	0	-58007
International marine bunkers***	0	0	-9228	0	0	0	0	0	0	0	-9228
International aviation bunkers***	0	0	-7799	0	0	0	0	0	0	0	-7799
Stock changes	14642	-6238	-2734	0	0	0	0	0	0	0	5670
TPES	**1981952**	**541139**	**-7407**	**158543**	**44509**	**95844**	**46236**	**113508**	**-1070**	**0**	**2973254**
Transfers	-971	-1090	2490	0	0	0	0	0	0	0	429
Statistical differences	-9244	-52	2198	689	0	0	0	16	-14	0	-6407
Electricity plants	-920053	-125	-2253	-26070	-44509	-95844	-19980	-21917	502598	0	-628154
CHP plants	0	0	0	0	0	0	0	0	0	0	0
Heat plants	-121455	-67	-4625	-5263	0	0	0	-1468	0	95903	-36975
Gas works	-4777	0	0	1078	0	0	0	0	0	0	-3699
Oil refineries	0	-533291	517383	0	0	0	0	0	0	0	-15908
Coal transformation	-164982	0	0	0	0	0	0	0	0	0	-164982
Liquefication plants	-3642	2185	0	0	0	0	0	0	0	0	-1457
Other transformation	0	0	0	0	0	0	0	0	0	0	0
Energy industry own use	-56075	-4404	-30773	-21719	0	0	0	0	-56417	-11472	-180860
Losses	0	-872	-4	-1839	0	0	0	0	-25696	-1152	-29562

Columns present the "commodity balances" for all energy products

Source: IEA World Energy Balances 2017

Based on NBS data processed with IEA methodology

All data are comparable thanks to a common energy unit - Total energy can be defined

Understanding the three matrix blocks

Supply

Transformation

Final consumption

2015 ▼ | Indicators | Balances | Coal | Electricity and Heat | Natural Gas | Oil | Renewables and Waste

	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Production	1868159	214760	0	112618	44509	95844	46236	113508	0	0	2495635
Imports	108753	335483	53573	48640	0	0	0	0	534	0	546982
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Transfers	-971	-1090	2490	0	0	0	0	0	0	0	429
Statistical differences											07
Electricity plants											4
CHP plants											0
Heat plants											5
Gas works											9
Oil refineries											08
Coal transformation	-164982	0	0	0	0	0	0	0	0	0	-164982
Liquefaction plants	-3642	2185	0	0	0	0	0	0	0	0	-1457
Other transformation	0	0	0	0	0	0	0	0	0	0	0
Energy industry own use	-56075	-4404	-30773	-21719	0	0	0	0	-56417	-11472	-180860
Losses	0	-872	-4	-1839	0	0	0	0	-25696	-1152	-29562
Total final consumption	**700754**	**3423**	**477009**	**105420**	**0**	**0**	**26256**	**90138**	**419401**	**83279**	**1905679**
Industry	**538623**	**2066**	**54758**	**38506**	**0**	**0**	**210**	**0**	**276246**	**55722**	**966131**
Transport	**2442**	**0**	**262056**	**16602**	**0**	**0**	**0**	**2047**	**15448**	**0**	**298596**
Other											2
Residential											9
Commercial and public services											6
Agriculture / forestry	13637	0	17717	79	0	0	640	0	8943	25	41041
Fishing	0	0	0	0	0	0	0	0	0	0	0
Non-specified	21093	0	0	0	0	0	36	0	27499	2959	51586
Non-energy use	**55589**	**1357**	**90804**	**9980**	**0**	**0**	**0**	**0**	**0**	**0**	**157730**
-of which chemical/petrochemical	*0*	*1357*	*55381*	*9980*	*0*	*0*	*0*	*0*	*0*	*0*	*66718*

Rows present energy flows across the various products

Three main "blocks" of flows

Source: IEA World Energy Balances 2017

Based on NBS data processed with IEA methodology

1: Energy supply

	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Production	1868159	214760	0	112618	44509	95844	46236	113508	0	0	2495635
Imports	108753	335483	53573	48640	0	0	0	0	534	0	546982
Exports	-9602	-2866	-41220	-2715	0					0	-58007
International marine bunkers***					0					0	-9228
International aviation bunkers***					0					0	-7799
Stock changes					0					0	5670
TPES					44509					0	2973254

Producers	Mt	% of world total
Saudi Arabia	583	13.5
Russian Federation	546	12.6
United States	537	12.4
Canada	220	5.1
Islamic Rep. of Iran	200	4.6
People's Rep. of China	200	4.6
Iraq	191	4.4
United Arab Emirates	182	4.2
Kuwait	159	3.7
Brazil	135	3.1
Rest of the world	1 368	31.8
World	**4 321**	**100.0**

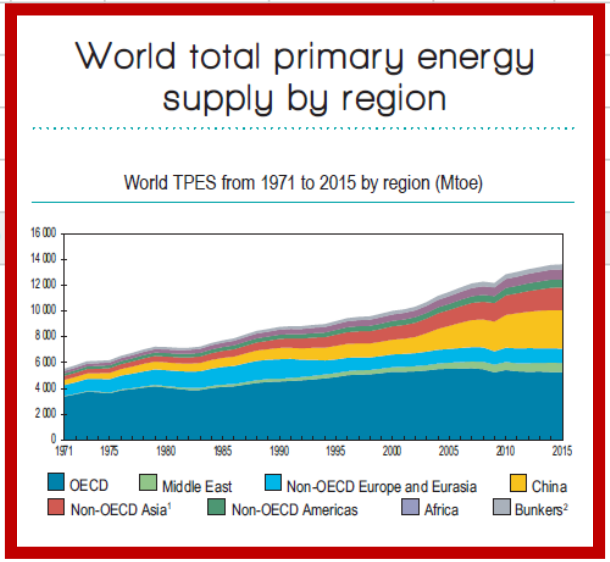
2016 provisional data

Net exporters	Mt
Saudi Arabia	369
Russian Federation	243
Iraq	148
United Arab Emirates	125
Canada	116
Nigeria	104
Kuwait	100
Venezuela	98
Angola	86
Islamic Rep. of Iran	64
Others	539
Total	**1 992**

2015 data

Net importers	Mt
United States	348
People's Rep. of China	333
India	203
Japan	165
Korea	139
Germany	91
Italy	67
Spain	65
Netherlands	59
France	57
Others	514
Total	**2 041**

2015 data



Source: IEA, Key World Energy Statistics, 2017

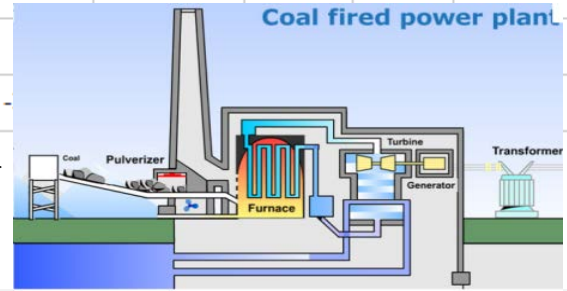
"High-level" information: **Total primary energy supply, production, trade, etc…**

2: Transformation and energy sectors

	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Electricity plants	-920053	-125	-2253	-26070	-44509	-95844	-19980	-21917	502598	0	-628154
CHP plants	0	0	0	0	0	0	0	0	0	0	0
Heat plants	-121455	-67	-4625	-5263	0	0	0	-1468	0	95903	-36975
Gas works	-4777	0							0	0	-3699
Oil refineries	0	-533291							0	0	-15908
Coal transformation	-164982	0	0	0	0	0	0	0	0	0	-164982
Liquefication plants	-3642	2185	0	0	0	0	0	0	0	0	-1457
Other transformation	0	0							0	0	0
Energy industry own use									0		

Transforming energy sources

Input (coal) →



→ **Output (electricity)**

The concept of efficiency = output / input

3: Final consumption

	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Total final consumption	**700754**	**3423**	**477009**	**105420**	**0**	**0**	**26256**	**90138**	**419401**	**83279**	**1905679**
Industry	**538623**	**2066**	**54758**	**38506**	**0**	**0**	**210**	**0**	**276246**	**55722**	**966131**
Transport	**2442**	**0**	**262056**	**16602**	**0**	**0**	**0**	**2047**	**15449**	**0**	**298596**
Other	**104100**	**0**	**69391**	**40332**	**0**	**0**	**26046**	**88091**	**127706**	**27556**	**483222**
Residential	49185	0	35944	30102	0	0	21807	88091	65061	22409	312599
Commercial and public services	20185	0	15731	10150	0	0	3564	0	26204	2163	77996
Agriculture / forestry	13637	0	17717	79	0	0	640	0	8943	25	41041
Fishing	0	0	0	0	0	0	0	0	0	0	0
Non-specified	21093	0	0	0	0	0	36	0	27499	2959	51586
Non-energy use	**55589**	**1357**	**90804**	**9980**	**0**	**0**	**0**	**0**	**0**	**0**	**157730**
-of which chemical/petrochemical	*0*	*1357*	*55381*	*9980*	*0*	*0*	*0*	*0*	*0*	*0*	*66718*

Deliveries of energy products to all final consumers

Understanding efficiency from the energy balance

Overall targets relate to the energy intensity of the economy

Main energy-related targets in China 13th Five Year Plans

		Unit	2010	2015	2020	Growth rate(%)	Type
Total primary energy production		Billion tce		3.6	4	2 (annual)	Indicative
Total energy consumption		Billion tce	3.61	4	<5	<3 (annual)	Indicative
Energy consumption reduction per unit of GDP (energy intensity)		**%**			**-15%**		**Mandatory**
CO_2 emission reduction per unit of GDP (carbon intensity)		**%**			**-18%**		**Mandatory**

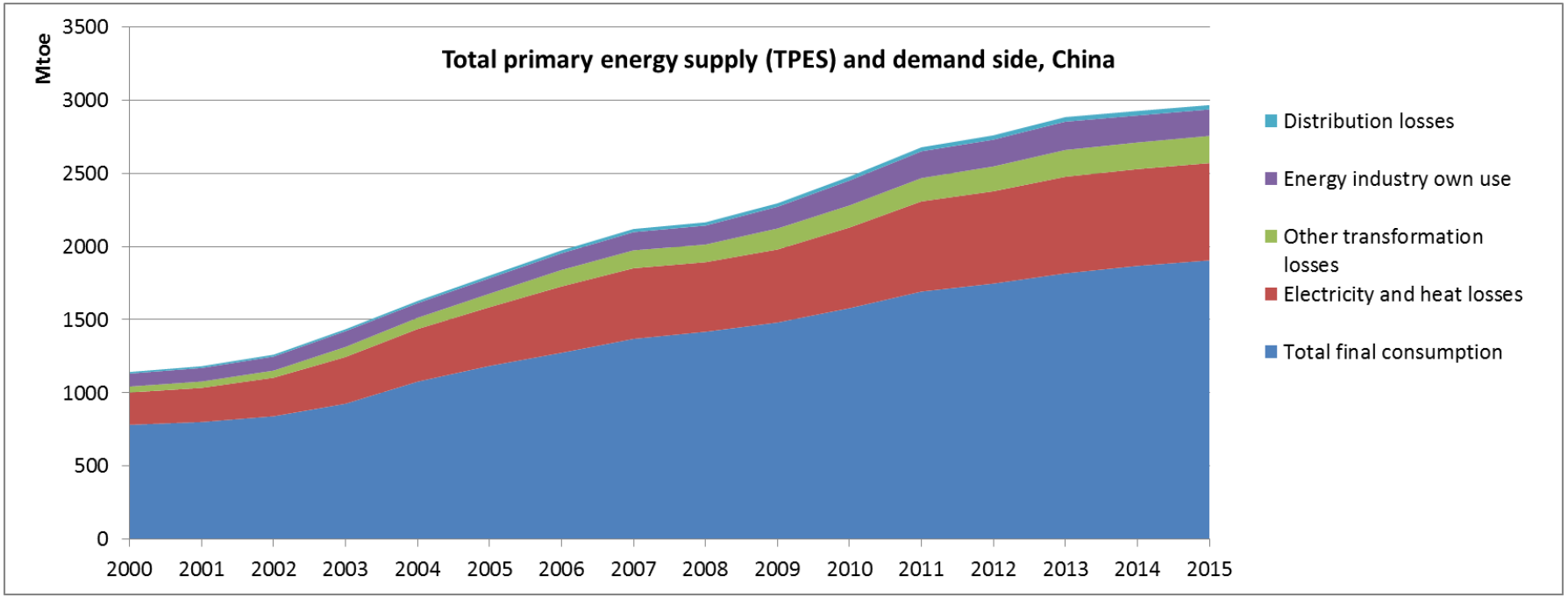
Energy intensity is defined as energy / GDP, and reflects energy efficiency progress among other factors

Energy intensity trends for China

Source: IEA World Energy Balances 2017

Based on NBS data processed with IEA methodology

Understanding why TPES and energy intensity (TPES/GDP) vary



Source: IEA World Energy Balances 2017

Based on NBS data processed with IEA methodology

Overall intensity TPES/GDP depends on efficiency across all demand-side sectors: transformation/energy and final consumption

Transformation efficiency: electricity and heat generation example

Primary electricity is obtained from natural sources such as hydro, wind and solar power, whereas primary heat is obtained from geothermal and solar thermal power. Secondary electricity and heat is produced e.g by burning primary combustible fuels such as coal, natural gas, oil and renewables and wastes. The annual questionnaires classify electricity and heat generating plants into three groups:

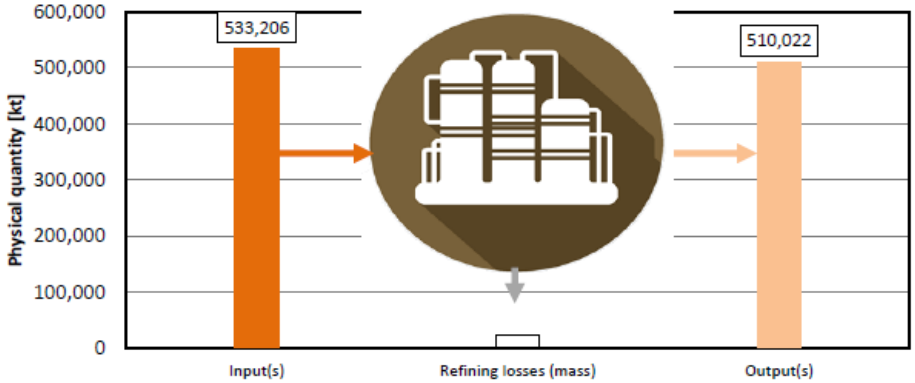
1) Electricity-only plants, which generate electricity only;
2) Heat-only plants, which generate heat only;
3) Combined heat and power plants (CHP), which generate heat and electricity in a combined process.

	Input(s) [ktoe]				Output(s)			
	Coal	Natural gas	Oil	Biofuels/ Waste	Electricity	Heat	Efficiency	*Must always be between 0-100%!*
					GWh	TJ		
4) Electricity-only plants	-920,053	-26,072	-2,378	-21,917	4,327,748		38%	
5) CHP plants	0	0	0	0	0	0	..	
6) Heat plants	-121,455	-5,263	-4,692	-1,468		4,016,045	72%	

Efficiency: output/input (energy units) -- Need good calorific values data for each product. Efficiency computations help checking data quality.

Transformation efficiencies: refinery example

A refinery takes crude oil and separates it into different fractions, then converts those fractions into usable products, and these products are finally blended to produce a finished product. These products are the fuels and chemicals used every day. In a refinery, portions of the outputs from some processes are fed back into the same process, fed to new processes, fed back to a previous process or blended with other outputs to form finished products. Oil products produced and used for energy purposes must be accounted within production.



Refining losses (mass) = Input(s), Total - Output(s), Total
= 533206 kt - 510022 kt
= **23184 kt**
Must always be > 0 !

share of the input: *4.3%*

Ranges:

< 0%	Impossible
0 - 5%	Reasonable
5% - 10%	High
> 10%	Suspicious

Refinery losses are mass differences which appear between the total oil throughput of the refinery (reported as Refinery Intake Observed in Table 1) and the total gross production of finished products (reported in Table 2A). The losses arise through genuine oil losses and the conversion of refinery statistics used within the refineries to mass units.

Oil refinery losses are within reasonable range.

Refinery efficiency: output/input (energy units) < 100% because of energy losses.

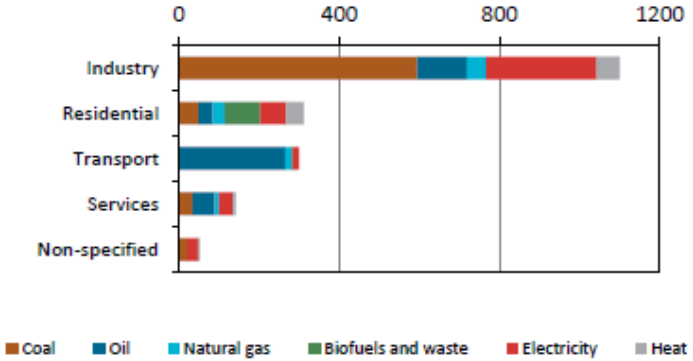
Efficiency in final consumption sectors

Graph 3: Electricity production by source

DEMAND

FINAL ENERGY CONSUMPTION

Total final consumption (TFC) was 1906 Mtoe in 2015. Industry is the largest energy-consuming sector at 1100 Mtoe. It represents 58% of TFC. Residential sector accounted for 16% of TFC in 2015.



Graph 4: Total final consumption, Mtoe

1. Excludes electricity trade
2. Includes geothermal, solar, wind, tide/wave/ocean, heat and other.

Source: IEA World Energy Balances 2017

Based on NBS data processed with IEA methodology

The energy balance helps understand trends of energy use across final sectors. More data would be required to assess end-use efficiency progress

Understanding renewables from the energy balance

Targets mention “non-fossil” consumption, capacity and generation

Main energy-related targets in China 13th Five Year Plans

		Unit	2010	2015	2020	Growth rate(%)	Type
Energy mix	**Non-fossil energy consumption in primary consumption**	%		**9.2%**	**12%**	**15%**		**Mandatory**
	Non-fossil electricity installed capacity	%			**35%**	**39%**	**4**	**Indicative**
	Non-fossil electricity generation	%			**27%**	**31%**	**4**	**Indicative**
	Natural gas consumption	%		4%	5.9%	10%	4.1	Indicative
	Coal consumption	%		69.2%	64%	58%	-6	Mandatory
Solar	**Solar power generation capacity**	**GW**			**43.19**	**110**		
	of which: distributed PV	**GW**		**26**	**43.1**	**60**		
	Utility scale PV	**GW**				**45**		
	Light and heat	**GW**			**0.1**	**5**		
Bioenergy	**Power generation capacity from biomass**	**GW**			**10.3**	**15**		
	of which: Direct Combustion from traditional biomass	**GW**			**5.3**	**7**		
	Waste	GW			4.7	7.5		
	Biogas	**GW**			**0.3**	**0.5**		
	Biogas (methane)	**bcm**			**19**			
	Large-scale biogas	**bcm**				**8 (annually)**		
	Solid biomass	**Mt**			**8**	**30 (annually)**		
	Bio-ethanol	**Mt**			**2.1**	**4 (annually)**		
	Bio-diesel	**Mt**			**0.8**	**2 (annually)**		

Several targets in the five-year plan rely on complete renewable energy data to be tracked

What are the renewable energy products to be included in the balance?

SIEC Headings			Correspondences	
Section/ Division/ Group	Class	Title	CPC Ver.2	HS 2007
5		Biofuels		
51		Solid biofuels		
511		Fuelwood, wood residues and by-products		
	5111	Wood pellets	39280*	4401.30*
	5119	Other fuelwood, wood residues and by-products	03130, 31230, 39280*	4401.10, 4401.21, 4401.22, 4401.30*
512	5120	Bagasse	39140*	2303.20*
513	5130	Animal waste	34654*	3101*
514	5140	Black liquor	39230*	3804.00*
515	5150	Other vegetal material and residues	01913, 21710, 34654*, 39120*, 39150*	0901.90*, 1213, 1802*, 2302*, 2304, 2305, 2306, 3101
516	5160	Charcoal	34510	4402
52		Liquid biofuels		
521	5210	Biogasoline	34131*, 34139*, 34170*	2207.20*, 2905.11*, 2905.13*, 2905.14*, 2909.19*
522	5220	Biodiesels	35490*	3824.90*
523	5230	Bio jet kerosene		
529	5290	Other liquid biofuels		
53		Biogases		
531		Biogases from anaerobic fermentation		
	5311	Landfill gas	33420*	2711.29*
	5312	Sewage sludge gas	33420*	2711.29*
	5319	Other biogases from anaerobic fermentation	33420*	2711.29*
532	5320	Biogases from thermal processes		

SIEC Headings			Correspondences	
Section/ Division/ Group	Class	Title	CPC Ver.2	HS 2007
62		Municipal waste		
620	6200	Municipal waste	39910	3825.10
7		Electricity		
70		Electricity		
700	7000	Electricity	17100	2716
8		Heat		
80		Heat		
800	8000	Heat	17300	2201.90*

Source: United Nations International Recommendations for Energy Statistics (IRES)
https://unstats.un.org/unsd/energy/ires/IRES-web.pdf

Refers to SIEC, Standard International Energy products Classification

It is important to collect data for all renewable products (biofuels)
Also: electricity heat can be generated from renewables.

Biofuels in the energy balance for China

ktoe	Municipal waste (ren)	Primary solid biofuels	Biogases	Biogasoline	Biodiesels	Bio jet kerosene	Charcoal
Production	0	99222	7447	1344	703	0	0
Imports	0	0	0	0	0	0	0
Exports	0	0	0	0	0	0	0
Stock changes	0	0	0	0	0	0	0
Total primary energy supply	0	99222	7447	1344	703	0	0
Electricity plants	0	-18125	0	0	0	0	0
CHP plants	0	0	0	0	0	0	0
Heat plants	0	-453	0	0	0	0	0
Total final consumption	0	80644	7447	1344	703	0	0
Industry	0	0	0	0	0	0	0
Transport	0	0	0	1344	703	0	0
Domestic aviation	0	0	0	0	0	0	0
Road	0	0	0	1344	703	0	0
Rail	0	0	0	0	0	0	0
Residential	0	80644	7447	0	0	0	0
Services	0	0	0	0	0	0	0
Agriculture/forestry/fishing	0	0	0	0	0	0	0

Source: IEA World Energy Balances 2017, Based on NBS data processed with IEA methodology

Renewable energy products are used directly across all transformation and consumption sectors. Are the data complete across products and sectors?

What are the renewable sources of electricity and heat?

ELECTRICITY Unit: MWh
Total
Hydro
Hydro-1 MW
Hydro 1-10 MW
Hydro 10+ MW
Pumped hydro
Geothermal
Solar photovoltaic
Solar thermal
Tide, wave and ocean
Wind
Industrial waste
Municipal waste (renew.)
Municipal waste (non-renew)
Solid biofuels
Biogases
Biodiesels
Other liquid biofuels

HEAT Unit: TJ
Total
Geothermal
Solar thermal
Industrial Waste
Municipal waste (renew.)
Municipal waste (non-renew)
Solid biofuels
Biogases
Biodiesels
Other liquid biofuels

Source: IEA Renewables questionnaire: http://www.iea.org/media/statistics/questionnaires/Renewables_questionnaire_instructions_2016.pdf

Data from all sources need to be collected to produce a complete energy balance

Electricity generation from non-combustible renewables in the energy balance

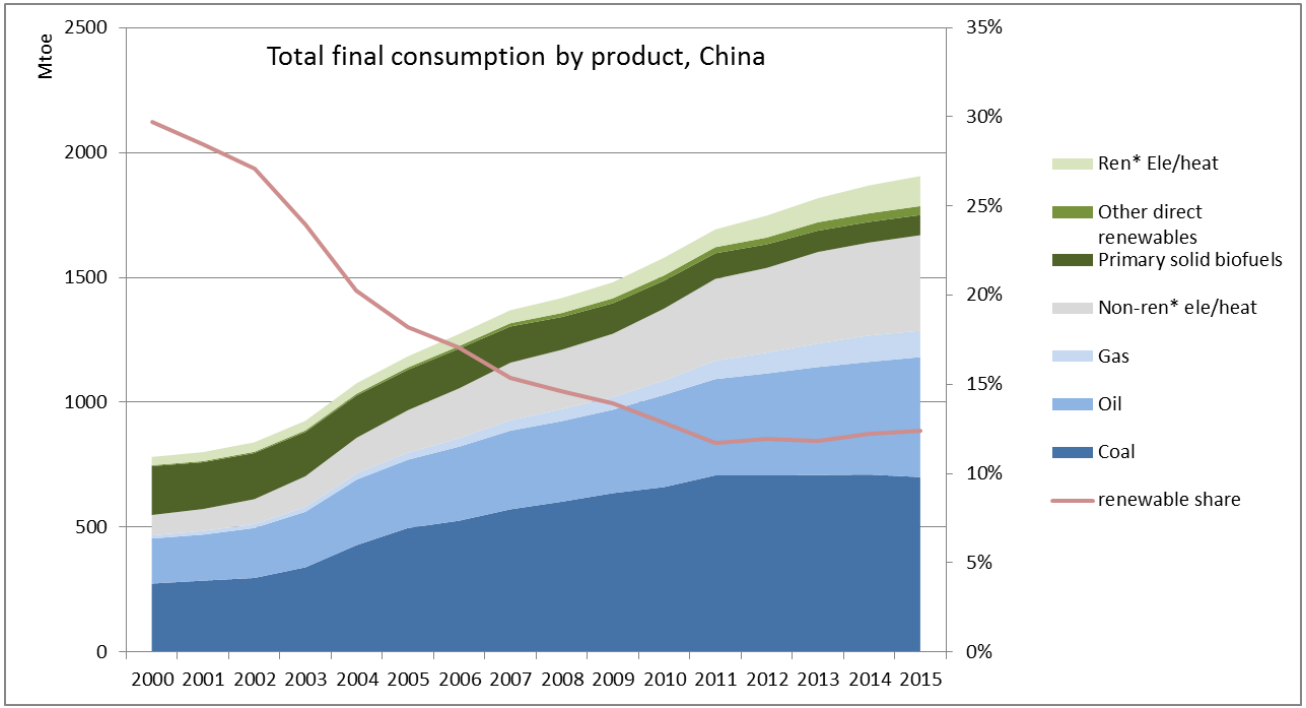
China

ktoe	Hydro	Geothermal	Solar photovoltaics	Solar thermal	Tide, wave and ocean	Wind	Electricity from non-comb. renewables	Total electricity
Production	**95844**	**5059**	**3889**	**21311**	**1**	**15976**	**0**	**0**
Imports	0	0	0	0	0	0	**0**	**534**
Exports	0	0	0	0	0	0	**0**	**-1604**
Total primary energy supply	**95844**	**5059**	**3889**	**21311**	**1**	**15976**	**0**	**-1070**
Transformation processes	**-95844**	**-107**	**-3889**	**-7**	**-1**	**-15976**	**115824**	**502598**
Main activity producer electricity plants	-95844	-107	0	-7	-1	-15976	**111935**	**485850**
Autoproducer electricity plants	0	0	-3889	0	0	0	**3889**	**16747**

Source: IEA World Energy Balances 2017, Based on NBS data processed with IEA methodology

Generation from all renewable sources contributes to the total electricity generation

What is the share of renewables in final consumption for China?



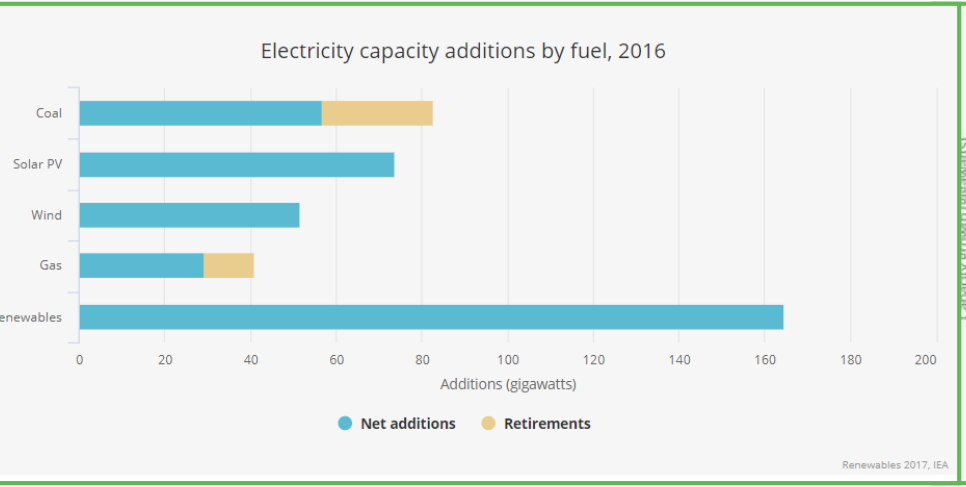
* IEA estimation based on Global Tracking Framework methodology

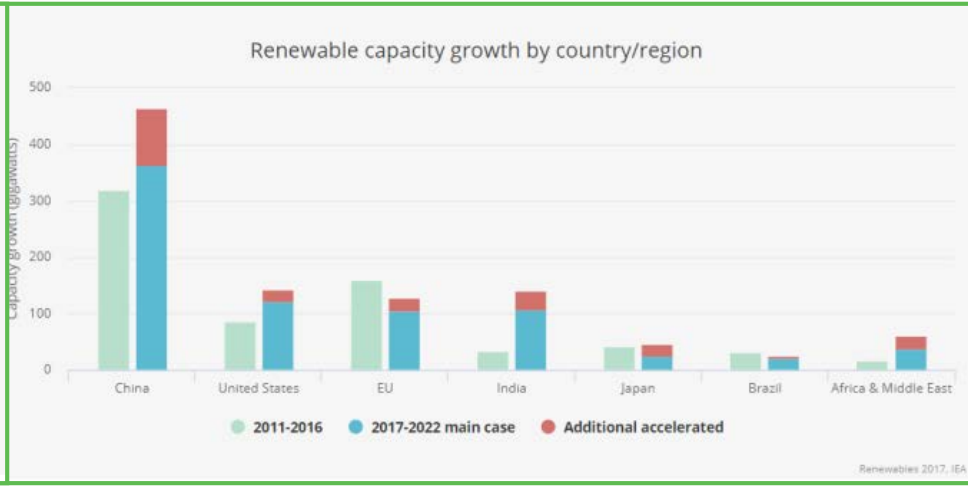
Source: IEA World Energy Balances 2017,
Based on NBS data processed with IEA methodology

Renewables in final consumption include direct use and the renewable fraction of electricity/heat

Beyond energy balances: what other relevant information to collect?

Renewables: capacity data by technology





Source: IEA Renewables 2017

It is important to track installed and retired capacities by size and type

Capacities relate to generation through “capacity factors”

Electric Power Monthly

Data for February 2018 | Release Date: April 24, 2018 | Next Release: May 24, 2018 | full report

Previous Issues — Issue: March 2018 — Format: pdf

Table 6.7.B. Capacity Factors for Utility Scale Generators Not Primarily Using Fossil Fuels, January 2013-February 2018

Period	Nuclear	Conventional Hydropower	Wind	Solar Photovoltaic	Solar Thermal	Landfill Gas and Muncipal Solid Waste	Other Biomass Including Wood	Geothermal
Annual Factors								
2013	89.9%	38.9%	32.4%	NA	NA	68.9%	56.7%	73.6%
2014	91.7%	37.3%	34.0%	25.9%	19.8%	68.9%	58.9%	74.0%
2015	92.3%	35.8%	32.2%	25.8%	22.1%	68.7%	55.3%	74.3%
2016	92.3%	38.2%	34.5%	25.1%	22.2%	69.7%	55.6%	73.9%
2017	92.2%	45.2%	36.7%	27.0%	21.8%	70.9%	50.7%	76.4%

eia U.S. Energy Information Administration

Example for a **specific installation**

Generation

$$\frac{740,000\ \text{MW·h}}{(365\ \text{days}) \times (24\ \text{hours/day}) \times (290\ \text{MW})} = 29.1\%.$$

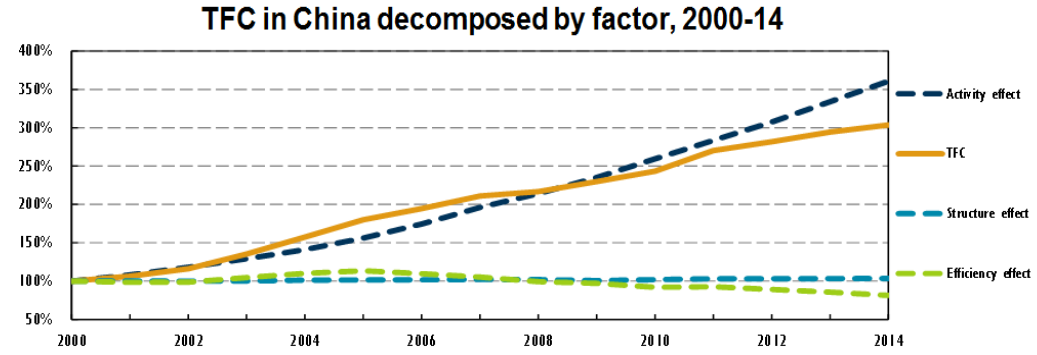
Capacity factor

Capacity

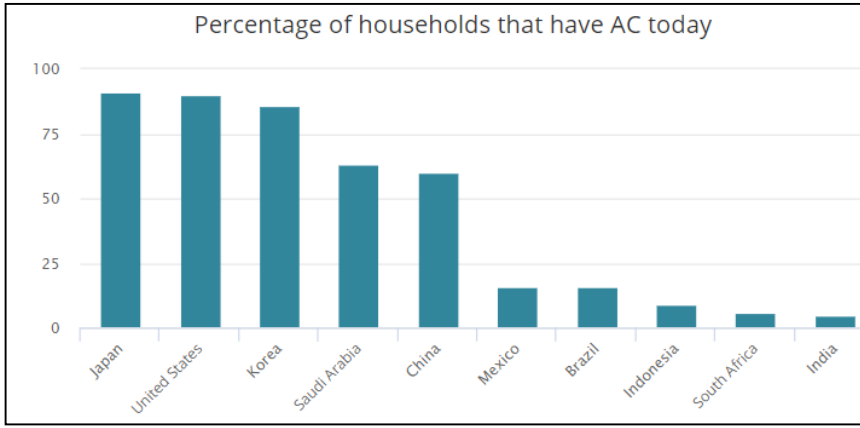
For example, solar PV capacity factors depend on average solar irradiation (latitude/cloud cover) and operational conditions

Energy efficiency: more detailed end-use data than in energy balances

Across all of China's end-use sectors, energy efficiency improved by more than 19% since 2000 and the pace of change appears to be quickening.



Source: IEA Energy Efficiency 2016



Source: IEA The future of cooling, 2018

End-use data across sectors of final consumption help understand demand drivers

The importance of good balances to monitor efficiency and renewables

- Energy balances are a key piece of information to track energy targets
- Energy balances are essential to understand efficiency of energy use across transformation and consumption sectors – therefore energy intensity trends
- Complete energy balances across energy sources are essential to track the change in renewable shares across sectors.
- Data collection following coherent methodologies enhances comparability of energy balances across regions and countries

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