International Energy Agency

Tracking energy efficiency indicators in households

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Joint APEC-IEA training workshop on end-use energy consumption data – Nov. 16th 2022

Why is the residential sector important?

Residential buildings and appliances determine our quality of life!

Overview

1. What we can learn from the **energy balances**?

2. What can we learn from **end-use data and energy efficiency indicators**?

   Examples from similar economies

   Collecting end use data and **developing indicators**

3. How to **collect data** on residential buildings?

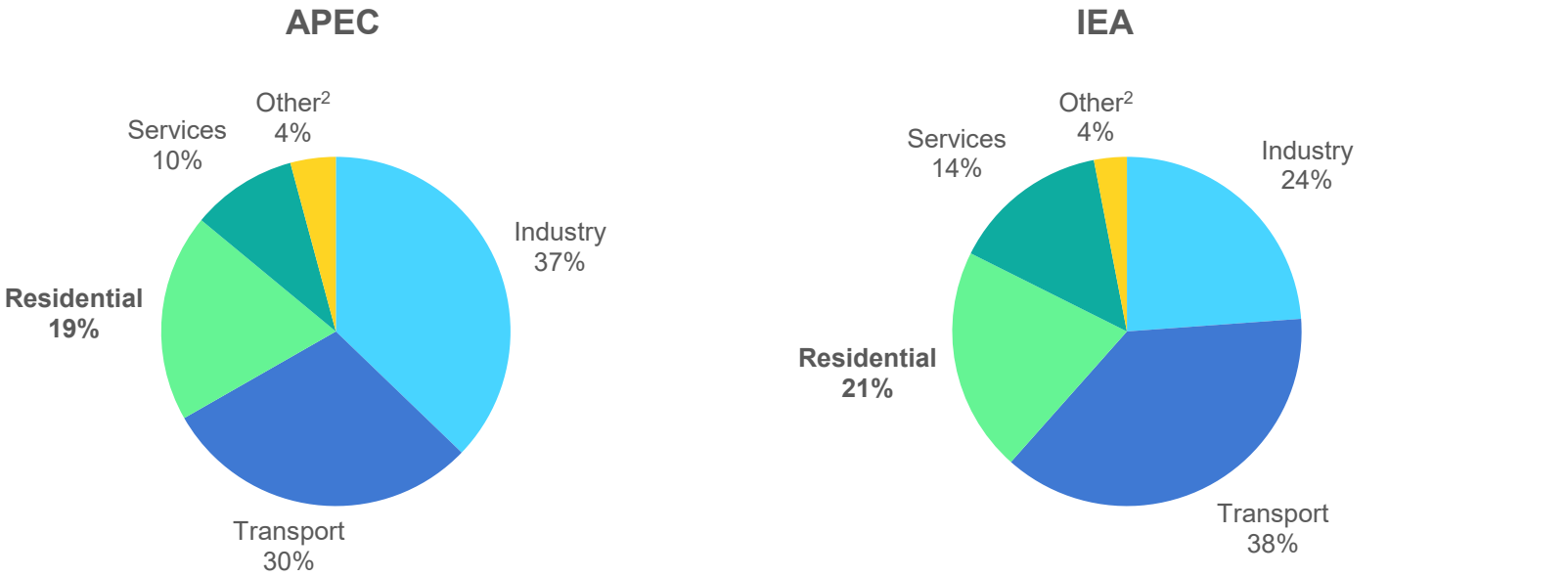
   Data collection: **a dialogue** with other economies

Appendix: how to perform **temperature correction**?

What can we learn from the energy balances?

Residential consumes a fifth of final energy in APEC and IEA

Total final energy consumption[1] in APEC and IEA in 2019

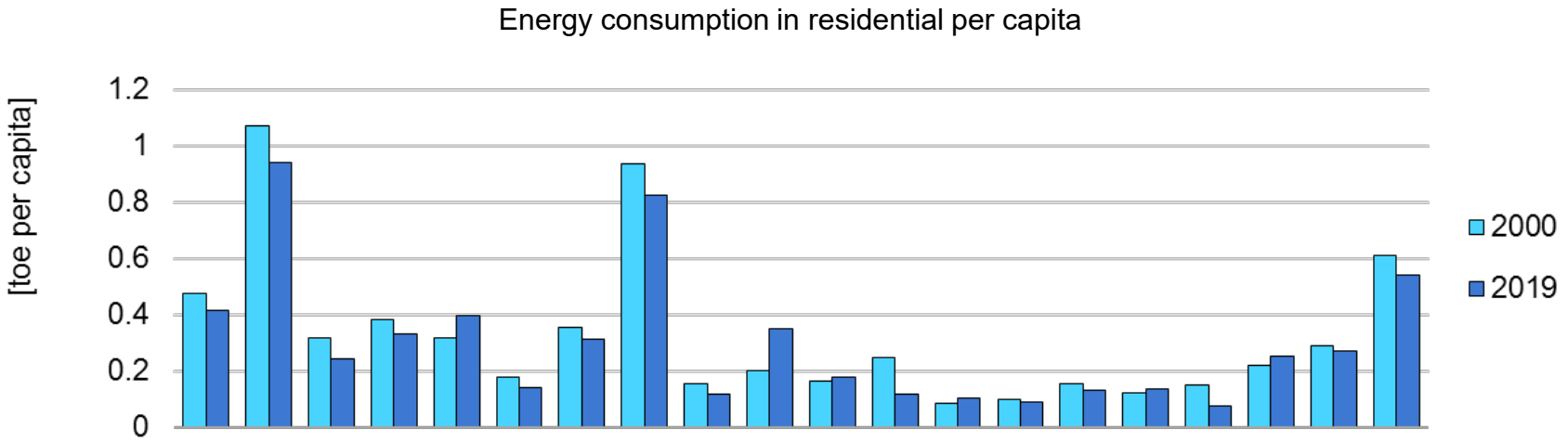


[1] *Total final energy consumption excluding non-energy use*
[2] *Other includes agriculture, forestry, fishing and non-specified final consumption*

Source: IEA Energy Balances, 2021

The residential sector accounts for about 20% of the final energy consumption, both in the APEC and IEA economies. It's the third largest sector, after industry and transport.

Residential energy consumption varies between economies

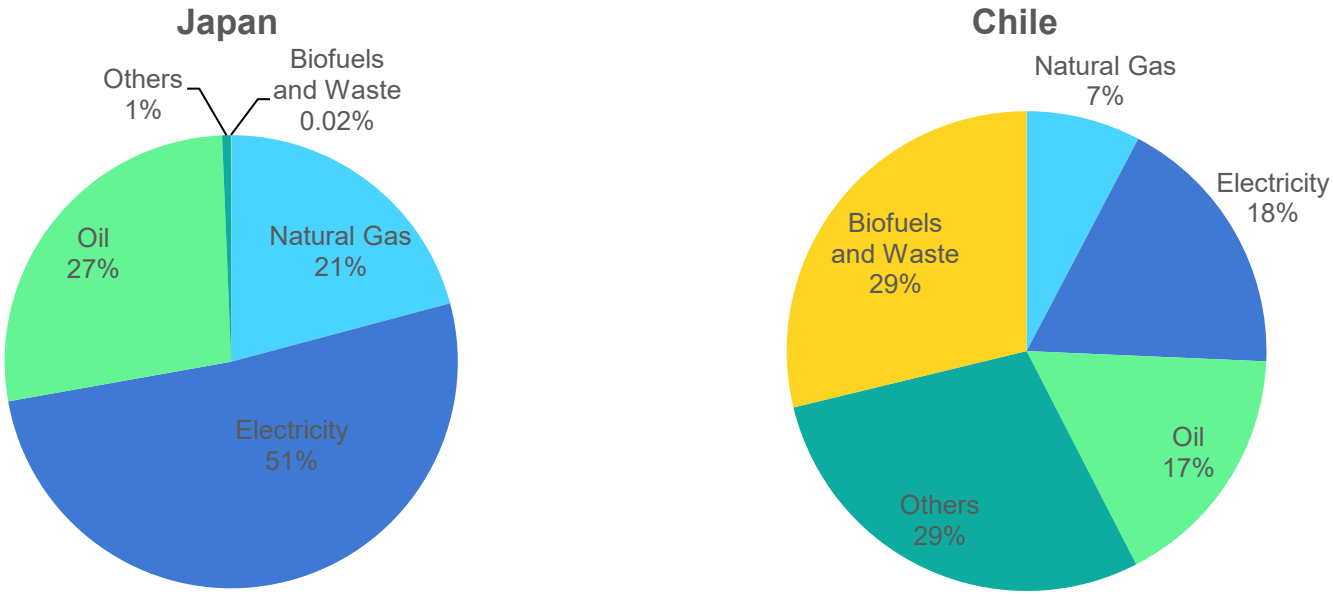


Source: IEA Energy Balances, 2021

Residential consumption is very dependent on the climate and the quality of life (size of dwellings, appliances…), so it varies greatly between economies. Per capita consumption decreased in most places.

Fuel share in residential sector

Energy consumption in residential sector in Japan and Chile in 2019



Source: IEA Energy Balances, 2021

Fuel share may vary depending on heating and cooling systems, main fuel for cooking, and use of residential appliances.

What else do we need to know to track efficiency in residential?

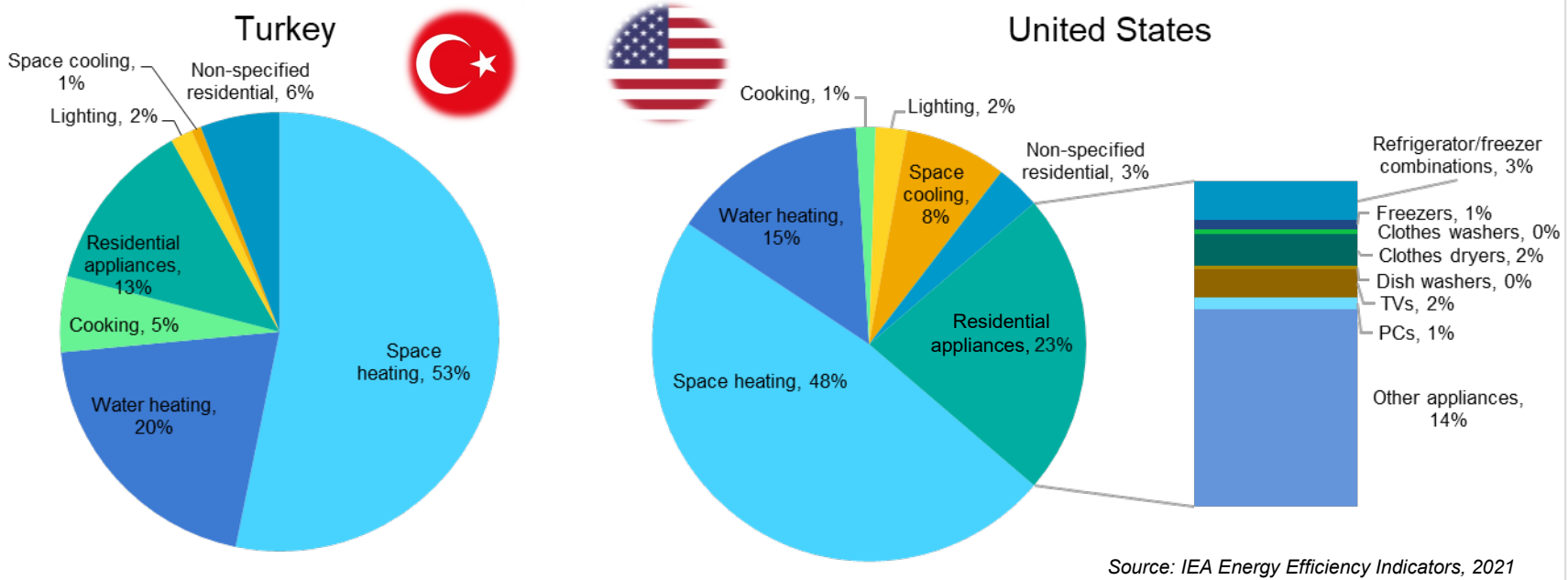
- Which **end uses** consume the most energy (heating, cooking, cooling…)?
- Which **aspect of our life** will be affected in case of **energy price spike**?
- What is the **share of LPG / electricity** used for cooking?
- Are we using energy for **space heating** more efficiently over time?

What can we learn from end-use data and energy efficiency indicators?

Examples from similar economies

Detailed end-use data provides more information for policy focus

Residential energy consumption by end use in Turkey and the United States, 2019

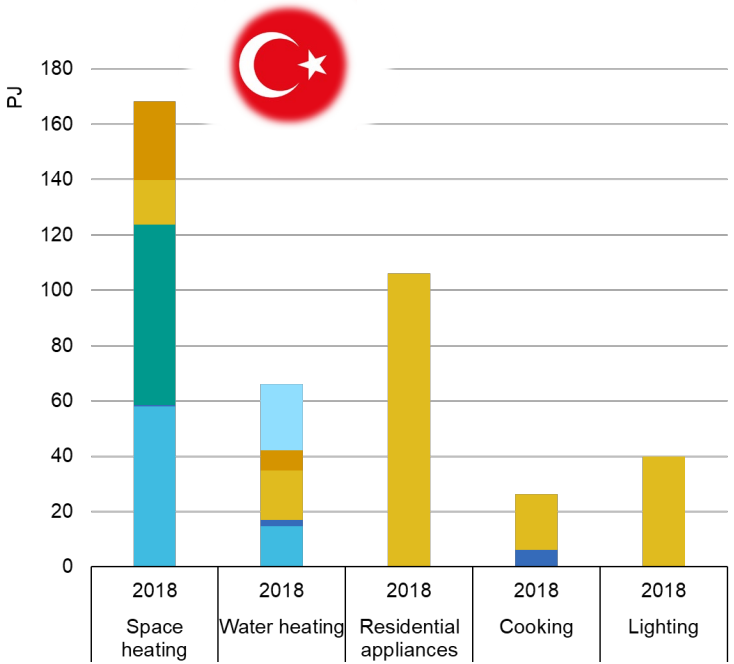


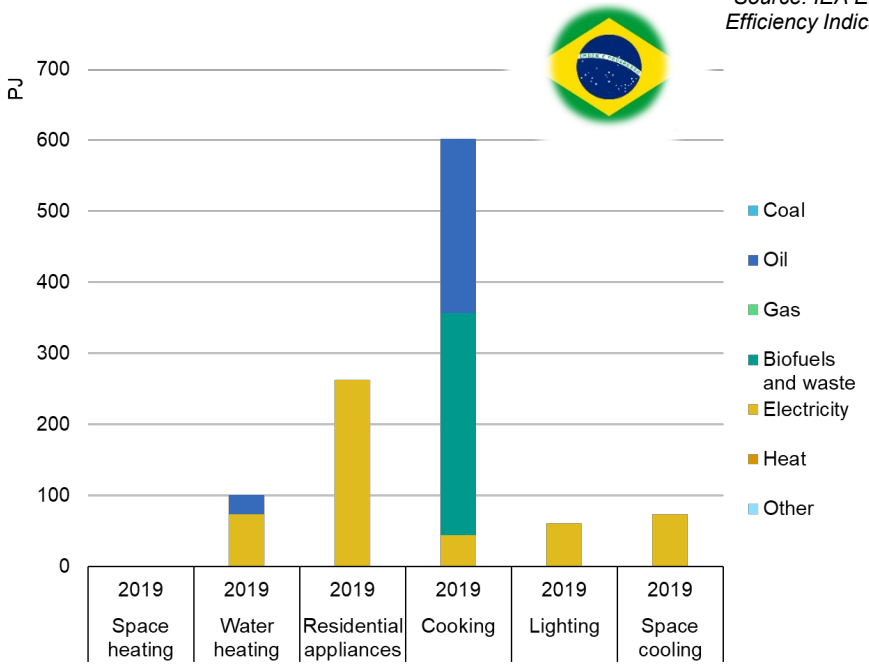
Source: IEA Energy Efficiency Indicators, 2021

Detailed consumption by end use allows to analyse energy consumption.
Turkey and the United States show consumption similarities despite being very different countries.

Fuel share by end use gives crucial insights on the energy system

Residential energy consumption by fuel and end use, in Turkey (left, 2018) and Brazil (right, 2019)

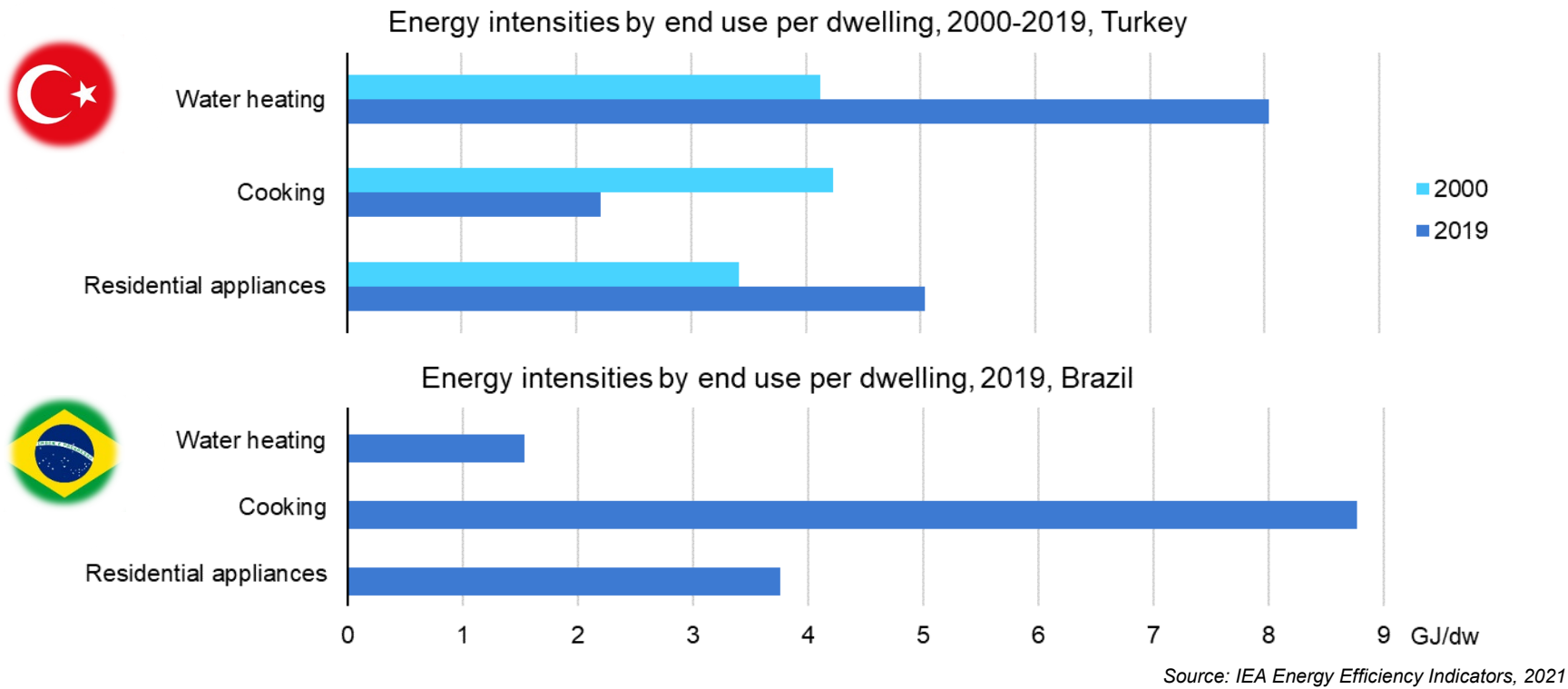




Source: IEA Energy Efficiency Indicators, 2021

Consumption data split by end use and by fuel allows to understand the impact of weather, technology deployment and cultural habits on the energy system.

Efficiency indicators to compare periods and regions

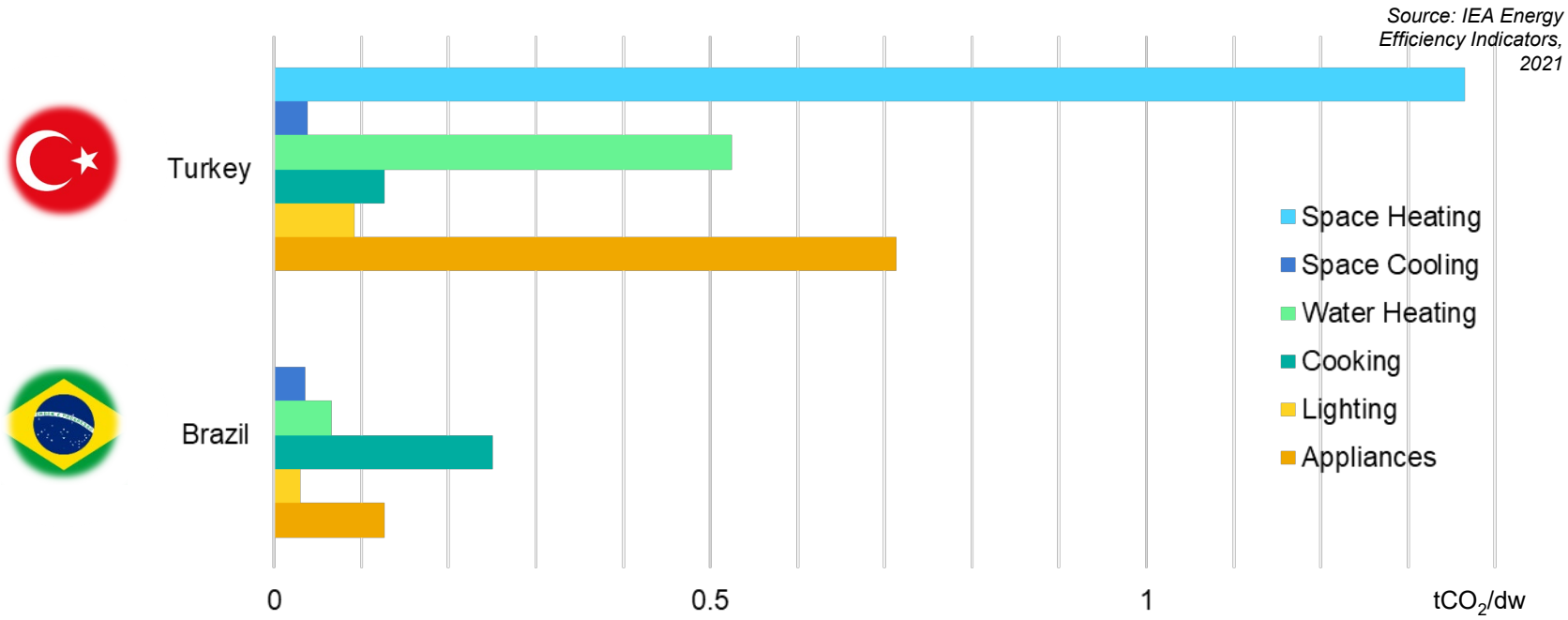


Source: IEA Energy Efficiency Indicators, 2021

Residential consumption by end use and activity data allow to identify the most intensive end uses, follow the evolution through time and compare regions.

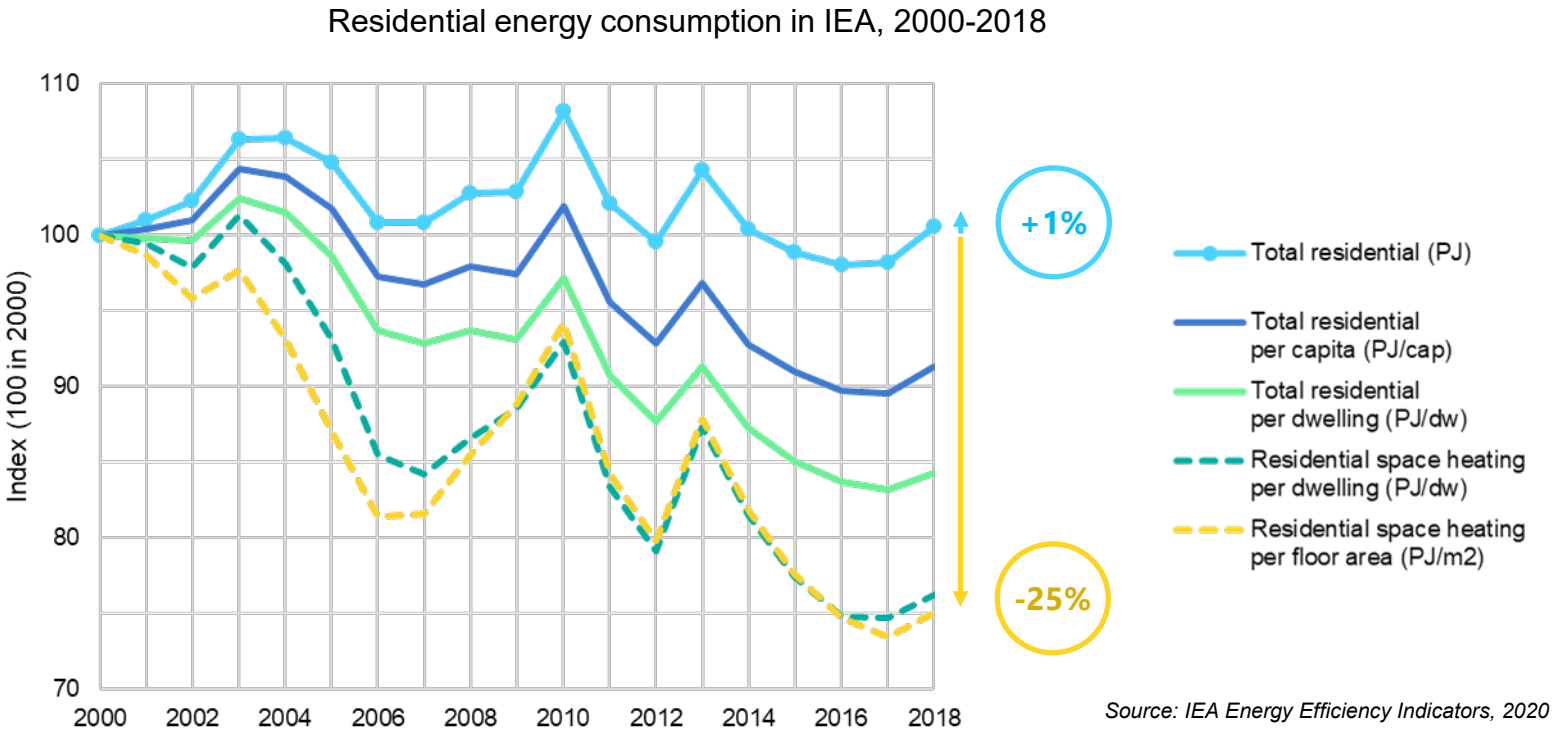
Breaking into different carbon intensities for each end use

Residential carbon intensity of various end uses, in Turkey (left) and Brazil (right) in 2019



End use and fuel shares of residential consumption allow to identify the most intensive end uses. It also clarifies why, from the fuels on which they rely, providing key information to tailor energy policies.

Efficiency indicators to explain consumption patterns and trends



Source: IEA Energy Efficiency Indicators, 2020

Efficiency indicators help understand the trends and key drivers of energy consumption, here thanks to residential activity data: population, number of dwellings and size of dwellings.

Collecting end use data and developing energy efficiency indicators

Residential indicators – Energy and activity data

Energy consumption data

- Space heating*
- Space cooling*
- Water heating
- Cooking
- Lighting
- Appliances energy consumption
  (refrigerator, freezer, cloth washer, cloth dryer, dish washer, TV, computer)

**: Temperature corrected, using HDD and CDD*

Space heating

Space cooling

Water heating

Cooking

Lighting

Appliances

Activity data

- Population
- Number of occupied dwellings
- Residential floor area
- Appliances stock and diffusion

Residential indicators – Energy and activity data

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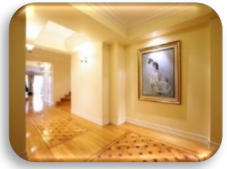
Population

Occupied dwellings



Residential floor area

Appliances stock and diffusion

Icon credits: agus raharjo (creative commons)

Occupied dwellings *vs* total dwellings

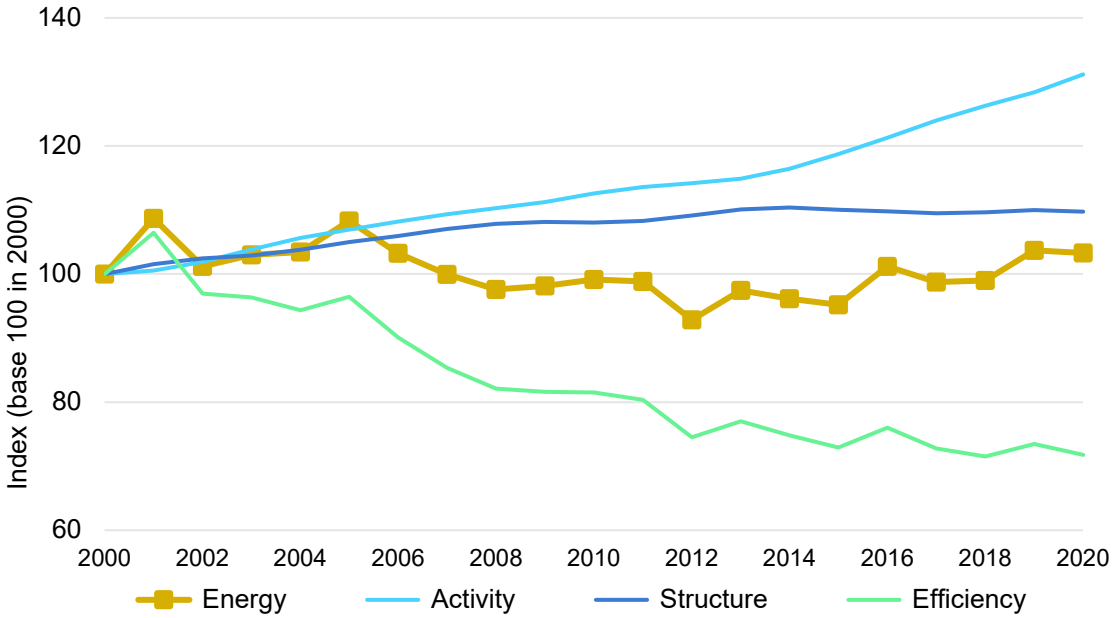
Primary residences

Unoccupied dwellings

Vacation homes

What drives the residential energy consumption?

Drivers of residential energy consumption, New Zealand, 2000-2020



Source: IEA Energy Efficiency Indicators, 2021

Kaya-like equation

Energy consumption

Energy efficiency (energy / activity)

$$E = \sum_{s,f} \frac{E_{s,f}}{A_s} \cdot \frac{A_s}{A} \cdot A$$

Economic structure (sectoral activity / total activity)

Total activity

for each end use s and for each fuel f

Decomposition analysis from detailed end use and activity data gives the respective impact of key drivers of residential energy consumption, and providing key insights for policy design.

Decomposition analysis for the residential sector

Factors of activity, structure and efficiency effects for each residential end use in our decomposition analysis

Sector	Subsector/ End use	Activity	Structure	Efficiency effect
Residential	Residential space heating	Population	Floor area per population	Temperature corrected space heating energy consumption per floor area
	Residential water heating	Population	Occupied dwellings per population	Water heating energy consumption per occupied dwelling
	Residential cooking	Population	Occupied dwellings per population	Cooking energy consumption per occupied dwelling
	Residential space cooling	Population	Floor area per population	Temperature corrected space cooling energy consumption per floor area
	Residential lighting	Population	Floor area per population	Lighting energy consumption per floor area*
	Residential appliances	Population	Appliances stock per population	Appliances energy per appliance stock

Source: IEA Energy Efficiency Indicators, 2021

Activity is tracked though population, number of dwellings, residential floor area, and appliances stock. Various indicators can be build, but one needs to choose carefully the most relevant.

How to collect data on residential buildings?

Methods to collect residential end-use and activity data

 *Administrative sources*	**Basis** as many data are often already gathered. Essential starting point.	*National statistics office* *Land registry* *Building registers*
 *Survey*	Costly but **very effective**. To be **designed carefully**, ideally from existing one. **Representative sample** is key.	*Real estate* *Manufacturers / vendors* *Building managers or residents*
 *Measuring*	Costly but **very effective**. Often **focused** on specific equipment.	*Utilities* *Fuel vendors* *Smart meters*
 *Modelling*	**Complementary to survey** (e.g. for higher frequency) or stand-alone. Requires **robust input** data.	*Sales, stocks and replacement rates of heating / cooling systems and appliances* *New dwellings*

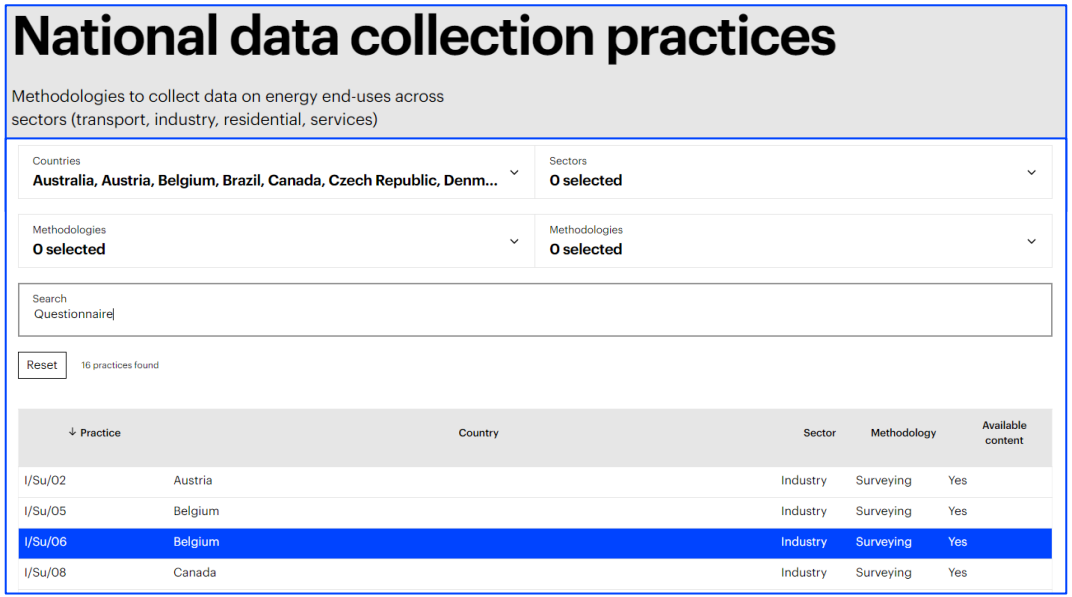
Always check what data may be available in other institutions and how to complete existing data collection, before setting a new one up.

Icon credits: Iconiqu; Nithinan Tatah

Data collection: a dialogue with other economies

What worked well? What to avoid?

IEA sharing platform – An experience database



Contact us at EnergyIndicators@iea.org and share your practice

https://www.iea.org/articles/national-data-collection-practices

A searchable database, gathering data collection practices from a variety of economies, to share expertise worldwide

Successful data collections – Tools

 *Administrative sources*	**Indonesia**	**Digitalise data storage** to efficiently share data
	USA	Consider **merging** with other surveys, **harmonising** data collections
 *Modelling*	**Australia**	**Consolidate estimates** used as input data through feedback
	New Zealand	Ensure **robust quality controls**, from input data to modelling assumptions
 *Survey*	**Philippines**	Carefully design questionnaire, focusing on **user-friendliness, interview time** and multiple languages
	USA	Carefully design surveying tool, including **error and check** management, and accuracy of qualitative questions

Carefully designed tools, based on needs and available resources, are essential for efficient data collections.

Icon credits: Iconiqu; Nithinan Tatah

Successful data collections – Resources and methodology

 *Administrative sources*	**Canada**	Need clear, **reliable institutional arrangements**
 *Measuring*	**New Zealand**	Allow resources and documenting over the **whole deployment time**
 *Modelling*	**Indonesia**	Carefully record **model documentation**
	Mexico	Define **clear assumptions**, in line with available **input data**
 *Survey*	**Hong Kong**	Ensure quality and resilience of the **interviewing staff**
	Thailand	Provide enough staff and resources for **data processing**

Durable resources – in staff, finances and framework – need to be allocated to ensure robust data collections.

Icon credits: Iconiqu; Nithinan Tatah

Successful data collections – Human factors

Administrative sources	**USA**	Ensure **long-term access** to the right respondents
Measuring	**New Zealand**	Ensure **longevity** of measurement agreements thanks to long-term relationships
Survey	**China**	Provide non-monetary incentives and modelling complement
	Indonesia	Establish **local community relationships** to obtain support and increase response rate
	Philippines	Reinforce **institutional arrangements** to ensure survey frequency

Foster relationships with every partner – institutions, companies, communities – is key for high quality data.

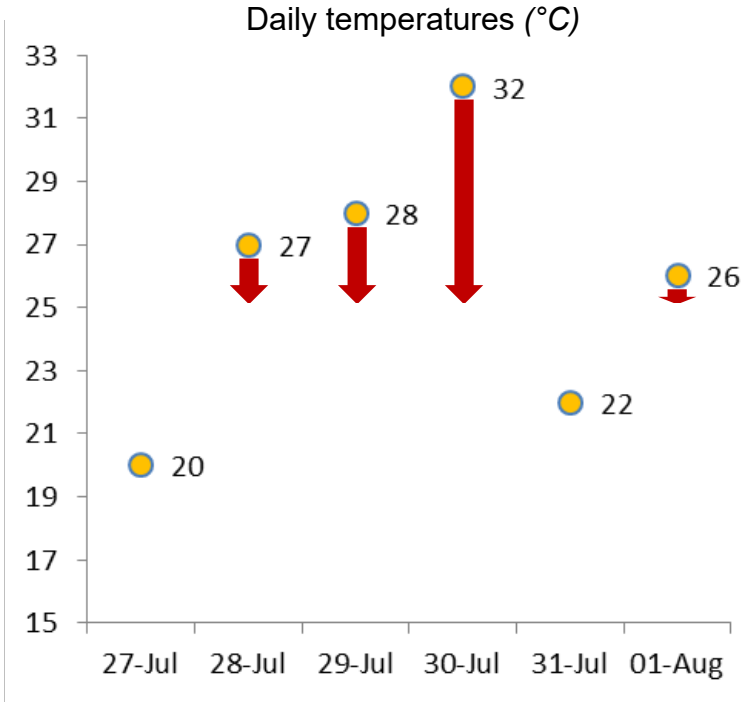
Icon credits: Iconiqu; Nithinan Tatah

APPENDIX
How to perform temperature correction?

Temperature correction – Cooling degree days

Method for CDD

1. Set a temperature threshold
2. For each day, compute the positive difference to the threshold
3. Sum up over the period



$$CDD_{(27Jul\text{-}01Aug)} = 0 + 2 + 3 + 7 + 0 + 1 = 13$$

With warmer weather, we consume more for space cooling in buildings.

Temperature correction – Adjusting energy consumption

Adjusted energy for space cooling
(simplified method)

$$E_{SC}^{adj.} = E_{SC} \times \frac{CDD^{avg}}{CDD_Y}$$

Adjusted energy consumption

Actual energy consumption

CDD of current year

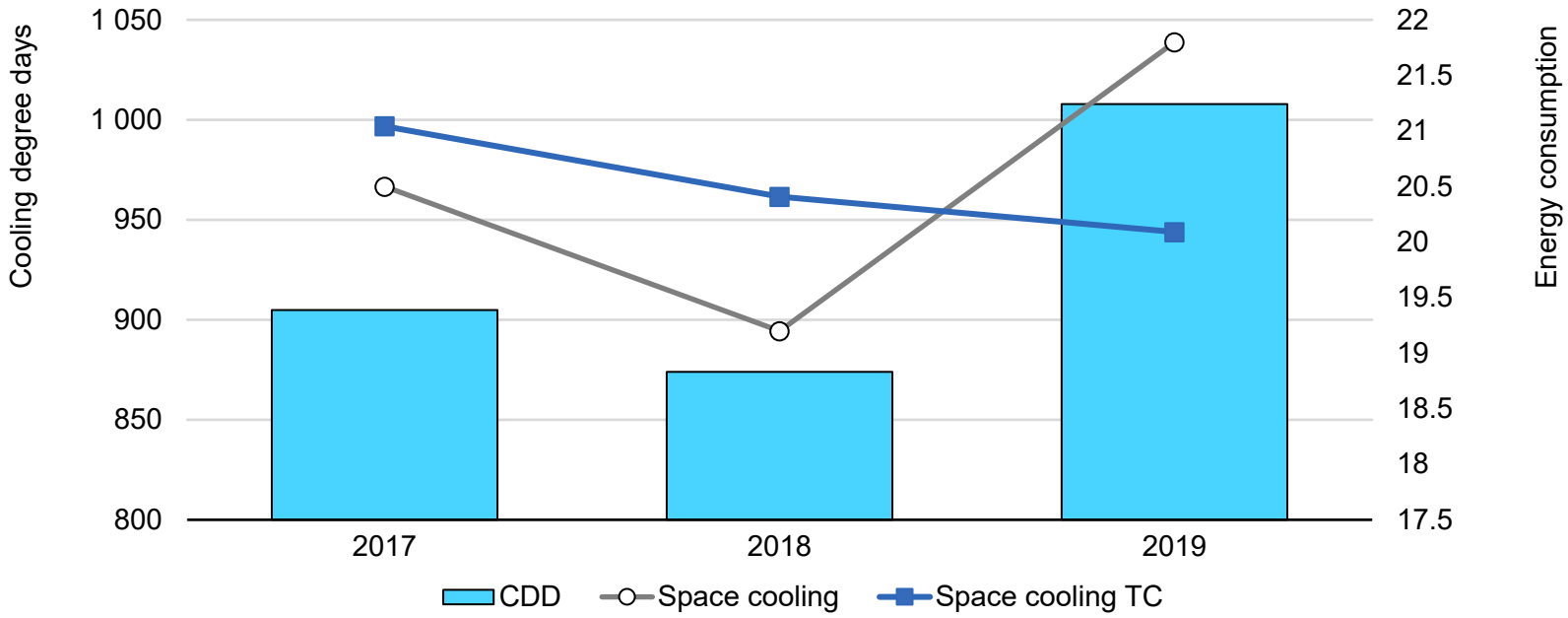
Average CDD

Calculation example

Average CDD over the period $CDD^{avg} = 929$

Year – Y	2017	2018	2019
CDD of year Y – CDD_Y	905	874	1008
Energy for space cooling – E_{SC} *(PJ)*	20.5	19.2	21.8
Adjusted energy for space cooling – $E_{SC}^{adj.}$ *(PJ)*	$20.5 \times \frac{929}{905} = 21.0$	$19.2 \times \frac{929}{874} = 20.4$	$21.8 \times \frac{929}{1008} = 20.1$

Temperature correction – Adjusted energy consumption



Temperature correction allows to identify more clearly the trends, removing the weather impact on consumption.