Total Electricity Demand Forecasting

Methodology description for short-term projection of total electricity demand for Belgium in the framework of the strategic reserve volume evaluation

Elia

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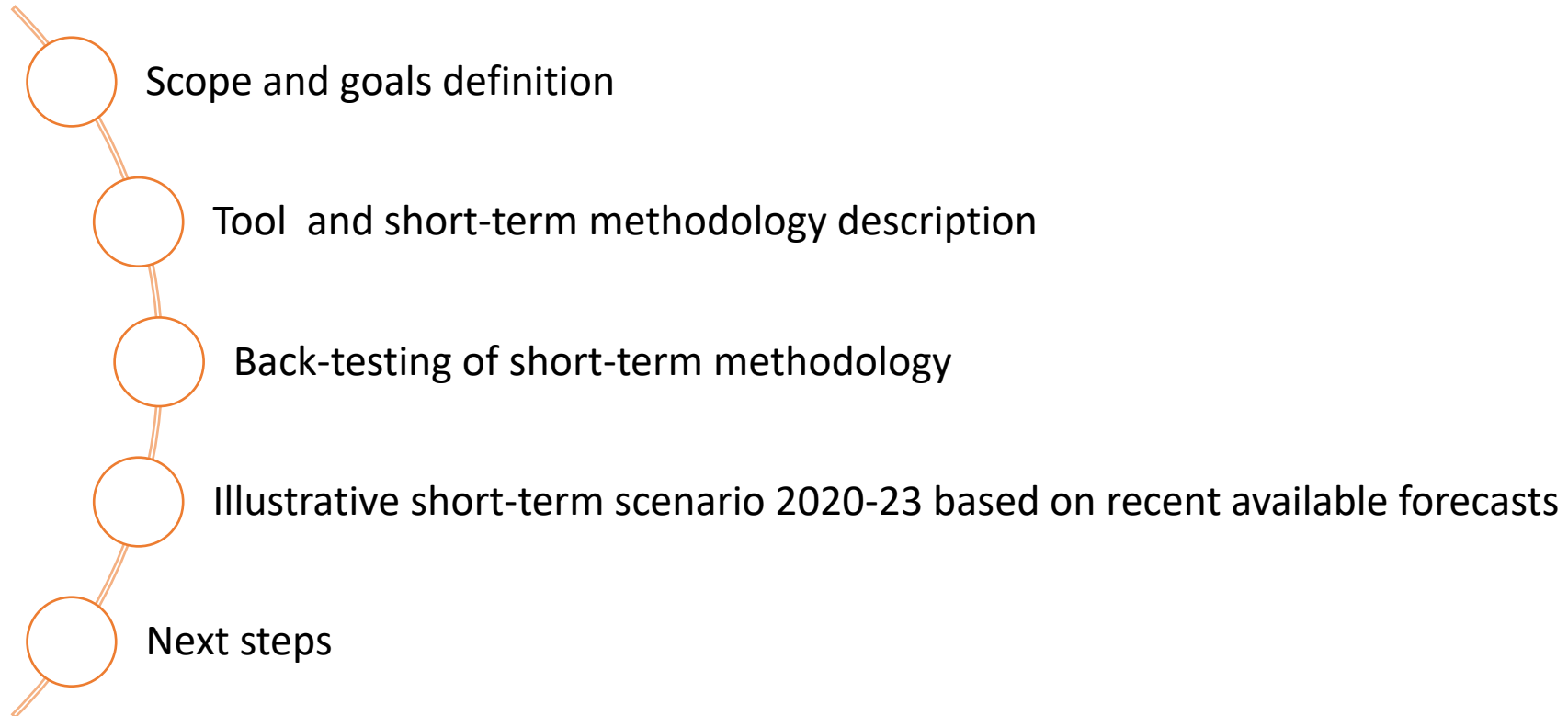**Climact**

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Maïté Jonas
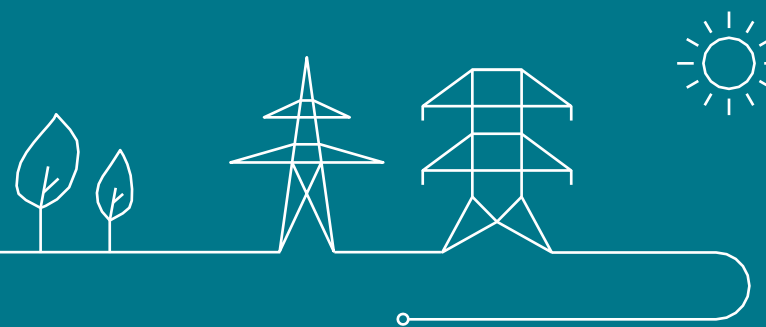
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June 2nd, 2020

Agenda

○ Scope and goals definition

○ Tool and short-term methodology description

○ Back-testing of short-term methodology

○ Illustrative short-term scenario 2020-23 based on recent available forecasts

○ Next steps

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Scope and goals

Elia initiated a project to improve the current projection modelling of total electricity demand for Belgium in the framework of strategic reserve study

Scope

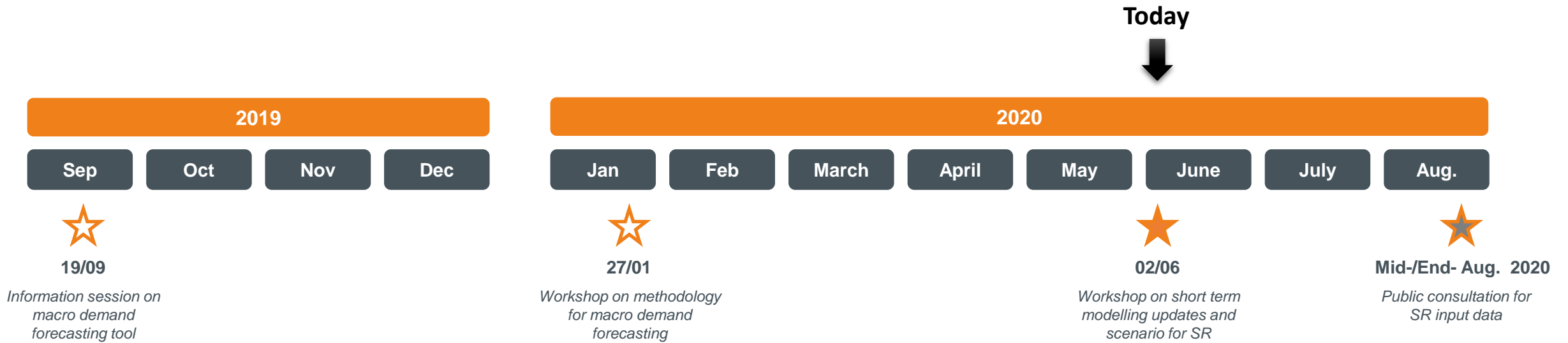*Project launched in the framework of the **strategic reserve volume evaluation** to forecast…*

- **…total electricity demand**

- …for **Belgium**

- …<u>at least</u> from **Y+1** to **Y+3**

Goals

- **Improve current methodology** in Elia in order to replace the IHS Markit projection for future studies

- Refine the approach in order **to better understand the main drivers** behind the evolution of total demand

- **Better integrate policy changes** in the demand forecasting (e.g. macro-economic trends, electric vehicle penetration, etc.)

- Use an **Open-source** tool with **transparent methodology** and **assumptions**

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This workshop completes the previous presentations organized end-2019 and in Jan 2020

Today

2019		**2020**

Sep	Oct	Nov	Dec		Jan	Feb	March	April	May	June	July	Aug.

19/09
Information session on macro demand forecasting tool

27/01
Workshop on methodology for macro demand forecasting

02/06
Workshop on short term modelling updates and scenario for SR

Mid-/End- Aug. 2020
Public consultation for SR input data

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- The **previous workshops** were focused on the **general characteristics/capability of the tool** proposed for the projection of total electricity demand for Belgium

- **This workshop** will be focused on **the methodology developed for short-term projection in the framework of strategic reserve evaluation** and **feedback** can be provided during the **public consultation on the methodology** (detailed report will be published) from the 3rd June to the 1st July

- The **feedback on the scenario/figures for total electricity demand** can be provided in the scope of the public consultation on input data planned for mid-/end- Aug.
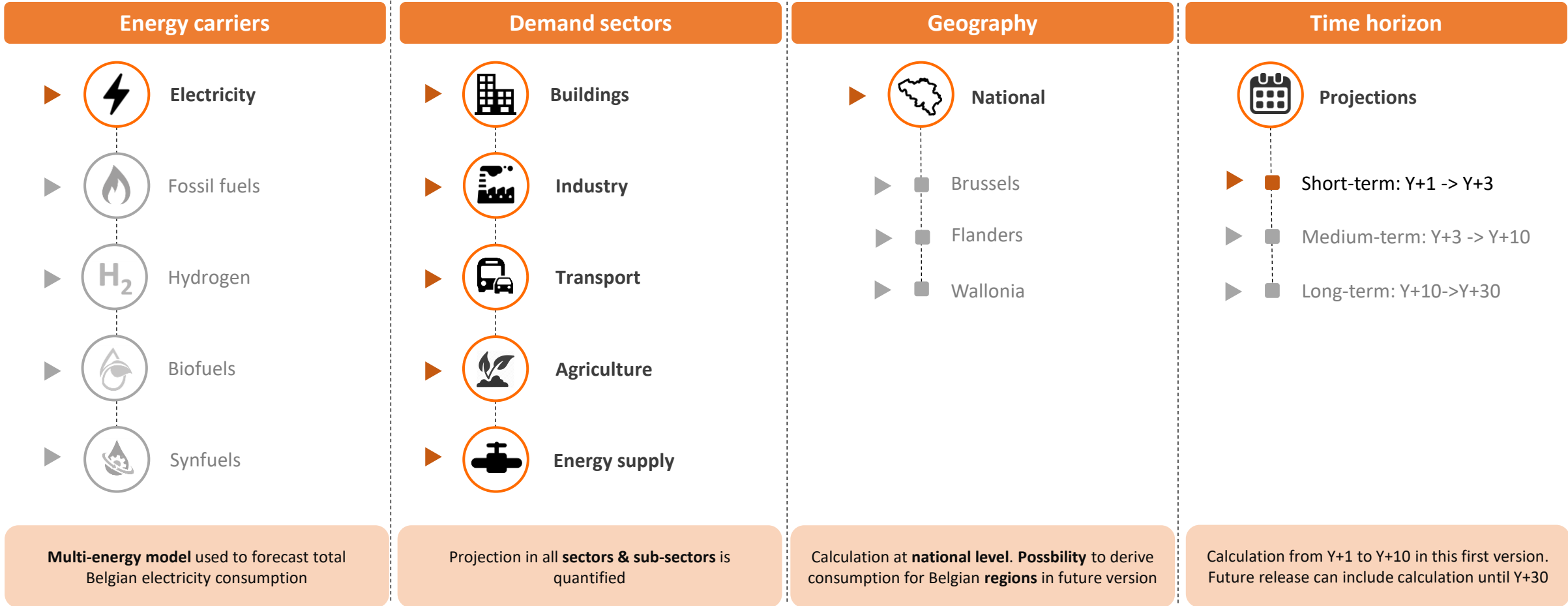
Tool description
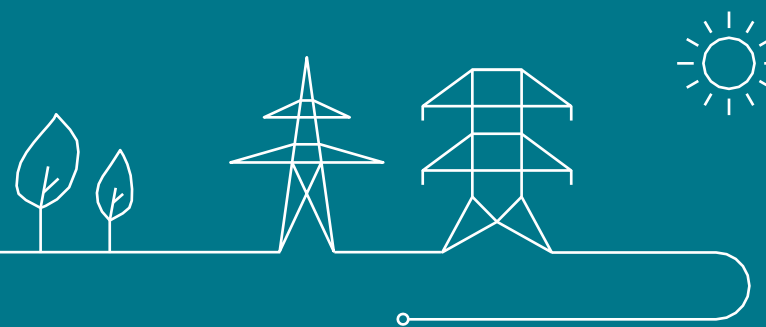
Scope of BECalc tool for total electricity demand forecasting project in the framework of the strategic volume determination exercise

Energy carriers

- **Electricity**
- Fossil fuels
- Hydrogen
- Biofuels
- Synfuels

Multi-energy model used to forecast total Belgian electricity consumption

Demand sectors

- **Buildings**
- **Industry**
- **Transport**
- **Agriculture**
- **Energy supply**

Projection in all **sectors & sub-sectors** is quantified

Geography

- **National**
  - Brussels
  - Flanders
  - Wallonia

Calculation at **national level**. **Possbility** to derive consumption for Belgian **regions** in future version

Time horizon

- **Projections**
  - Short-term: Y+1 -> Y+3
  - Medium-term: Y+3 -> Y+10
  - Long-term: Y+10->Y+30

Calculation from Y+1 to Y+10 in this first version. Future release can include calculation until Y+30

Legend

- Output in the scope of the Elia project for SR study
- Output out of scope of the Elia project for SR study

Update of the 2020 project: the baseyear for projections is now Y-1 (2019)

Short term methodology: general overview
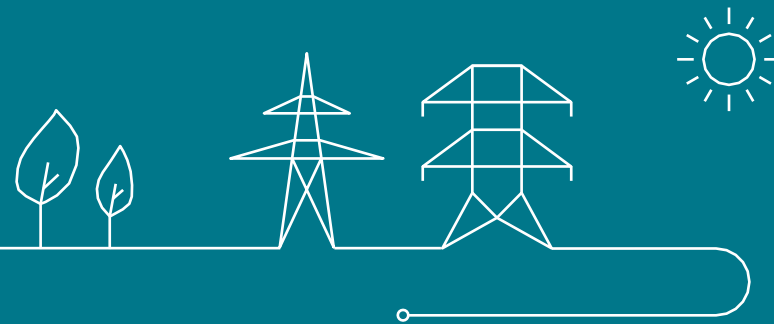
What is the goal of this short-term methodology?

Question

What is the expected electricity consumption for the period 2021-2023 accounting for available macroeconomic forecasts ?

Base tool

- BECalc includes many decarbonization options (= levers), both behavioural and technical

- BECalc computes their impact on energy, including the electricity consumption

Missing

- BECalc models a range of long term societal and technical trends but does not account for short-term macro-economic trends

- BECalc does not give a forecast about the most plausible evolution nor attach any specific likelihood to a given pathway

Needed features of the short-term methodology

- Model the impact of chosen **macroeconomic** variables on BECalc **activity** variables

  > How does an increase of the added value in a sector affect its energy consumption ?

- Account for macroeconomic **projections** from well-known and reliable sources

  > How is the added value expected to evolve up to 2023?

- Perform **sensitivity** analysis on the macroeconomic projections

  > What happens if the increase of added value is smaller than foreseen ?

Various models have been reviewed to assess which macroeconomic indicators they include to perform their projections

Model	Owner	Considered indicators
GEM-E3 [1] / PRIMES [2]	NTUA [3]	• Added Value per sector • Fuel prices/taxes • Energy/environment policies
AMADEUS	RTE	• Added Value per sector • Tertiary Jobs • Population and household size
IHS Markit	IHS Markit	• Added Value per sector • Tertiary Jobs • Disposable income

The literature review shows the macroeconomic indicators that are the most correlated to energy consumption

Source	Author	Considered indicator
Socio-technical factors influencing Residential Energy Consumption,	*SEREC, 2006*	• Income • Household size
The socio-economic, dwelling and appliance related factors affecting electricity consumption in domestic buildings	*Jones et al., 2015*	• Income • Household size
Analysis of Energy Efficiency trends and policies in BELGIUM using ODYSSEE-MURE databases and tools, 2018	*Econotec and DG Energy, 2018*	• GDP per sector • Private consumption (link with income)

SOURCE: Climact analysis

These macroeconomic indicators are chosen to be linked with BECalc activity variables

Macro-economic indicators	Activity variables

Average disposable income
- Passenger transport demand
- Appliance own and use
- Living space per person

Industry added value
- Freight transport demand
- Industry material production

Tertiary added value
- Surface for tertiary buildings

Environmental/energy policies
- Technology share of vehicles
- Renovation rate and depth

Legend
- Lifestyles
- Industry
- Residential
- Tertiary
- Transport

+

Population — Population

Households — Average household size

The link between macroeconomic and activity variables is expressed with a linear regression

1

Goal: investigate the link between macroeconomic variable **A** and activity variable **B**

⇨

2

Computation of the linear regression between **A** and **B** on historical values up to 2017
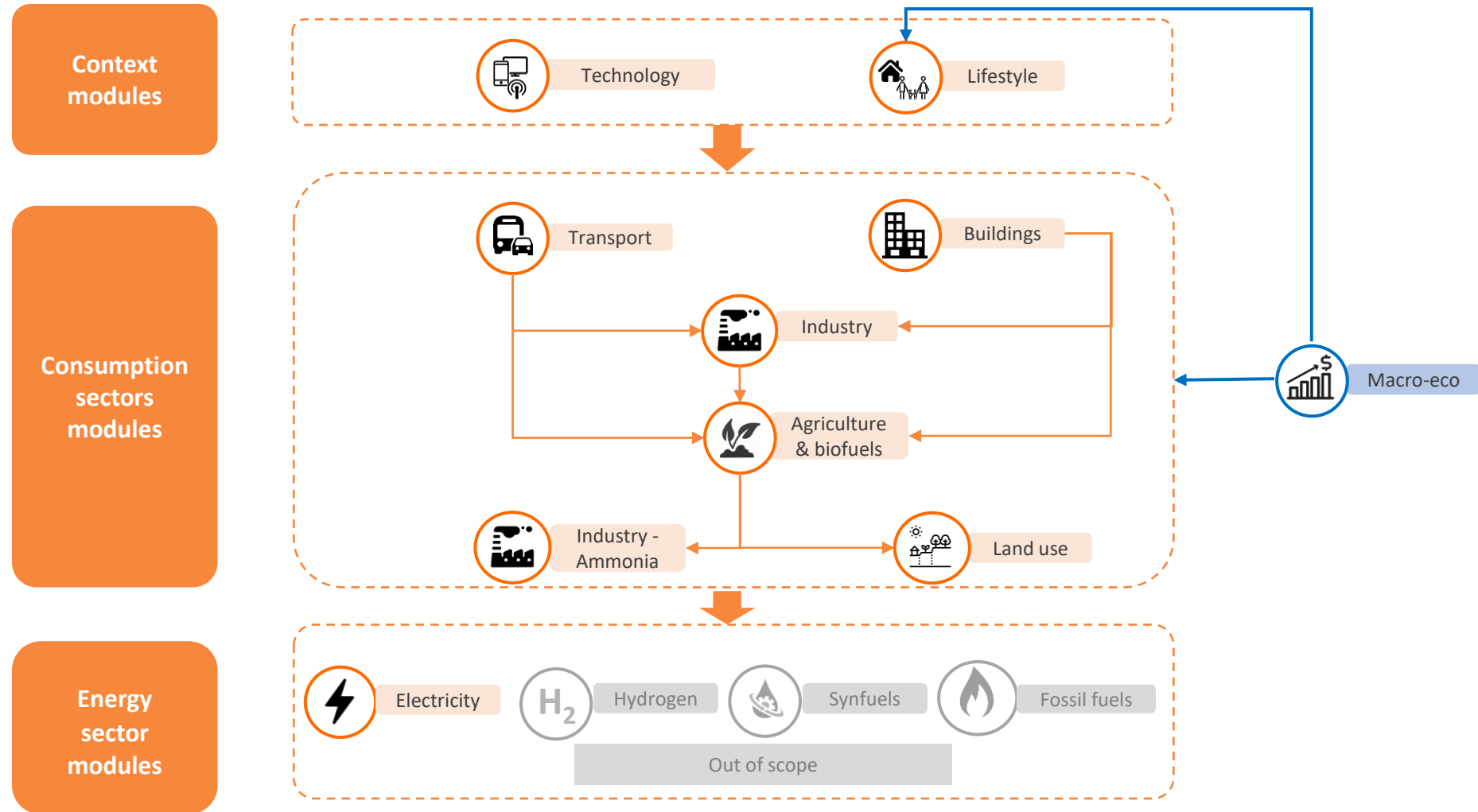
⇨

3

Compute $B^{proj} = a\, A^{proj} + b$

$$B = aA + b$$
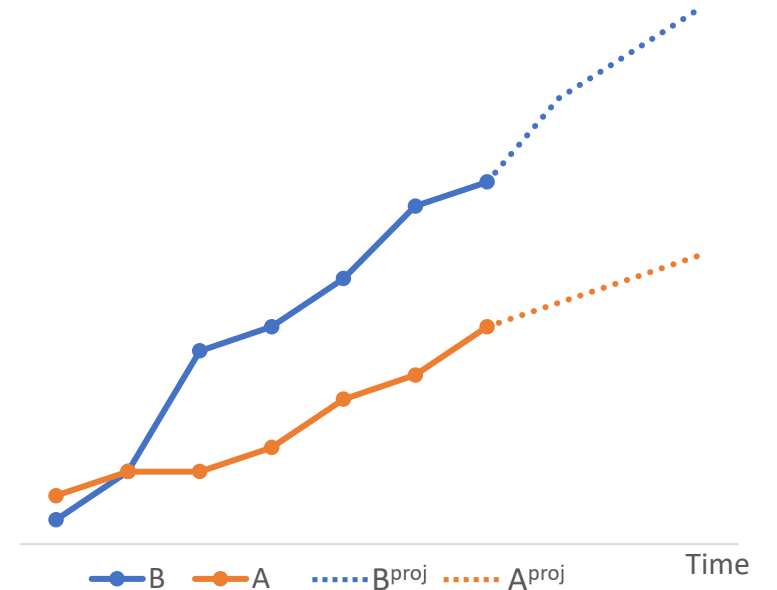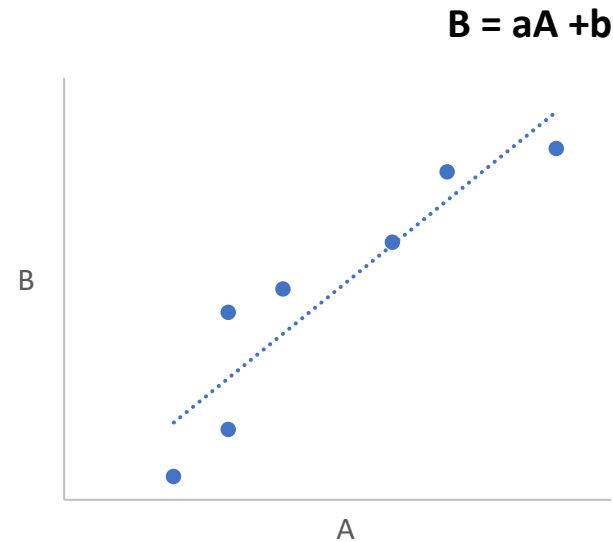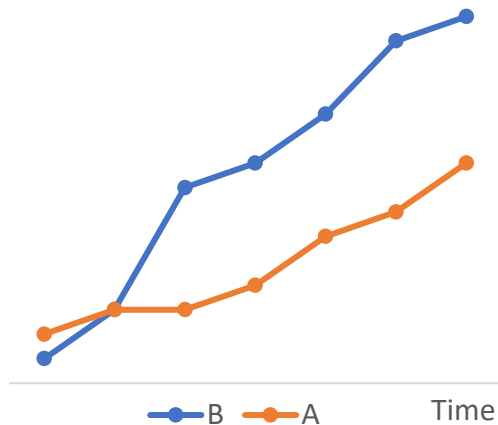
Generic example for illustrative purpose

The macro-economic module overrides activity variables (inputs) that are normally defined by levers in the original BECalc

SOURCE: BECalc

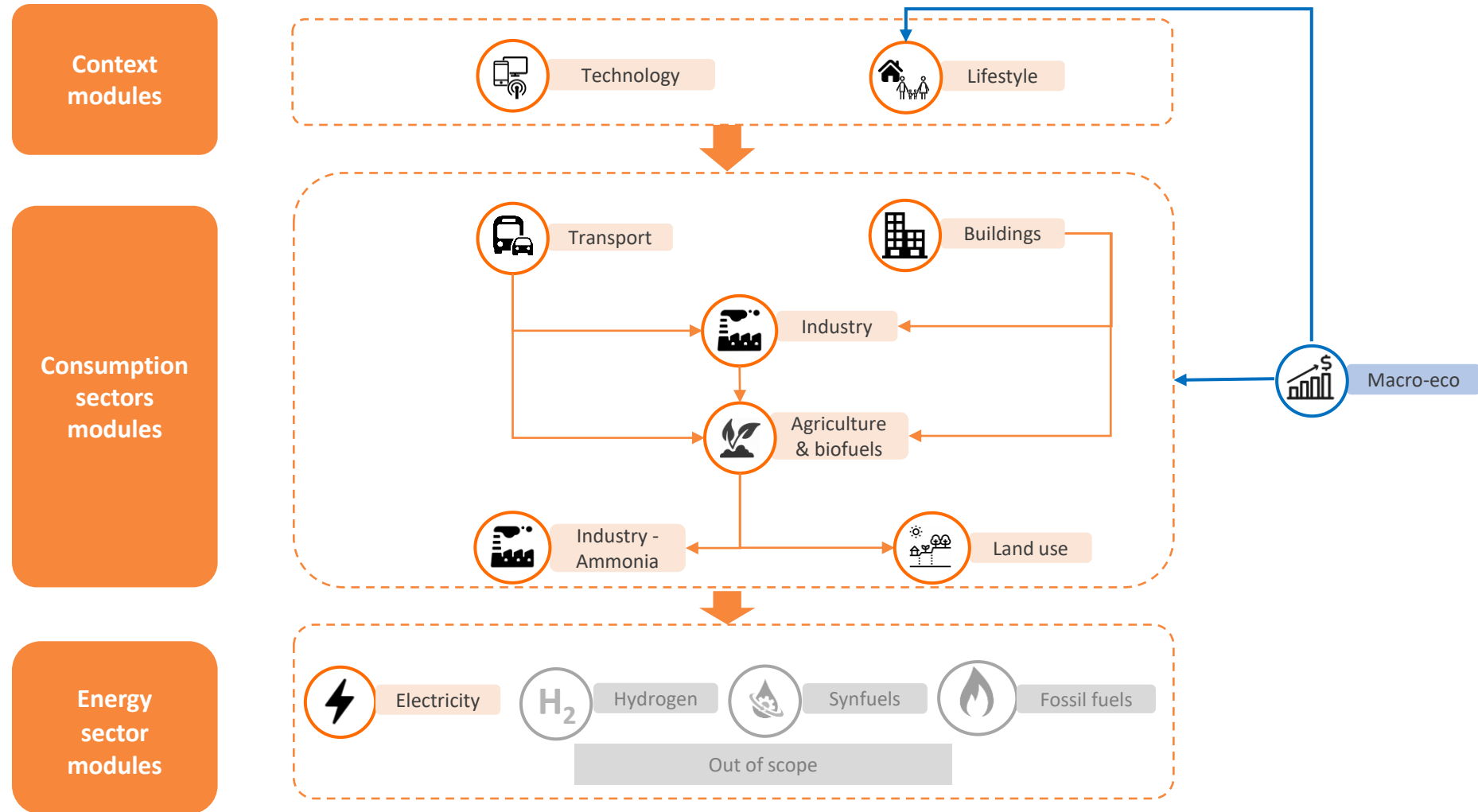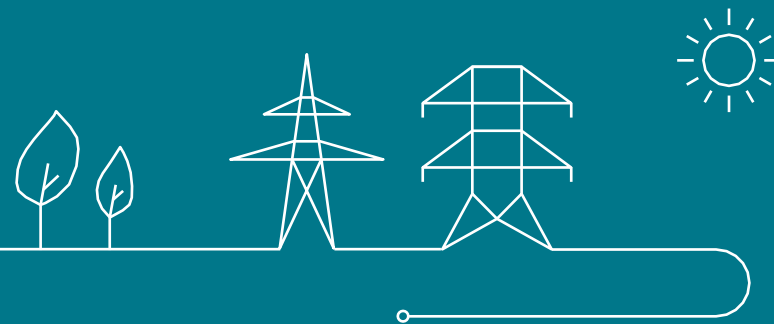# These macroeconomic indicators are chosen to be linked with BECalc activity variables

Macro-economic indicators

Activity variables

Average disposable income

Industry added value

Tertiary added value

Environmental/energy policies

| Passenger transport demand |
| Appliance own and use |
| Living space per person |
| Freight transport demand |
| Industry material production |
| Surface for tertiary buildings |
| Technology share of vehicles |
| Renovation rate and depth |

Legend

| Lifestyles |
| Industry |
| Residential |
| Tertiary |
| Transport |

+

Population

Households

| Population |
| Average household size |

The macro-economic module overrides activity variables (inputs) that are normally defined by levers in the original BECalc

SOURCE: BECalc

Short-term methodology: macroeconomic indicators

Income

Added Value

Policies

Review of the chosen macro-economic indicators

For each chosen macroeconomic indicator

→   Review historical data and short-term forecasts

→   Validate the links with BECalc activity variables

→   Review the resulting BECalc activity variables projections

- The projections shown hereunder correspond to the **latest available macroeconomic projections** (i.e. mainly projection before COVID crisis)
- They **do not account for the COVID crisis**
- **The next update of figures** should include the **next BFP projections accounting for the COVID impact** if these parameters are available

Short-term methodology: macroeconomic indicators

▶ **Income**

Added Value

Policies
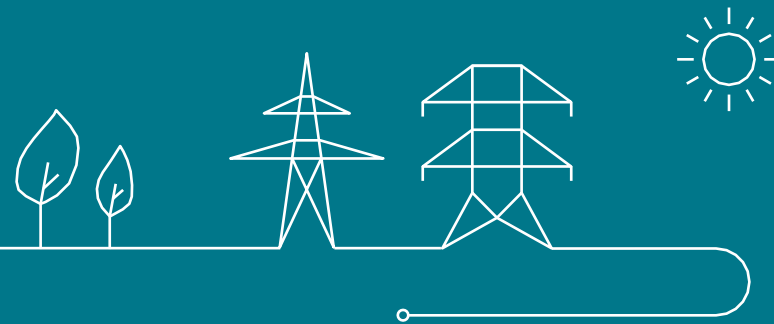
Historical data and short-term projections for the disposable income

Quantity	Unit	Historical source	Projection source	Next update
Disposable income	€/cap (nominal)	1995-2017, NBB stat	NBB, ECONOMIC REVIEW December 2019	June 2020

Disposable income
[€/cap]
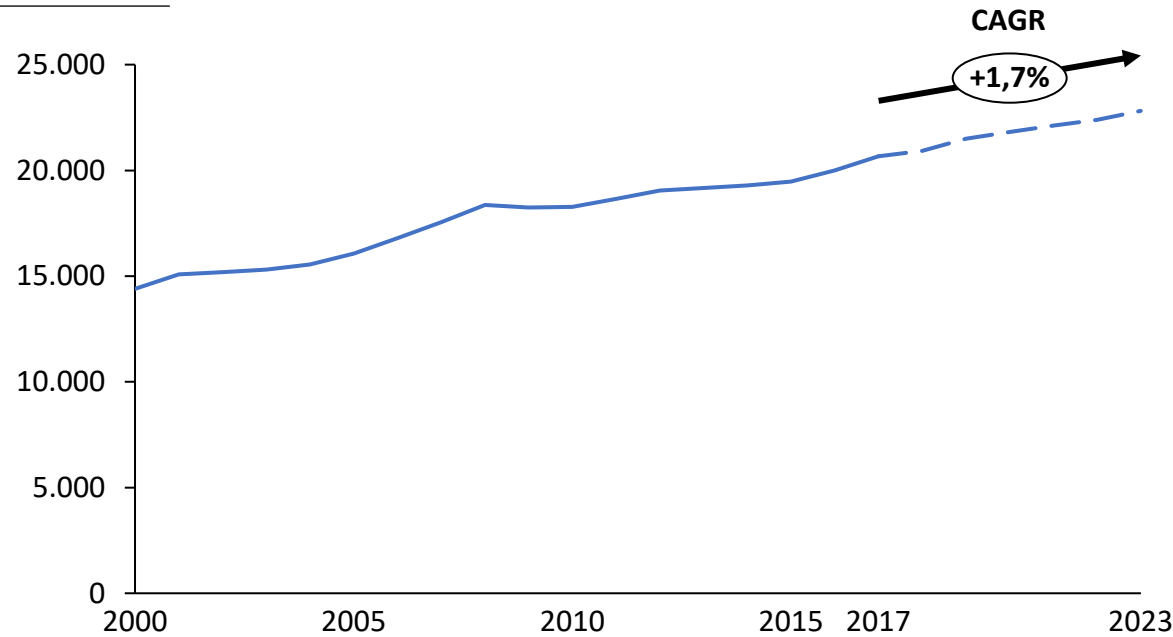
→ Forecast in line with observed past trends up to 2017

→ These projections do not account for the COVID crisis

→ The next update is foreseen with data from BFP, accounting for the COVID crisis

Appliance ownership is projected to grow due to the projected growth of disposable income and the positive correlation between them

Appliances/household
[normalized]

R²=0,91

R²=0,93

R²=0,91

Disposable Income [normalized]

● Washing machines ● Dryer ● TV

Appliances/household
[num]

+14%

+5%

+10%

── Washing machine ── Dryer ── TV - - - Projections
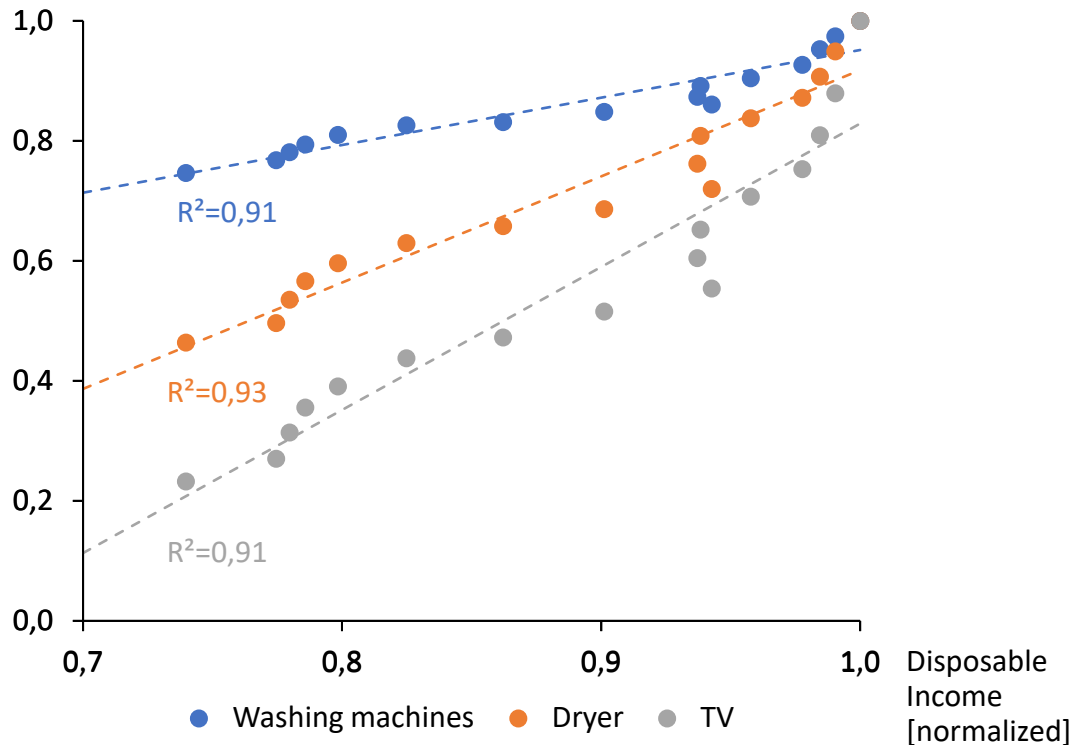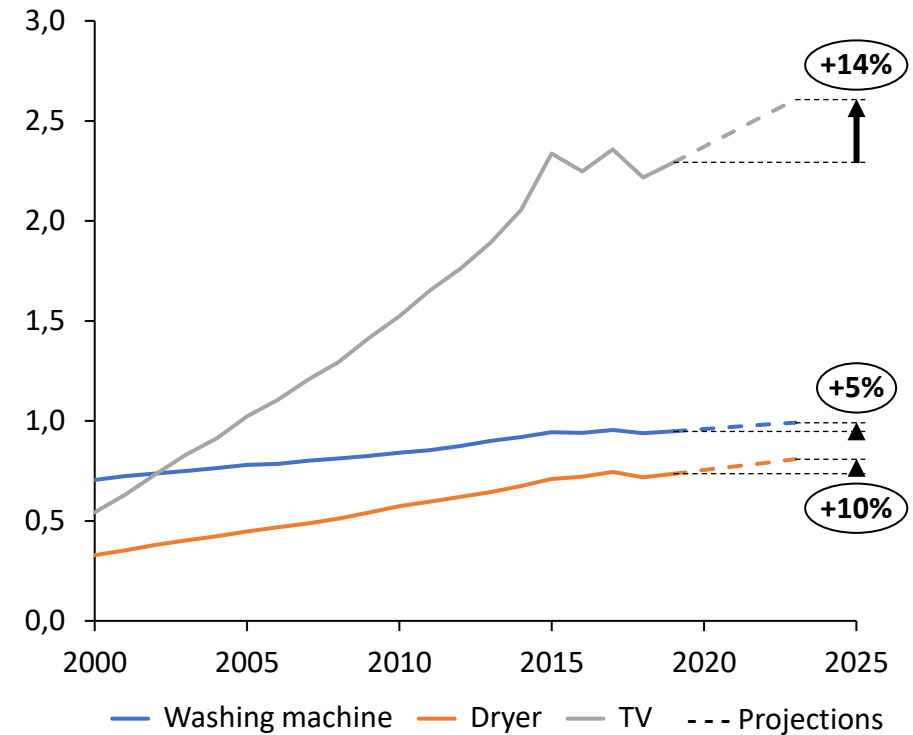
Sources: Climact model (BECalc), NBB.stat, BFP

Notes: R² computed on the period 2000-2015

Short-term methodology: macroeconomic indicators

- Income
- **Added Value**
- Policies
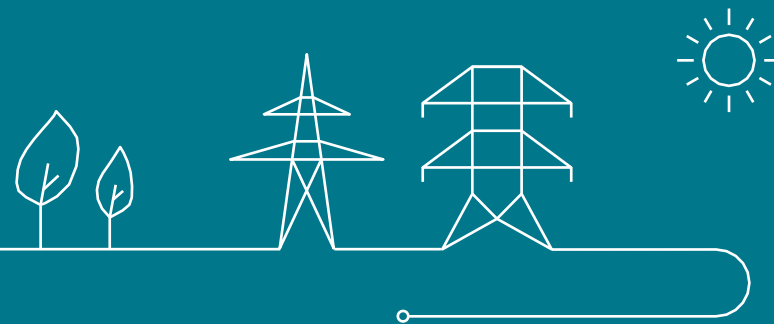
Mapping between economy sectors in the different classifications

BFP [1]		NBB.stat (NACE A38) [2]
Projections		Historical values
3. Industries manufacturières	a. Biens intermédiaires	BB
		CE,CF
		CG
		CH
	b. Biens d'équipement	CI,CJ,CK,CL
	c. Biens de consommation	CA
		CB
		CC
		CM
5. Services marchands	a. Transports et communication	HH,JB
	b. Commerces et Horeca	GG,II
	c. Crédit et assurances	KK
	d. Santé et action sociale	QA,QB
	e. Autres services marchands	RR,SS,JA,JC,LL,MA,MB,MC,NN
6. Services non-marchands	a. Administration publique et enseignement	OO,PP
	b. Services domestiques	TT

SOURCES: (1) BFP: "Correspondance secteurs BFP – NACE"
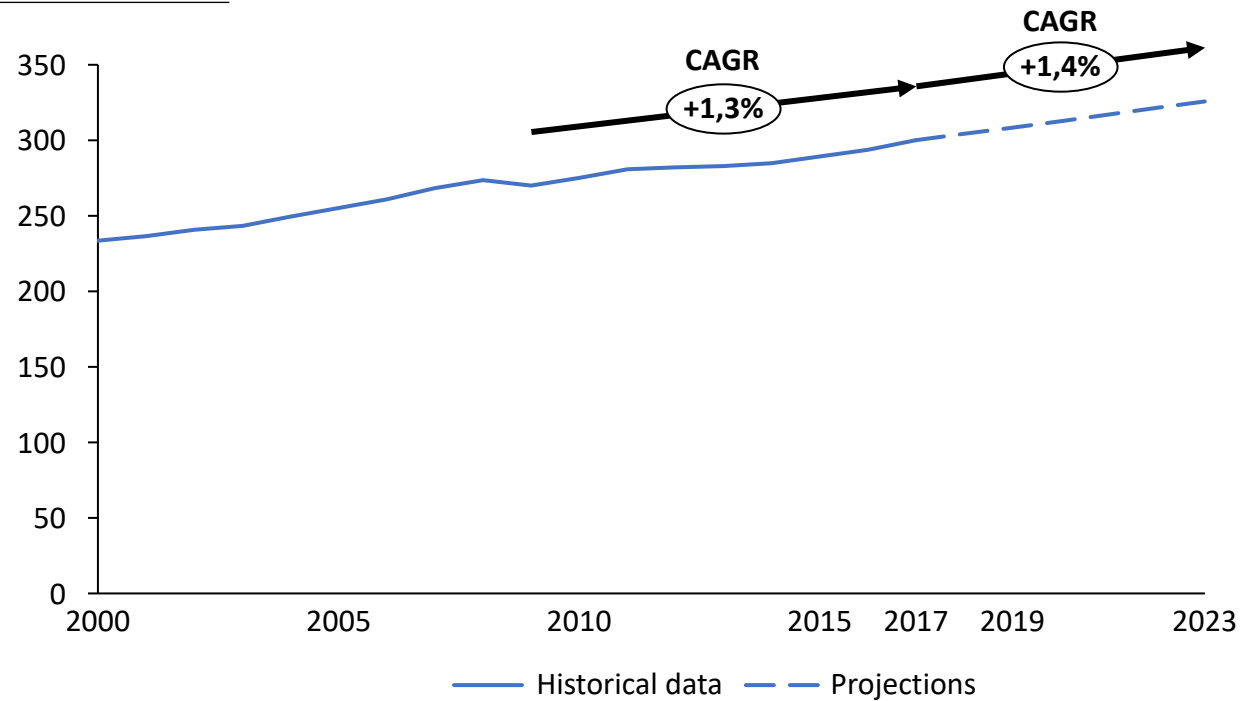
(2) NBB.stat

(3) BECalc

Historical data and short-term projections for the tertiary sector added value

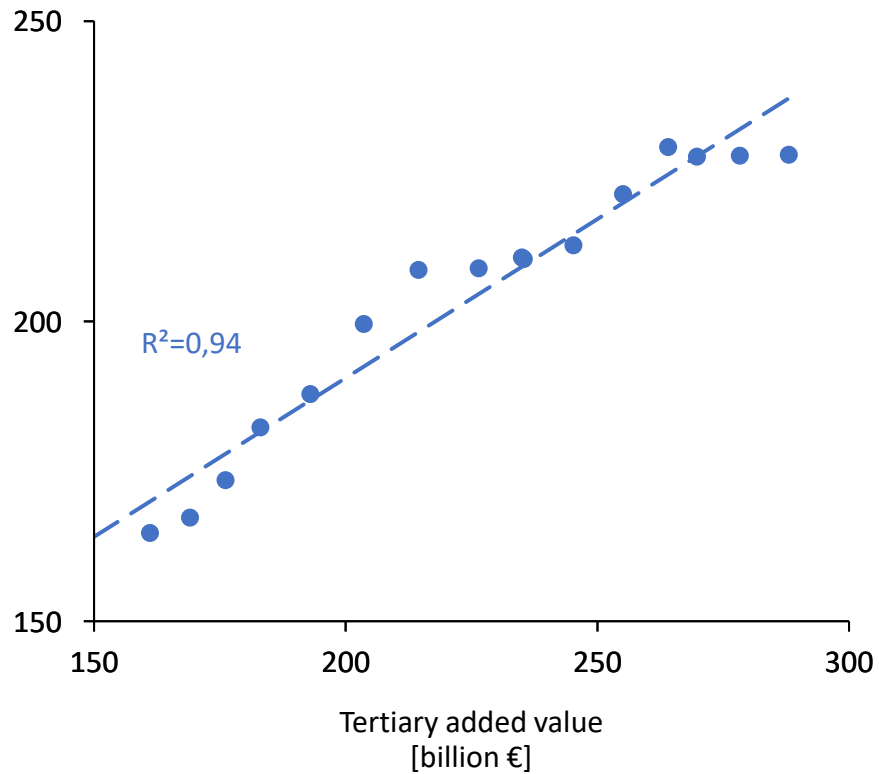| Quantity	Unit	Historical source	Projection source	Next update
Added value – tertiary sector	M€ (volume)	1995-2017, NBB stat	BFP, Perspectives économiques 2019-2024, June 2019 [1]	June 2020

Tertiary added value
[billion €]

→ Forecast in line with observed past trends up to 2017

→ These projections do not account for the COVID crisis. The tertiary sector activity is likely to be slowed down by the crisis

→ The next update is foreseen with data from BFP, accounting for the COVID crisis

Notes: (1) The last version (March 2020) of this publication does not contain detailed projections for economy sectors, hence the previous publication is used. It is based on previous NBB.stat figures from October 2018.
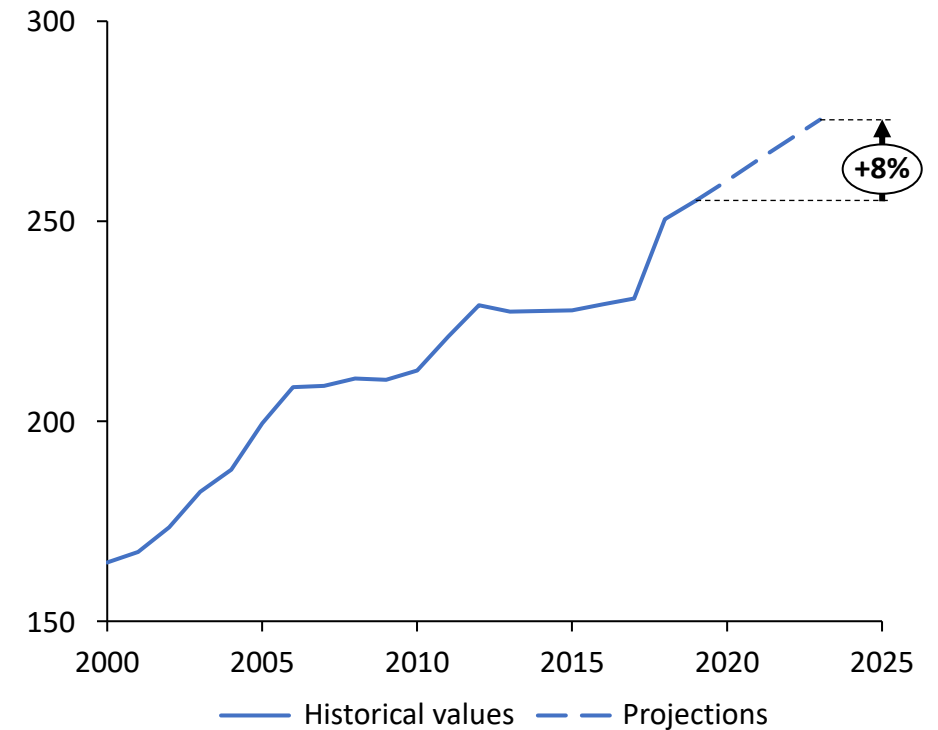
The tertiary buildings surface is projected to grow due to the projected growth of tertiary added value and the positive correlation between them

Tertiary buildings surface
[million m²]

Tertiary buildings surface
[million m²]

R²=0,94

+8%

Tertiary added value
[billion €]

Historical values — — Projections

Historical data and short-term projections for industrial subsectors added value

Quantity	Unit	Historical source	Projection source	Next update
Added value – industrial subsectors	M€ (volume)	1995-2017, NBB stat	Perspectives économiques 2019-2024, June 2019 [1]	June 2020

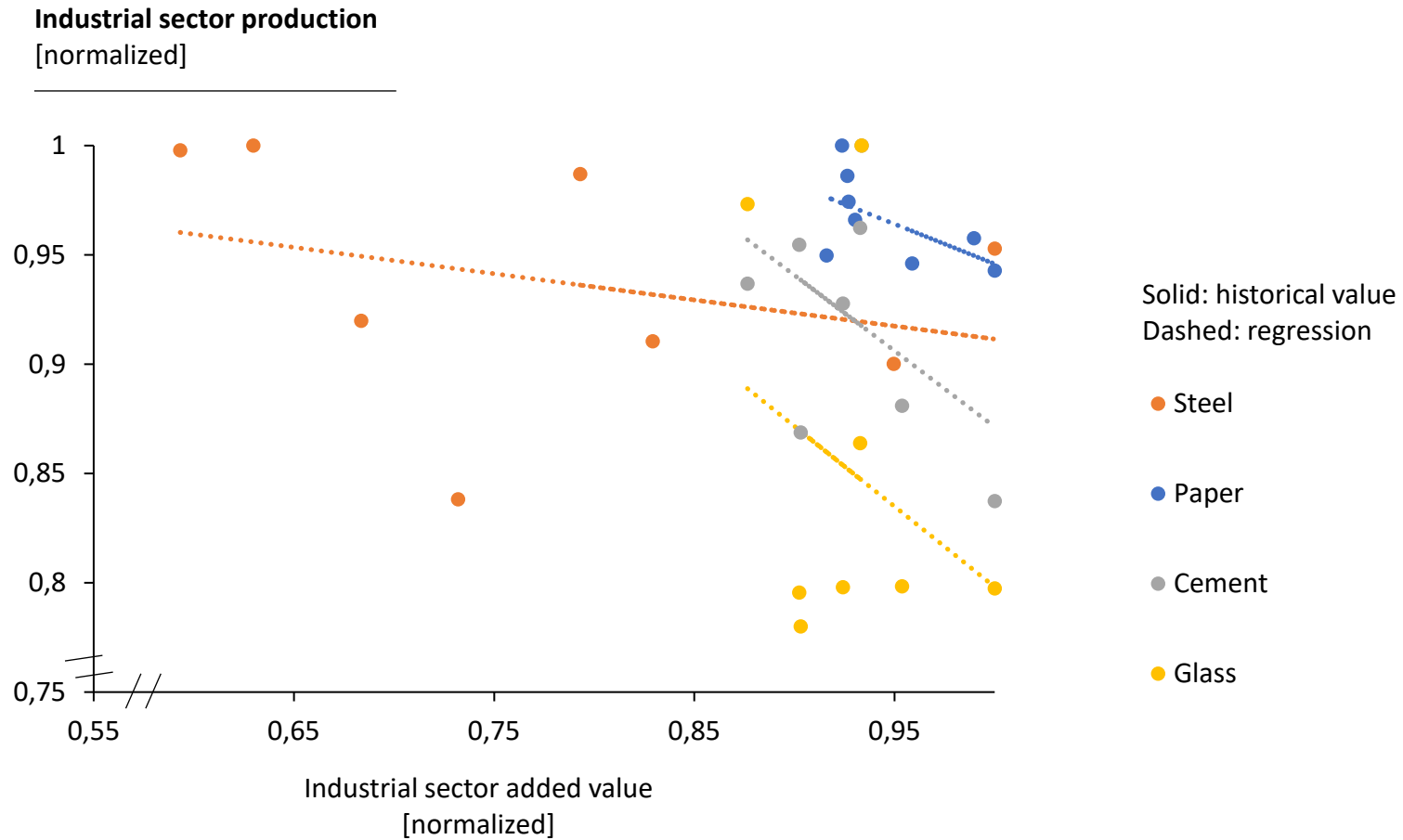**Industrial subsectors added value**
[billion €]
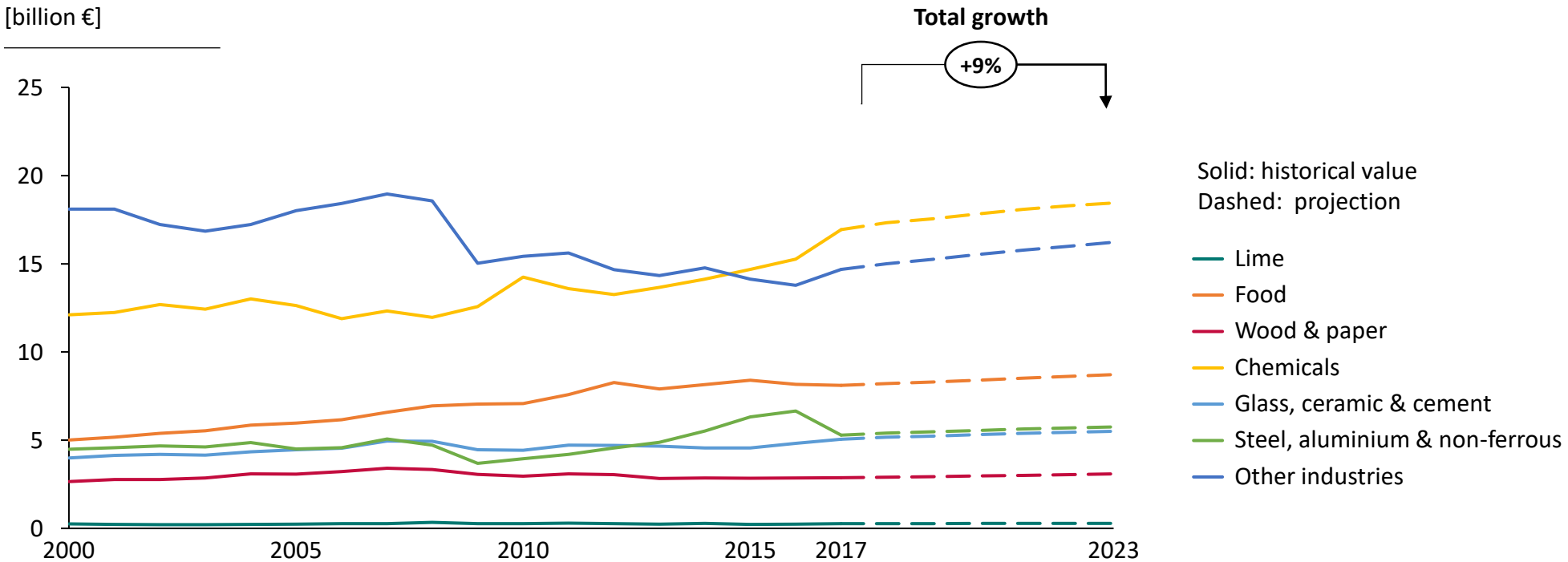
Total growth

+9%

Solid: historical value
Dashed: projection

— Lime
— Food
— Wood & paper
— Chemicals
— Glass, ceramic & cement
— Steel, aluminium & non-ferrous
— Other industries

Notes: (1) The last version (March 2020) of this publication does not contain detailed projections for economy sectors, hence the previous publication is used. It is based on previous NBB.stat figures from October 2018

For several industry sectors, linear regressions indicate a negative correlation between added value and physical output

Industrial sector production
[normalized]

Industrial sector added value
[normalized]

Solid: historical value
Dashed: regression

- Steel
- Paper
- Cement
- Glass

Drivers:

→ Shift towards higher added-value products

→ Circular and functional economy:

- Recyling: less primary material produced
- Lesser material intensity for the same product
- Longer product lifetime

Similar trends are found in the Industry database

of the Joint research Centre of the EC [2]

Sources: (1) Climact model (BECalc), NBB.stat, BFP
(2) The JRC Integrated Database of the European Energy Sector (JRC IDEES)

Additional data can help improve the quality of projections in the industry

Data completeness

Sector	
Aluminium	🟨 🟨
Cement	🟩 🟩 🟩
Ceramic	🟩 🟩 🟩
Chemicals: ammonia	🟩 🟩 🟩
Chemicals: chlorine	🟨 🟨
Chemicals: olefin	🟧
Chemicals: other	🟧
Food	🟧
Glass	🟩 🟩 🟩
Lime	🟩 🟩 🟩
Non-ferrous	🟧
Other industries	🟩 🟩 🟩
Paper	🟩 🟩 🟩
Steel	🟩 🟩 🟩
Wood	🟧

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- Regression on historical data can be improved for several sectors with incomplete historical data
- In particular, the different subsectors of the chemical industry lack sufficient data to establish meaningful correlation with the added value
- As a result, the projections for these sectors are flat despite the projected increase in added value
- The input of related stakeholders is welcome

Sources: Climact model (BECalc)

The industrial production is projected to decrease while the industrial added value is projected to increase

Production by subsector
[kt]
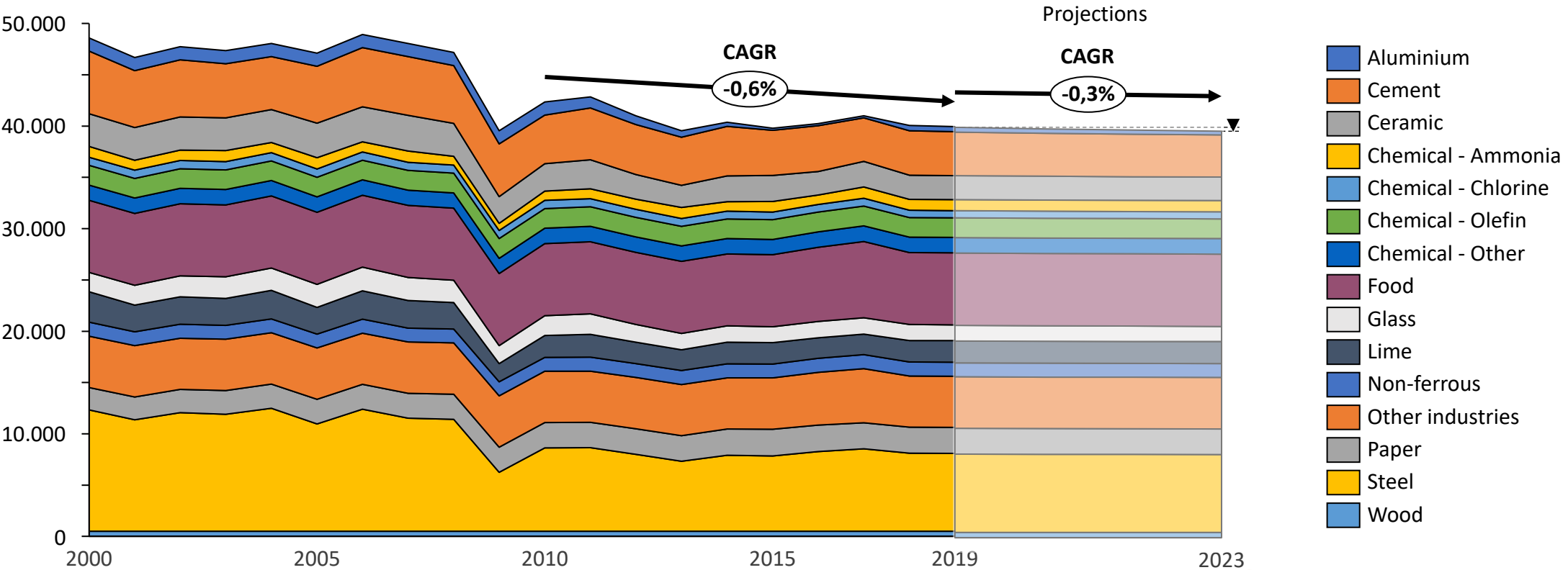
Sources: Climact model (BECalc), NBB.stat, BFP
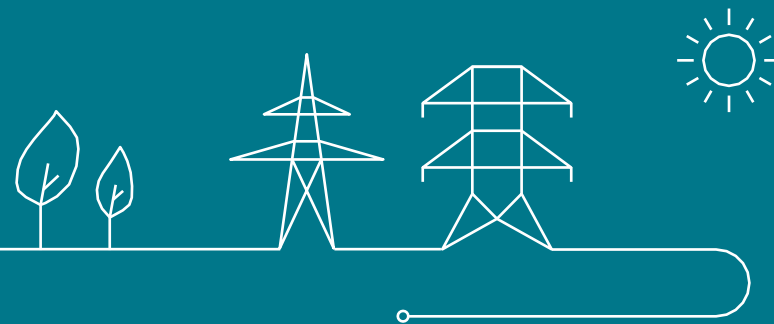
Short-term methodology: macroeconomic indicators
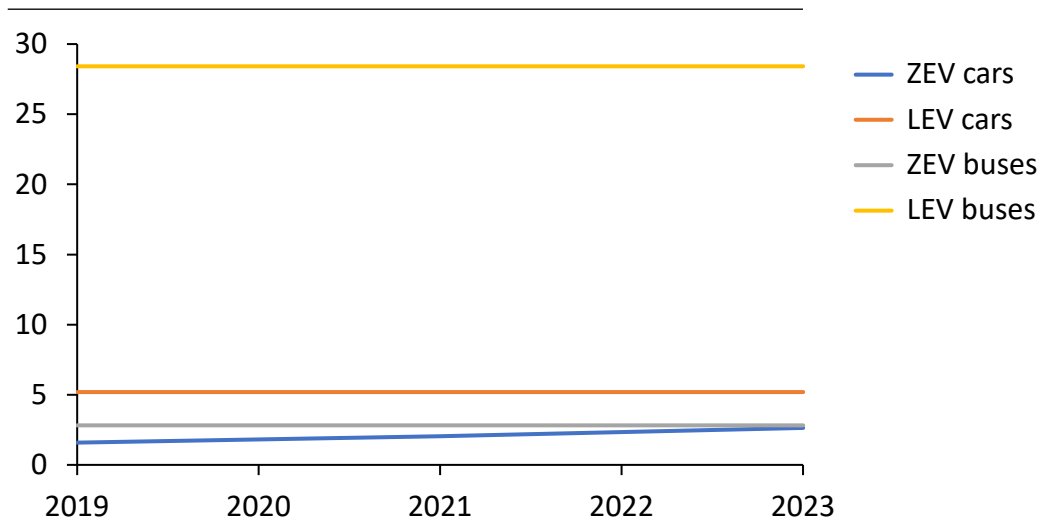
Income

Added Value

Policies

Impact of selected policies on transport and buildings energy consumption

Transport

National Energy and Climate Plan

- Gathers regional mobility policies

- Uptake of low- and zero-emission vehicles

Buildings

Regional renovation strategies

- Renovation depth

- Renovation rate

Low- and zero-emission vehicles share in new sales (WEM)
[%]

Legend:
- ZEV cars
- LEV cars
- ZEV buses
- LEV buses

Renovation rate in tertiary buildings (WAM)
[%]

Legend:
- Education
- Health
- Offices
- Others
- Commercial

Short-term methodology: backtesting
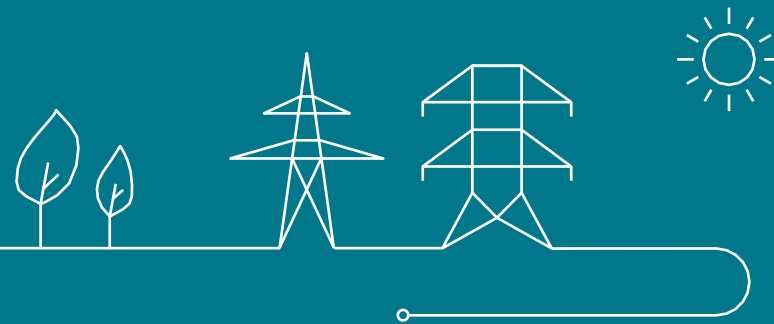
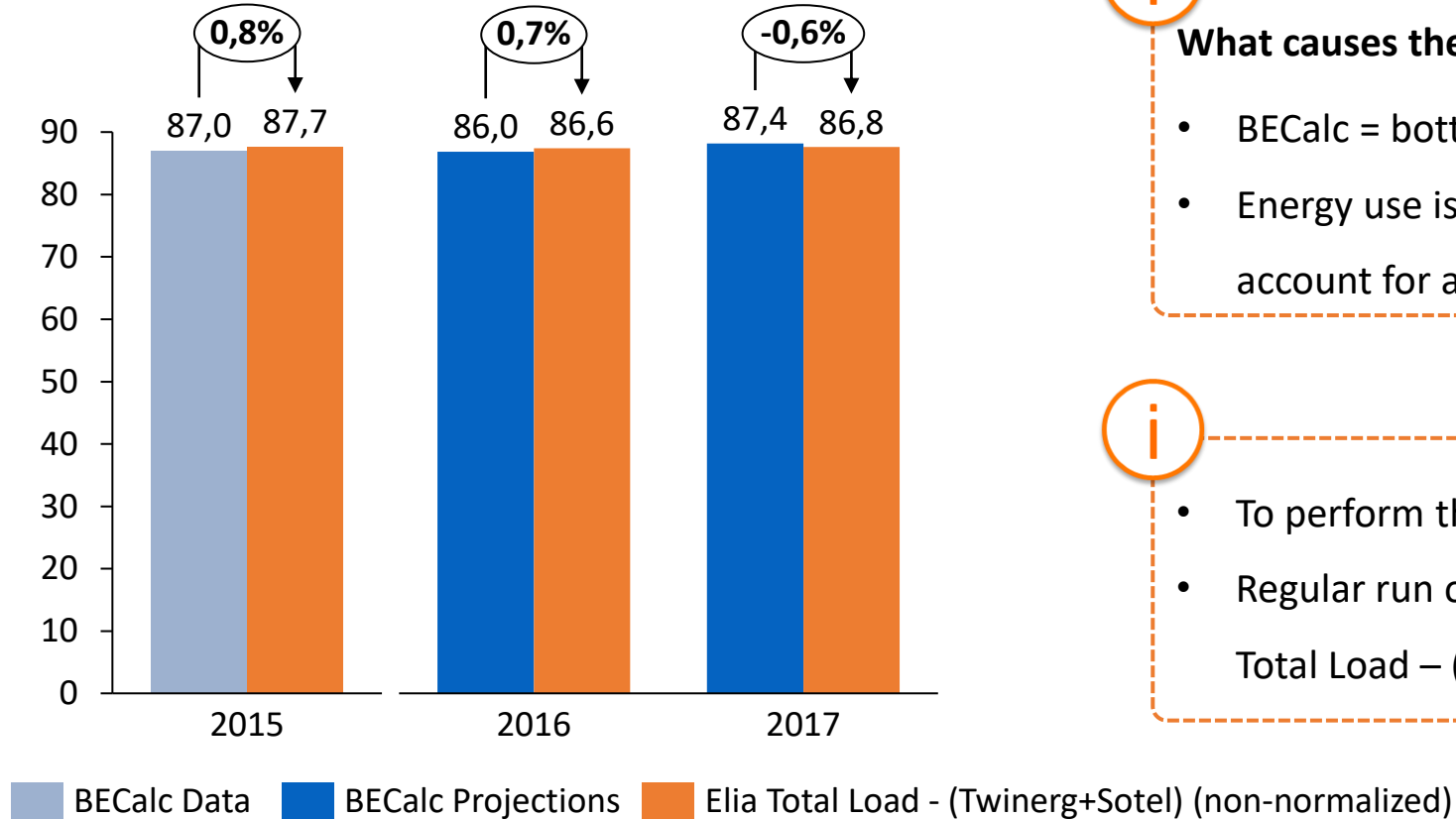# Backtesting of the macroeconomic methodology

Goals

- Check the quality of the results when applying the short-term forecasting method on historical years

- Compare the obtained results to historical figures measured by Elia

- 2015 considered as base year, projections are made for 2016 and 2017 using the macroeconomic methodology

- Activity variables influenced by macroeconomic variables are forecasted for 2016-2017 based on pre-2015 trends

- All other model variables are set to their known historical values for 2016-2017

The projection results are close to Elia total load figures

Final electricity consumption
[TWh]

Bar chart data:

Year	0,8% / 0,7% / -0,6%	BECalc Data	BECalc Projections	Elia Total Load - (Twinerg+Sotel)
2015	0,8%	87,0		87,7
2016	0,7%		86,0	86,6
2017	-0,6%		87,4	86,8

Legend:
- BECalc Data
- BECalc Projections
- Elia Total Load - (Twinerg+Sotel) (non-normalized)

ⓘ What causes the differences?

- BECalc = bottom-up approach

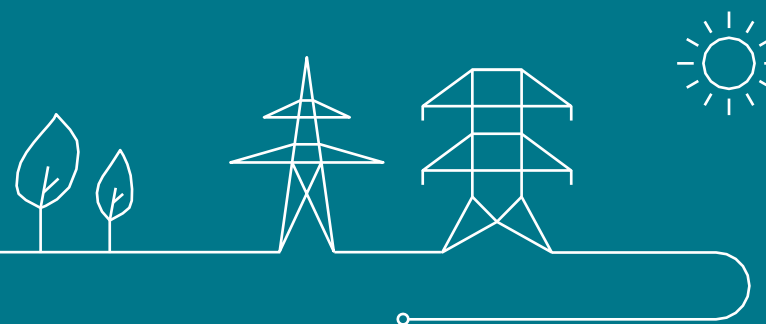- Energy use is calibrated against Eurostat energy balances to account for all energy vectors

ⓘ

- To perform this backtesting, calibration was disabled

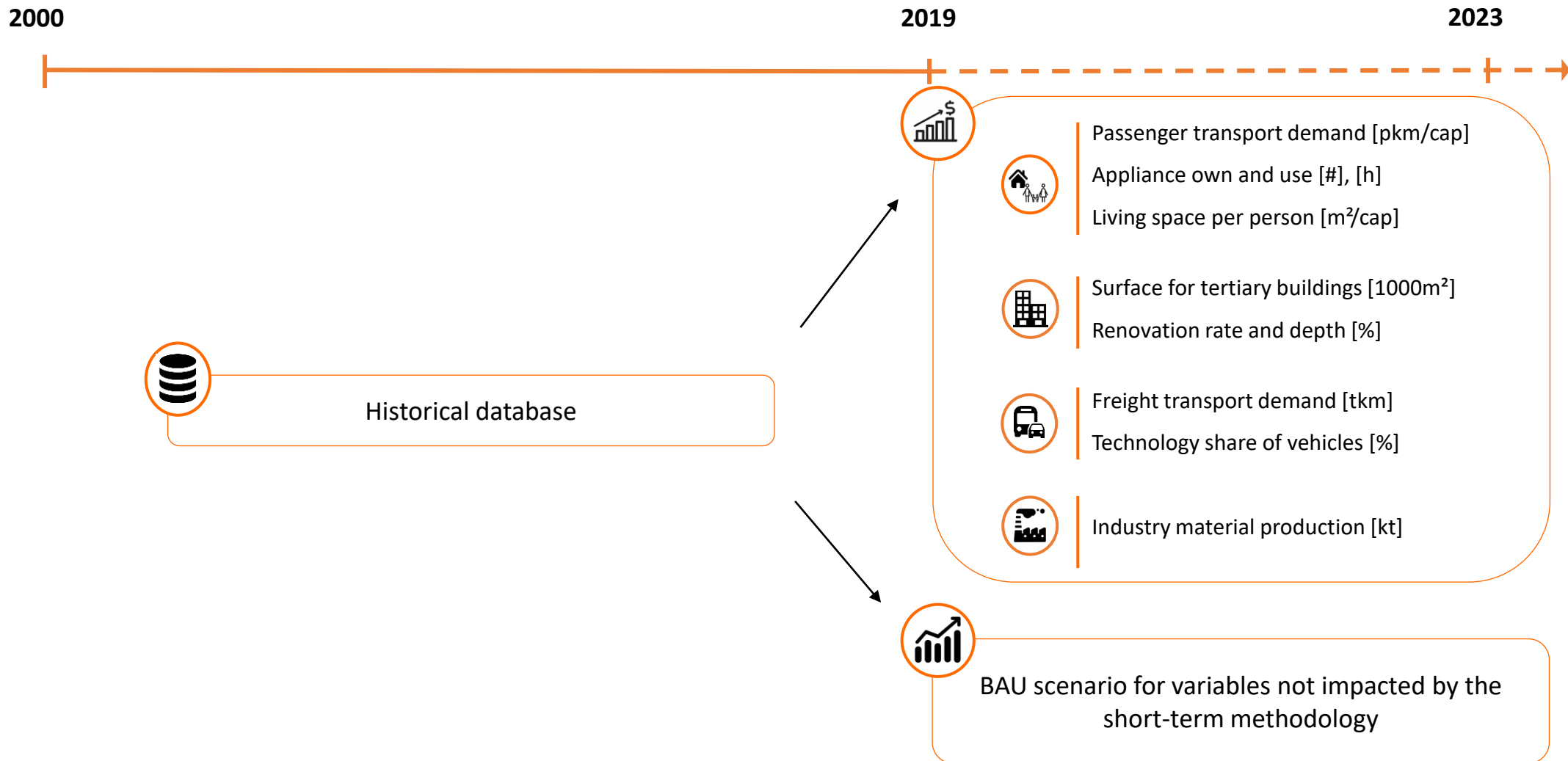- Regular run of the model includes calibration against Elia Total Load – (Twinerg + Sotel) [1]

NOTE: (1) Corresponds to the load in Luxemburg, included in the Elia Total Load
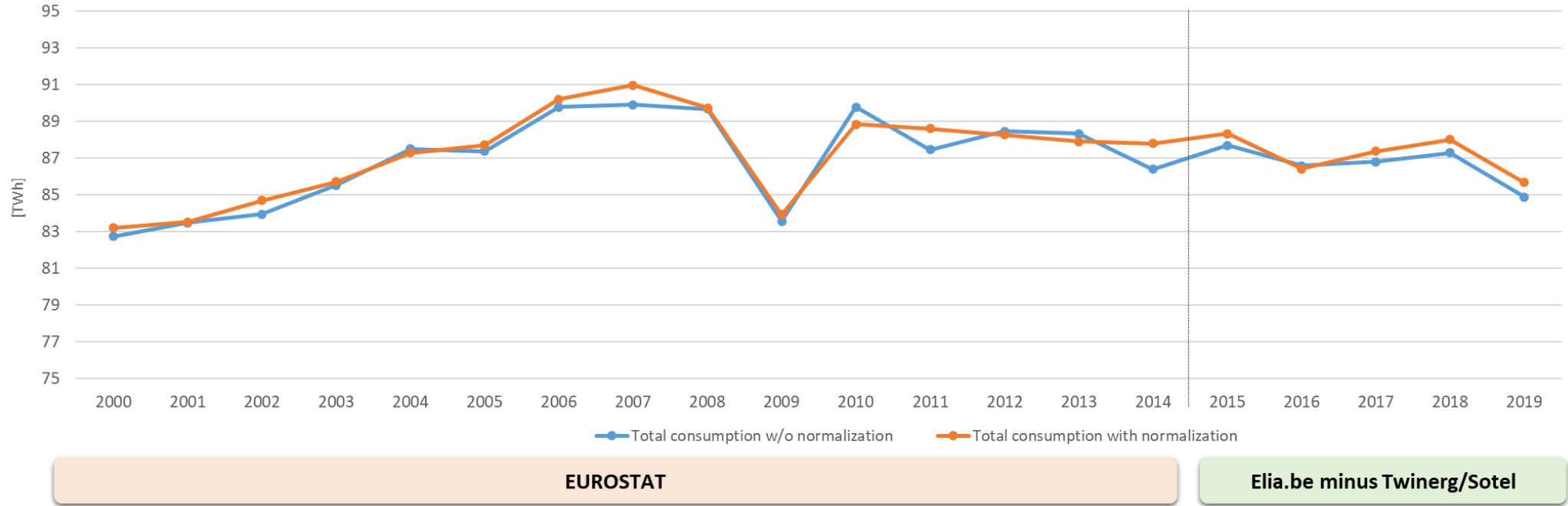
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Illustrative scenario for 2020-2023

Methodology for scenario construction

2000 — 2019 — 2023

Historical database

- Passenger transport demand [pkm/cap]
- Appliance own and use [#], [h]
- Living space per person [m²/cap]

- Surface for tertiary buildings [1000m²]
- Renovation rate and depth [%]

- Freight transport demand [tkm]
- Technology share of vehicles [%]

- Industry material production [kt]

BAU scenario for variables not impacted by the short-term methodology

Historical data for total electricity demand for Belgium

The historical data sources are indicated on the chart.
For the normalization, Elia applies a simple linear method based on the equivalent HDD, 'jours ouvrés' and amount of days in the year.

The normalization methodology is currently under review at Elia and could lead to slight differences in the historical normalization values.
In past studies other sources have been also used for historical data (ENTSOE.net for instance) where the same definition of consumption was used across all countries. Since the introduction of a common tool at ENTSO-E (for MAF2019), the consumption source is the one published on the Elia.be website which represents an estimation of the 'total electricity consumption' of Belgium.

Illustrative scenario construction

Process

- **Illustrative scenario** shown hereunder based on latest available projections (i.e. sources w/ forecasts before COVID crisis)

- It **does not represent the final figures** for the Strategic Reserve exercise

- The **final scenario** for the Strategic Reserve will be submitted to public consultation in August 2020

The final electricity consumption increases by 2.5 TWh between 2019 and 2023 in the illustrative scenario

Final electricity consumption – total
[TWh]

Delta 2019-2023
[TWh]

85.7   88.1   **+2.5**
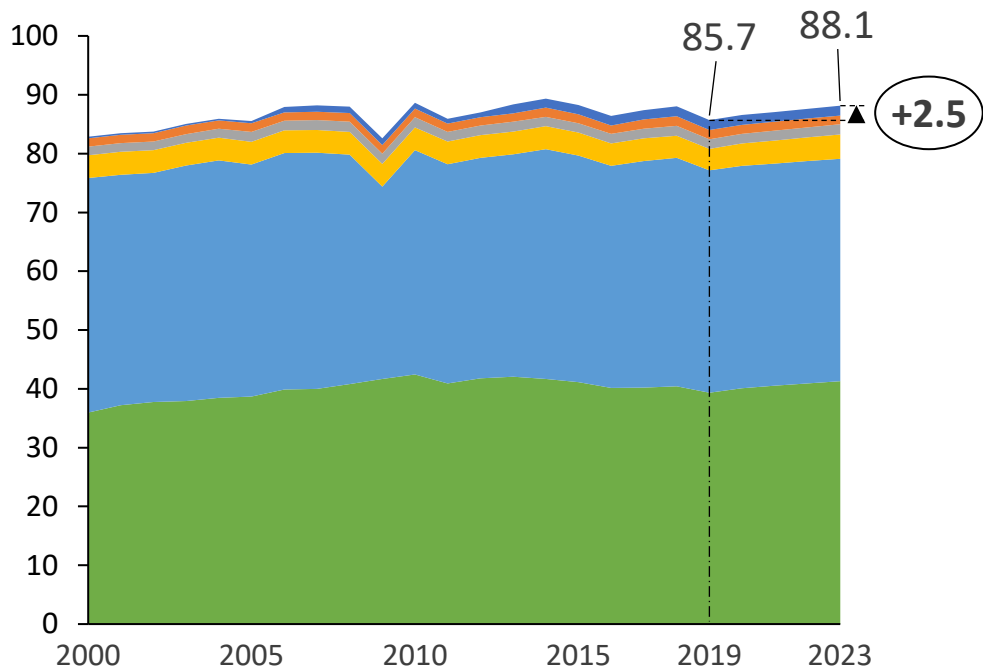
Sector	Delta
Agriculture	0
Refineries	-0,1
Transport	+0,1
Losses	+0,5
Industry	0
Buildings	+1,9

- The total electricity demand increases by 2,5 TWh between 2019 and 2023 in the illustrative scenario
- This increase is detailed by sector in the following slides

Sources: Climact - BECalc

CLIMACT · elia

The growing surface of tertiary buildings triggers an increase of the sector electricity consumption

Final electricity consumption - tertiary
[TWh]

Delta 2019-2023
[TWh]

- Ventilation — +0,17
- Cooling — +0,04
- Hotwater — +0,03
- Cooking — +0,09
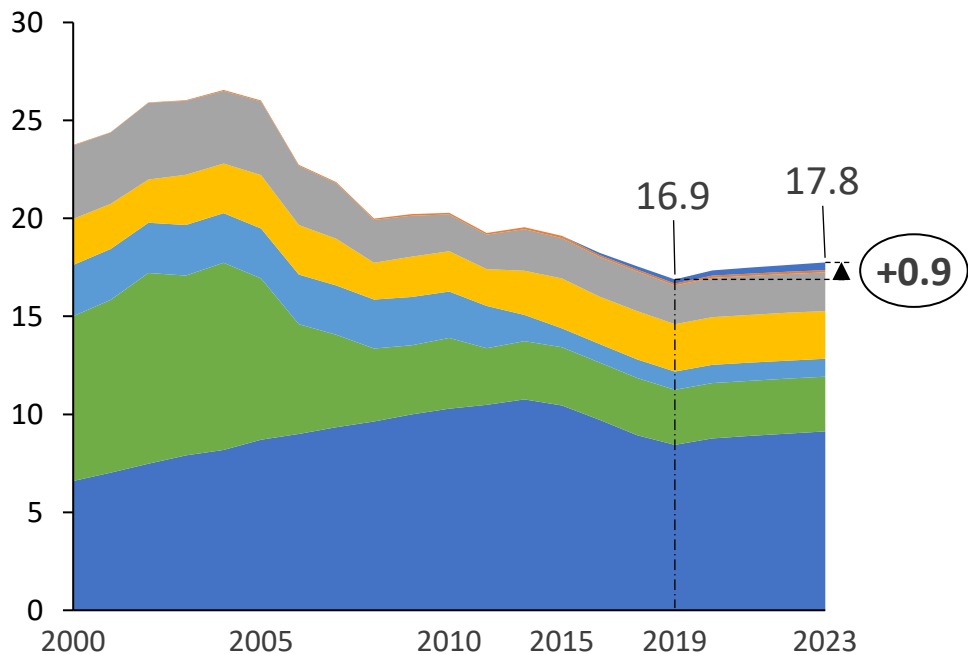- Lighting — -0,05
- Appliances — +0,44
- Heating — +0,35
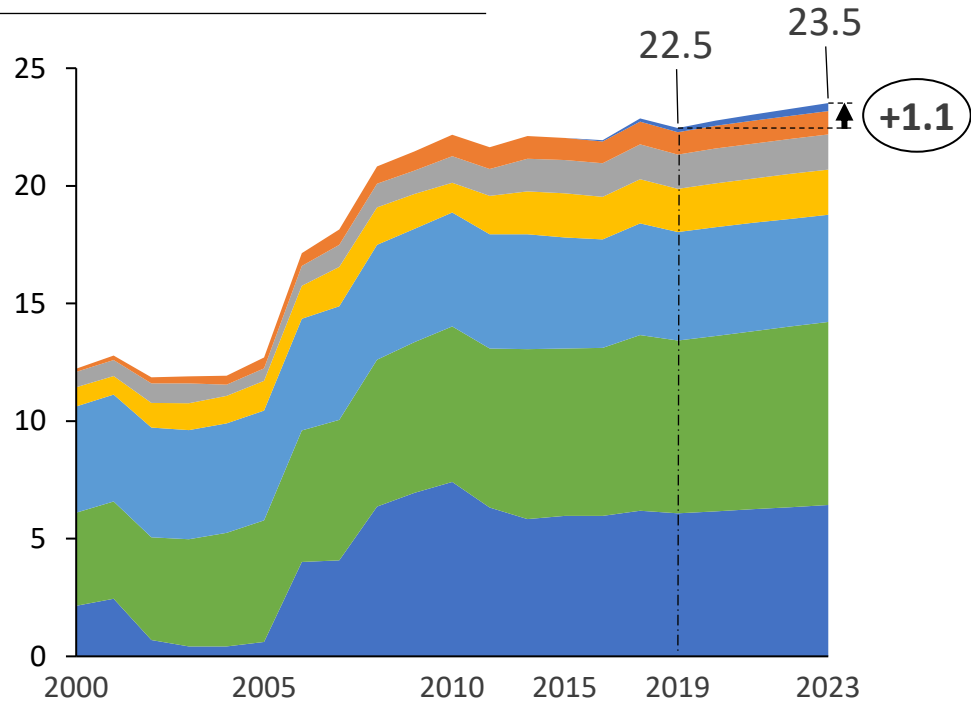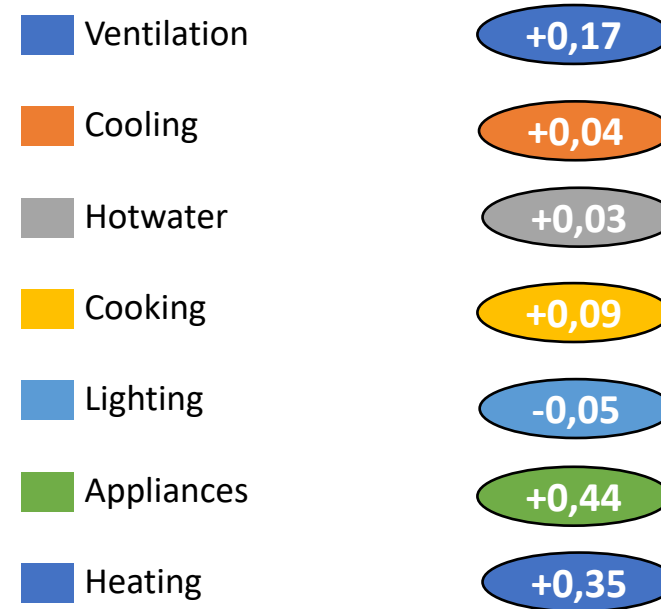
- Increase of tertiary buildings surfaces by 8% between 2019 and 2023

- Energy efficiency improvement of various electricity end-uses

➔ 5% increase of tertiary electricity consumption

Sources: Climact - BECalc

The increase of residential electricity consumption is mainly driven by an increasingly large amount of appliances

Final electricity consumption - residential
[TWh]

Delta 2019-2023
[TWh]

- Ventilation — **+0,19**
- Cooling — **+0,02**
- Hotwater — **-0,01**
- Cooking — **+0,03**
- Lighting — **-0,02**
- Heating — **-0,02**
- Appliances — **+0,69**

- The ventilation electricity use is increasing with the amount of air conditioning units, mainly in renovated and new buildings
- The amount of appliances and their duration of use is on the rise, causing the corresponding electricity consumption to increase

Sources: Climact - BECalc

Deep-dive on the electricity use of appliances in residential buildings

Illustrative example

The electricity use of appliances, here shown for washing machines, is the product of 4 variables

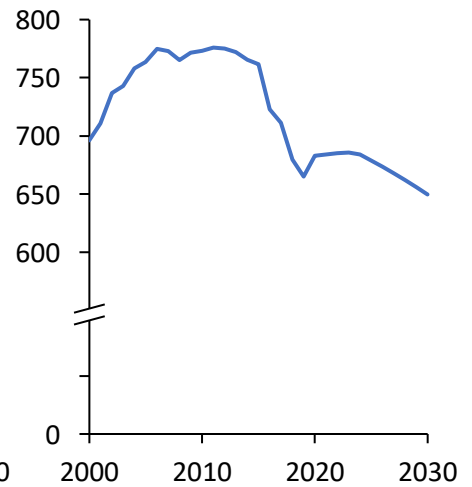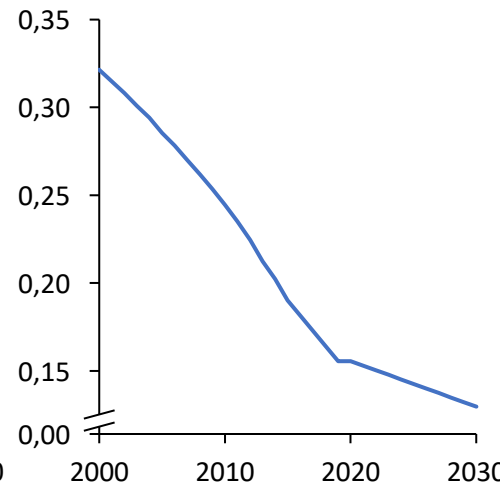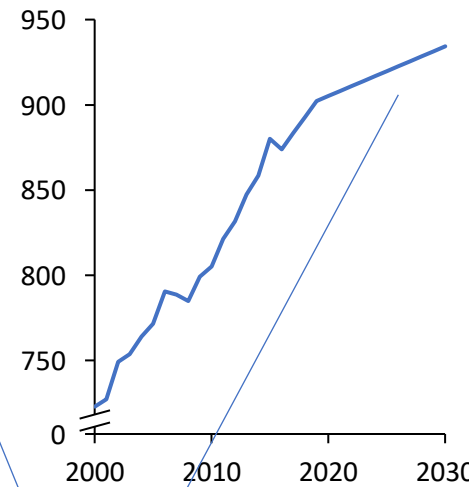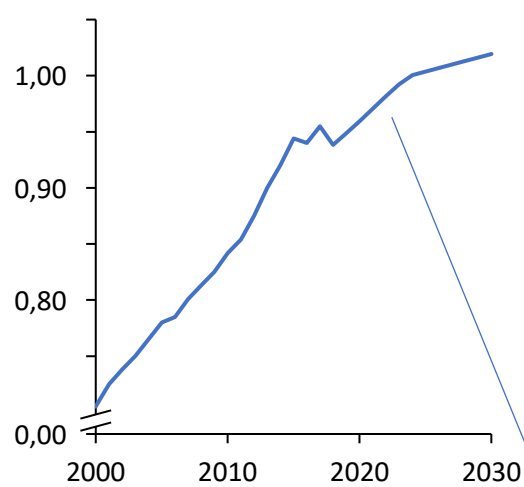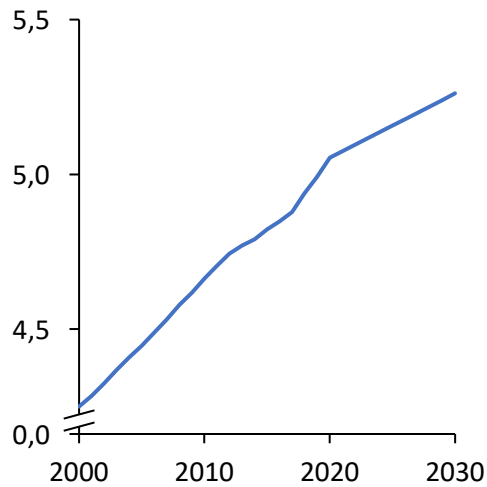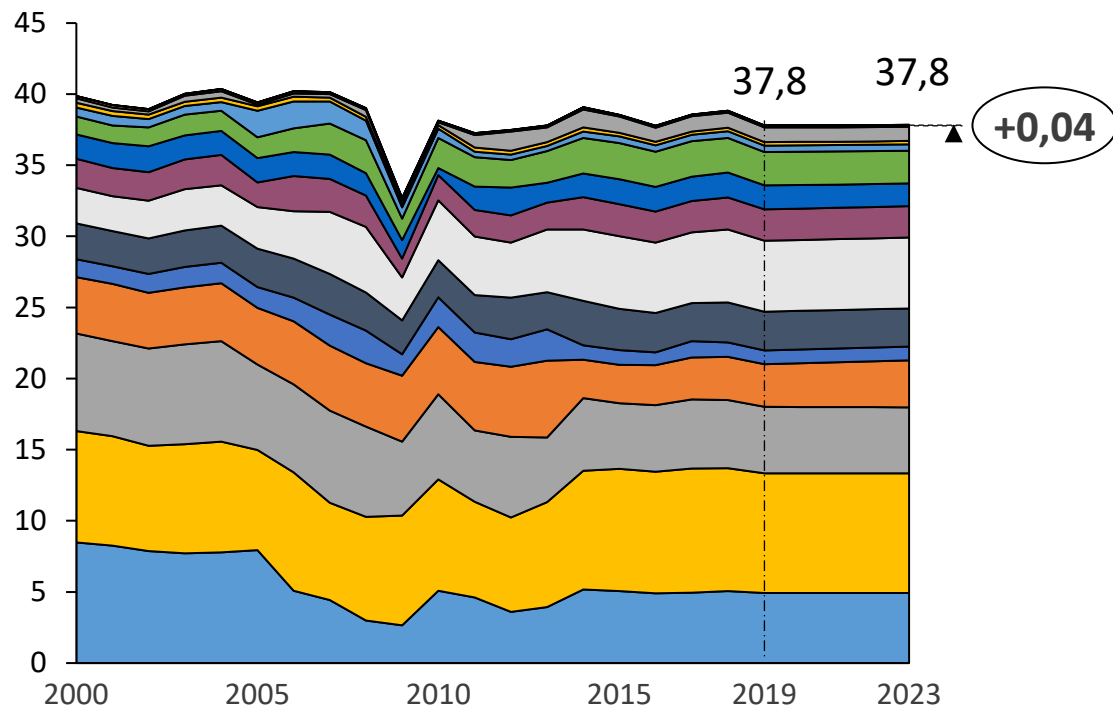| Households [million] | ✕ | Appliances/household [num] | ✕ | Duration of use [h] | ✕ | Average power [kW] | = | Electricity use [GWh] |

Due to increasing income

The electricity consumption is stagnating in the industry

Final electricity consumption - industry
[TWh]

Legend:
- Aluminium
- Lime
- Ceramic
- Cement
- Wood
- Chlorine
- Glass
- Non-ferrous
- Chemical -olefin
- Paper
- Ammonia
- Food
- Steel
- Other industries
- Chemical - other

Delta 2019-2023
[TWh]

- Ceramic: -0,03
- Chlorine: -0,06
- Glass: -0,09
- Paper: -0,06
- Food: +0,3
- Steel: -0,02

Chart values: 37,8 (2019), 37,8 (2023), +0,04

- General stagnation or slight decrease electricity consumption in industry
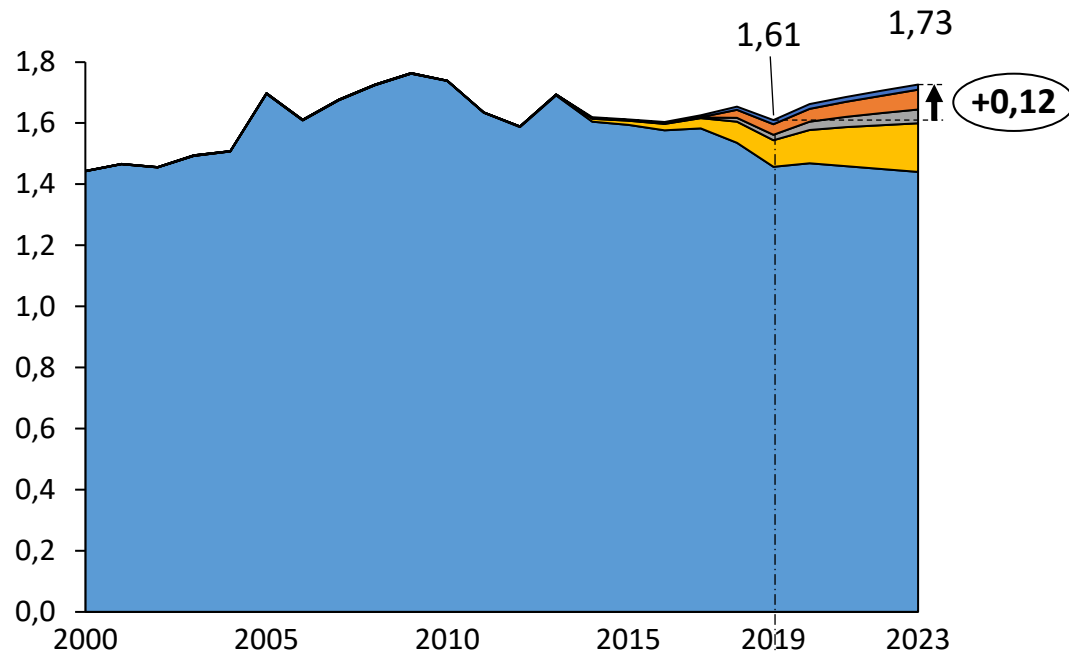- The food industry is the only sector with an increasing electricity demand
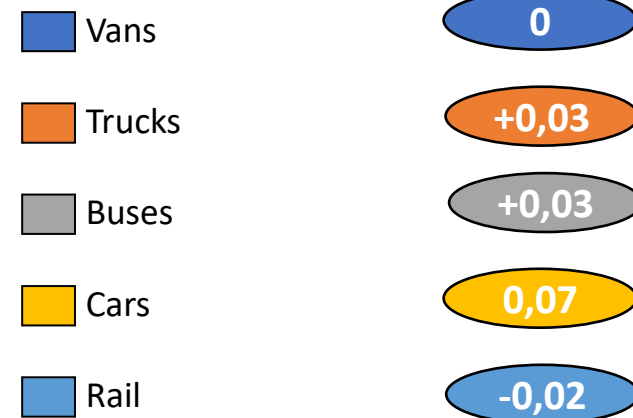
Sources: Climact - BECalc

A moderate uptake of electric vehicles drives the increase of electricity consumption in the transport sector

Final electricity consumption - transport
[TWh]

Delta 2019-2023
[TWh]

◼ Vans		0
◼ Trucks		+0,03
◼ Buses		+0,03
◼ Cars		0,07
◼ Rail		-0,02

- Moderate additional electrification of road modes, in line with the expected measures as communicated by the regions in the NECP (WEM)
- Slight decrease of rail electricity consumption with a stagnating activity (pkm and tkm) and slight energy efficiency improvements
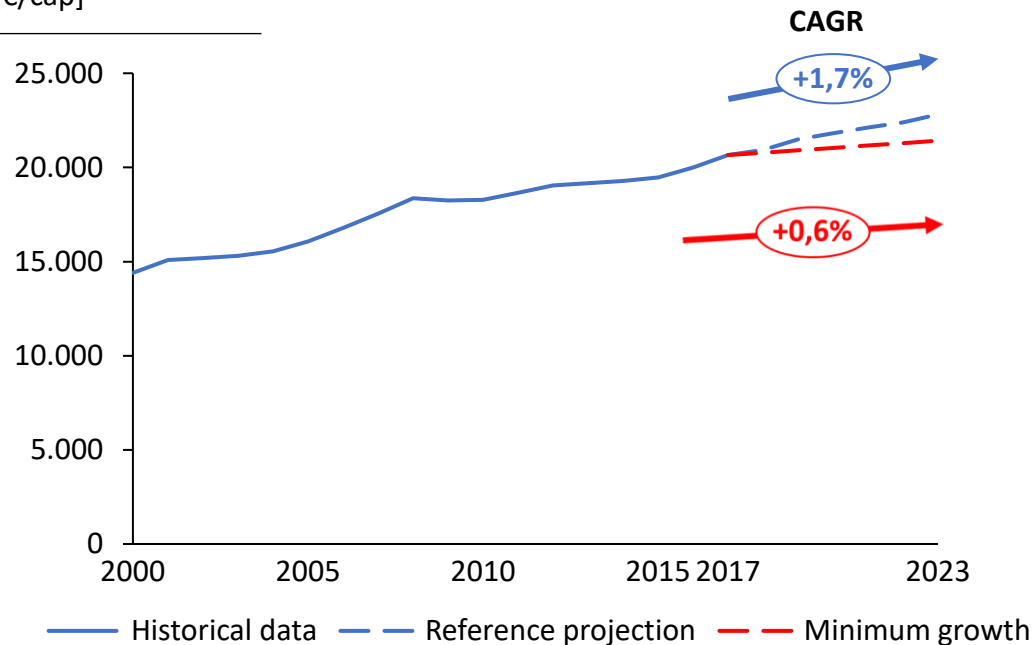
Sources: Climact - BECalc

How would the final electricity consumption evolve with more conservative macro-economic trends?

Disposable income
[€/cap]

CAGR

+1,7%

+0,6%

Historical data — — Reference projection — — Minimum growth

Tertiary added value
[billion €]

CAGR

+1,4%

+0,3%

Historical data — — Reference projection — — Minimum growth

- Conservative projections are made for disposable income and added value

- The minimum growth rate observed between 2013 and 2017 is applied from 2018 to 2023

- Lower disposable income and tertiary added value → tertiary buildings surface and residential appliance use lower than in the reference projection

How would the final electricity consumption evolve with more conservative macro-economic trends?

Theoretical conservative exercise

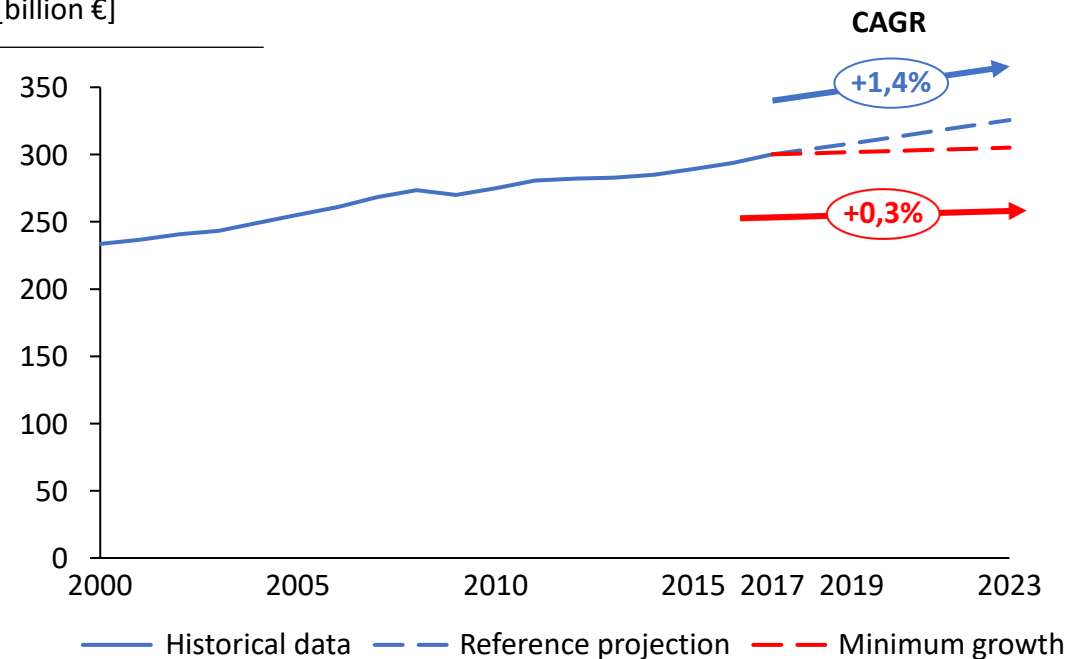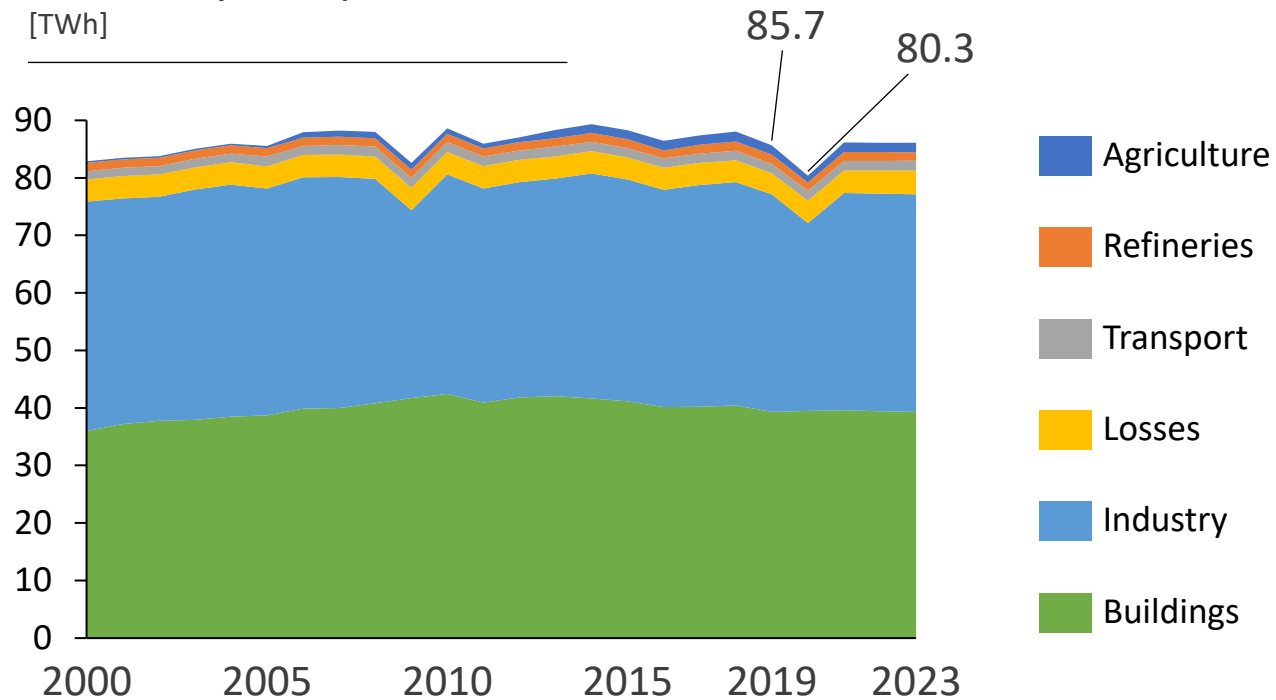**Final electricity consumption – total**
[TWh]

Delta 2019-2023 (conservative)
[TWh]

	Conservative	Reference
Agriculture	0	0
Refineries	-0,1	-0,1
Transport	+0,1	+0,1
Losses	+0,5	+0,5
Industry	0	0
Buildings	0	+1,9

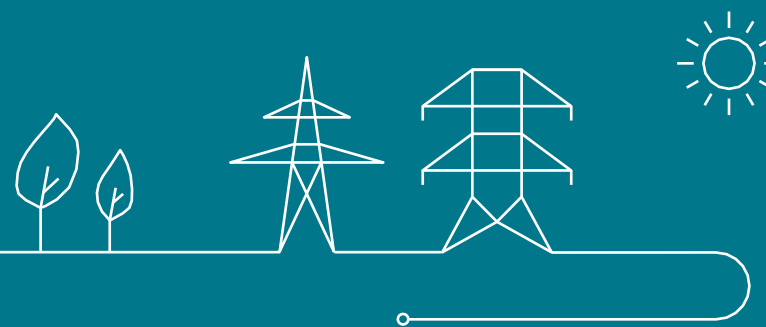**Delta 2019-2023 (reference)**
[TWh]

- Electricity consumption in 2020 in the industry is set to its 2009 level, corresponding to the financial crisis
- Lower growth of appliance use and tertiary buildings surface → no increase of buildings electricity consumption (vs 1.9 TWh in reference projection)
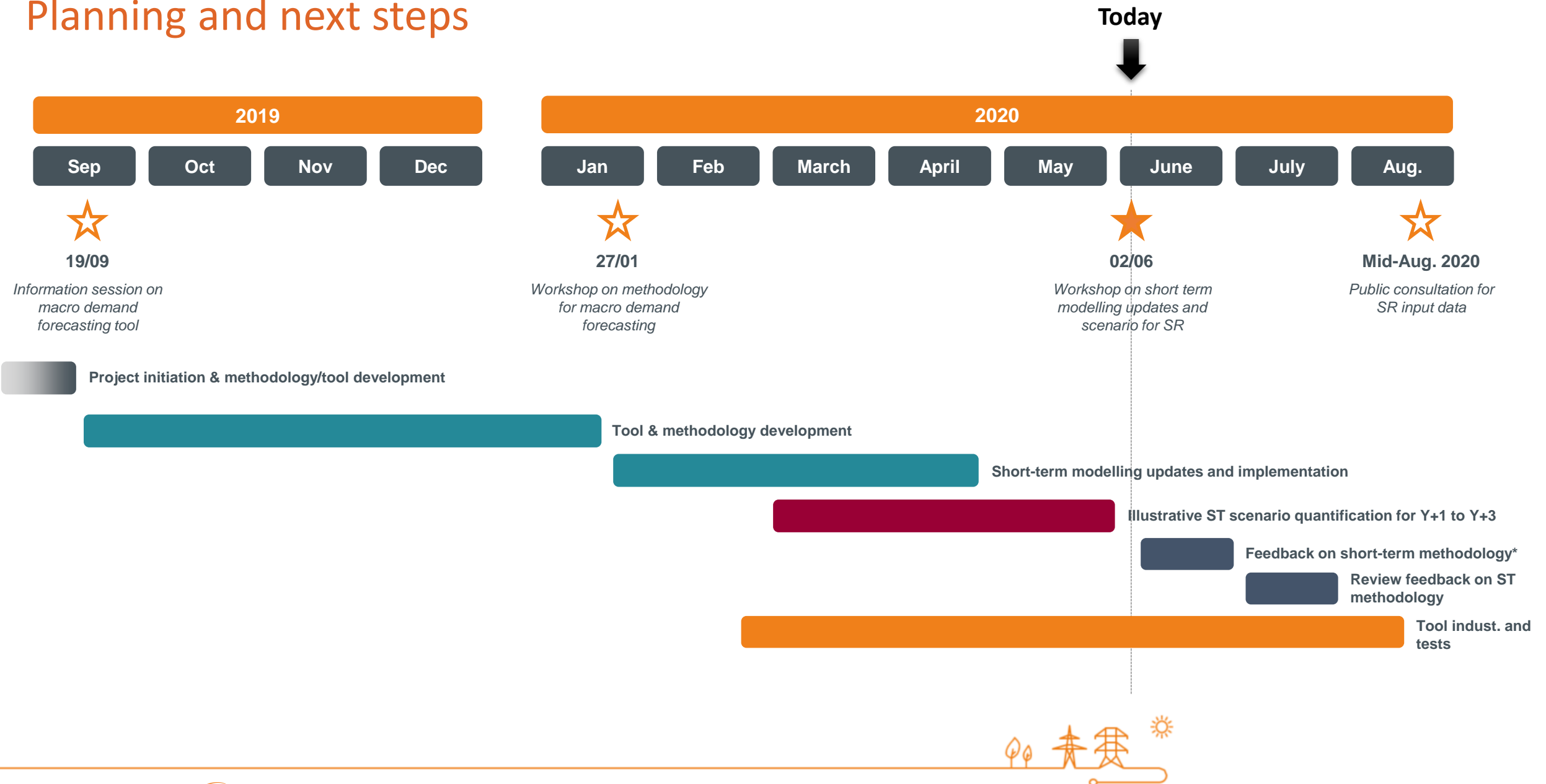
Sources: Climact - BECalc

Next steps

Planning and next steps

Today

2019					2020							
Sep	Oct	Nov	Dec		Jan	Feb	March	April	May	June	July	Aug.

19/09
Information session on macro demand forecasting tool

27/01
Workshop on methodology for macro demand forecasting

02/06
Workshop on short term modelling updates and scenario for SR

Mid-Aug. 2020
Public consultation for SR input data

Project initiation & methodology/tool development

Tool & methodology development

Short-term modelling updates and implementation

Illustrative ST scenario quantification for Y+1 to Y+3

Feedback on short-term methodology*

Review feedback on ST methodology

Tool indust. and tests

Interface will be publicly available on Elia website end Q2 - beginning Q3

Interface will be **publicly available** on **Elia website** before public consultation of input data for Strategic Reserve study with:
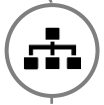
Data for each sector/sub-sector (Excel export)

Underlying **assumptions** for each sector

Report on **short-term methodology**

Feedback on methodology and scenario

3rd June - 1st July (public consultation on methodology): feedback on the short-term methodology for total electricity demand

Mid-/End- August (public consultation on input data): feedback on the scenario for total electricity demand

Thank you for your attention !

Back-up