

side coimpacts  
benefits  
impacts  
multiple  
nonenergy  
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**... of energy efficiency**



Calculating and Operationalising  
the Multiple Benefits of  
Energy Efficiency in Europe



Calculating and Operationalising  
the Multiple Benefits of  
Energy Efficiency in Europe

# Estimating impacts of energy efficiency

## *More than energy and greenhouse gas savings*



Johannes Thema

6 March 2018

IEA Multiple Benefits Workshop, 5-7 March 2018

French Foreign Affairs Ministerial Conference Center



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This document reflects only the author's view. The Agency is not responsible for any information it contains.

# Project background & objectives

## Quantification of multiple impacts of EE

Coordinated by  **Wuppertal  
Institut**

- Quantification & monetization of multiple impacts
- By EU member state & 21 EEI actions
- Common framework scenarios: based on 21 energy efficiency improvement (EEI) actions
- Extended Cost-Benefit analysis

### Air pollution

air pollutants  
health  
eco-system

### Resources

material footprint  
abiotic/biotic  
energy/non-energy  
unused extraction

### Social welfare

disposable income  
health  
productivity

### Macro economy

employment/ GDP  
public budget  
Fossil fuel/ETS prices  
Terms of Trade

### Energy system

energy system costs  
energy security



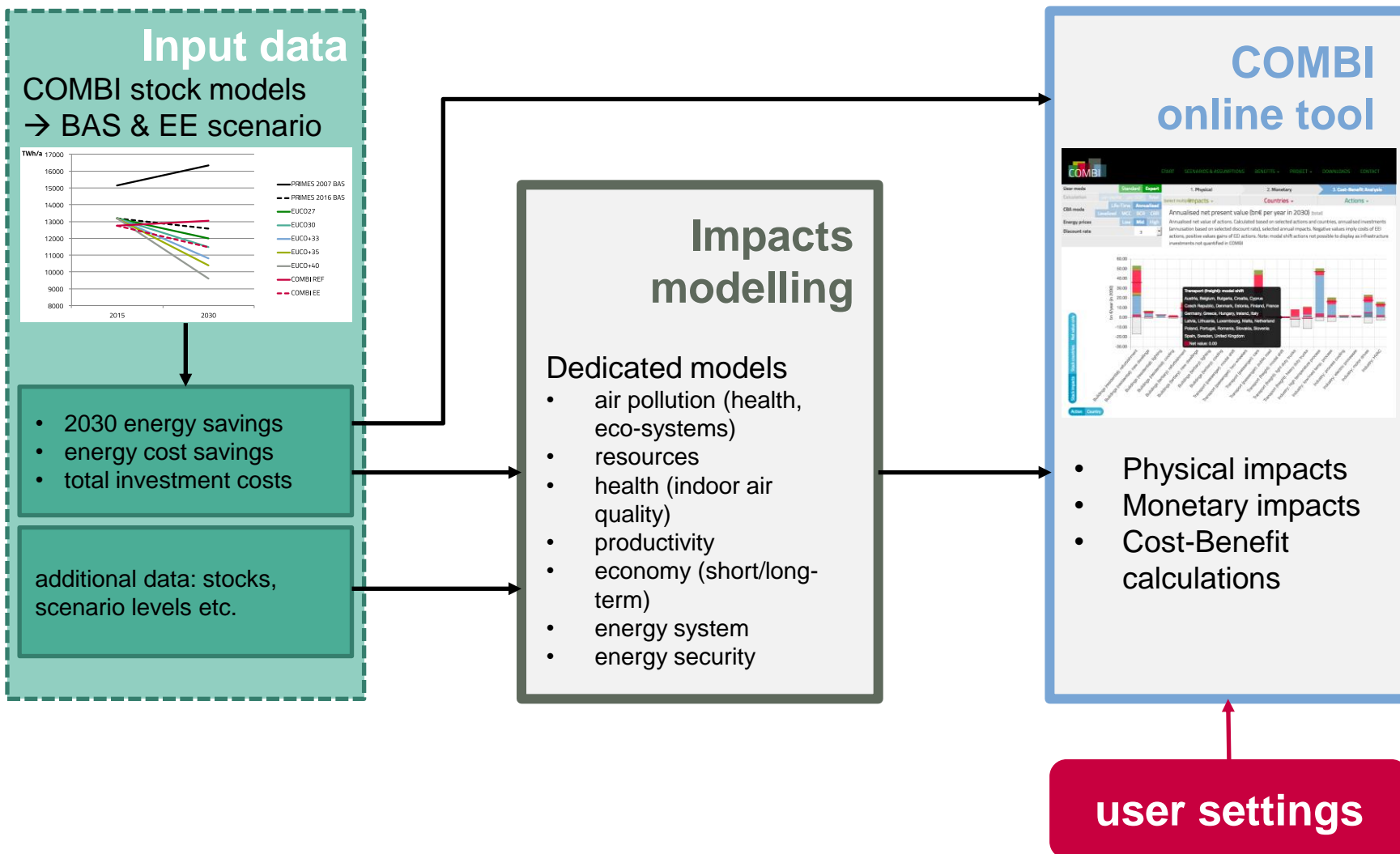
Copenhagen  
Economics



Funded by EU Horizon 2020 EE12 (GA 649724, approx 1M€)

- March 2015 – May 2018

# COMBI structure



# COMBI Input data 1

## 21 EEI actions

### Difference to PRIMES/EED-IA:

- disaggregated stock analysis model → bottom-up development of scenarios
- not complete energy system (excl. agric., only selected EEI actions, excl. supply sector)
- Multiple data sources: mostly EU stats & projects (ENTRANZE, PRIMES, FHG ISI, ECOFYS)

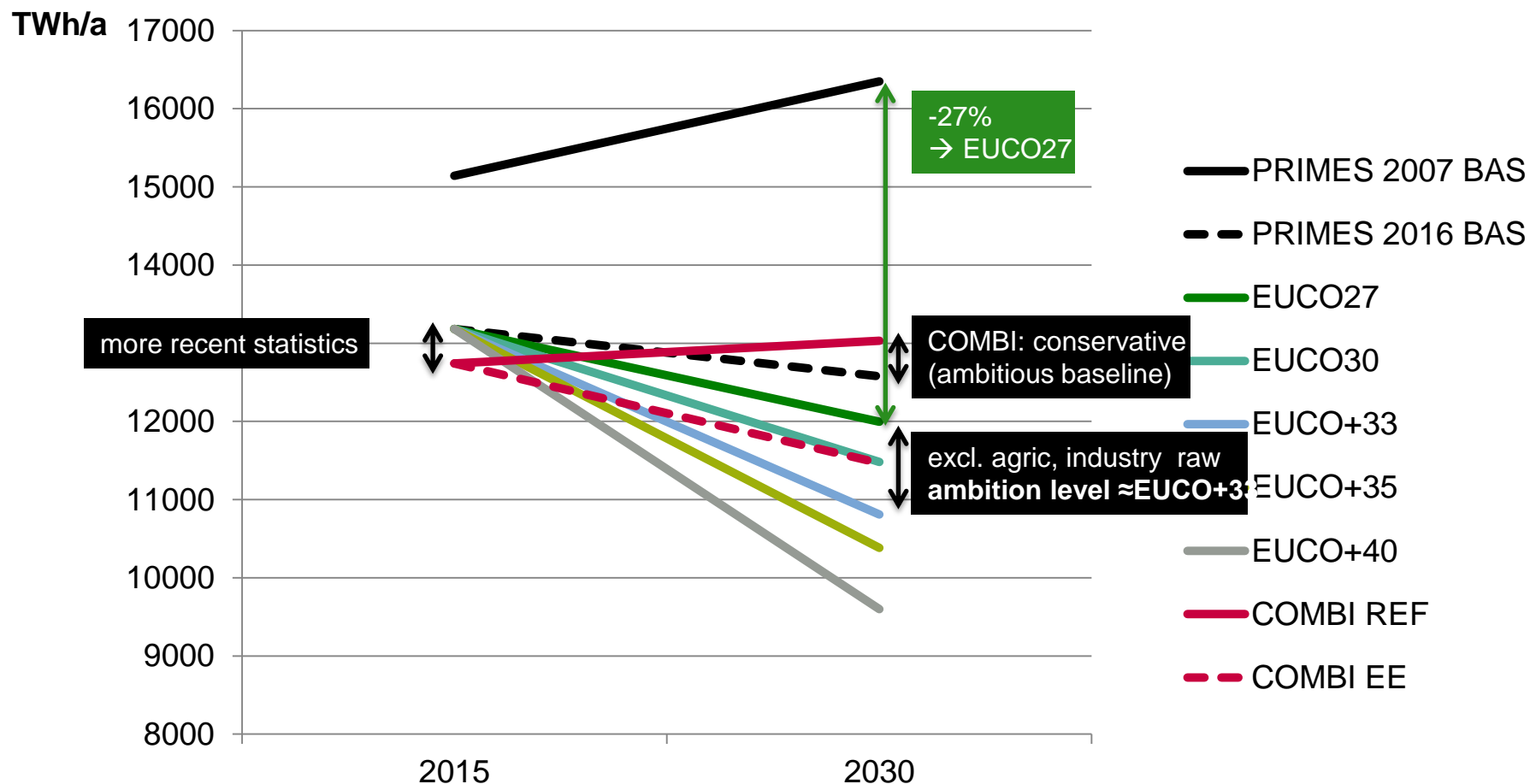
Buildings (residential & tertiary)	Transport	Industry
<p><b>Actions 1</b> (residential) <b>and 5</b> (non-residential): <b>refurbishment</b> of building shell + replacement of building systems (space heating, cooling and ventilation)</p> <p><b>Actions 2</b> (residential) <b>and 6</b> (non-residential): energy efficiency improvements of <b>new dwellings</b> or buildings, focusing on Passive House standards;</p> <p><b>Actions 3</b> (residential) <b>and 7</b> (non-residential): energy efficiency improvements for <b>lighting</b> systems;</p> <p><b>Actions 4</b> (residential) <b>and 8</b> (non-residential): energy efficiency improvements of <b>cold appliances</b> (residential) or product cooling (non-residential).</p>	<p><b>Actions 9 and 12:</b> <b>modal shifts</b> for both passenger and freight transport;</p> <p><b>Action 10:</b> energy efficiency improvements of motorized <b>two-wheelers</b>;</p> <p><b>Action 11:</b> energy efficiency improvements of passenger <b>cars</b>;</p> <p><b>Action 13:</b> energy efficiency improvements of <b>public road</b> transport, i.e. bus or coach;</p> <p><b>Action 14:</b> efficiency improvements of <b>light duty trucks</b> (LDTs);</p> <p><b>Action 15:</b> efficiency improvements of <b>heavy duty trucks</b> (HDTs).</p>	<p><b>Action 16:</b> energy efficiency improvements of <b>high temperature process heating</b> (furnaces, ovens, kilns, dryers, ...)</p> <p><b>Action 17:</b> energy efficiency improvements of <b>low and medium temperature process heating</b> (boilers and steam systems in general);</p> <p><b>Action 18:</b> energy efficiency improvements of industrial <b>process cooling and refrigeration</b>;</p> <p><b>Action 19:</b> energy efficiency improvements of <b>process specific use of electricity</b>, mainly electrochemical processes in non ferrous metals and chemicals;</p> <p><b>Action 20:</b> energy efficiency improvements of <b>motor drive systems</b>, including pumps, compressed air for utilities, compressed gas/air systems for processes; fans and blowers, and other motor applications;</p> <p><b>Action 21:</b> energy efficiency improvements of heating, ventilation and air-conditioning (<b>HVAC</b>) systems in industrial buildings.</p>

### → Outputs

- 2030 energy savings
- energy cost savings
- total investment costs
- additional data: stocks, scenario levels etc.

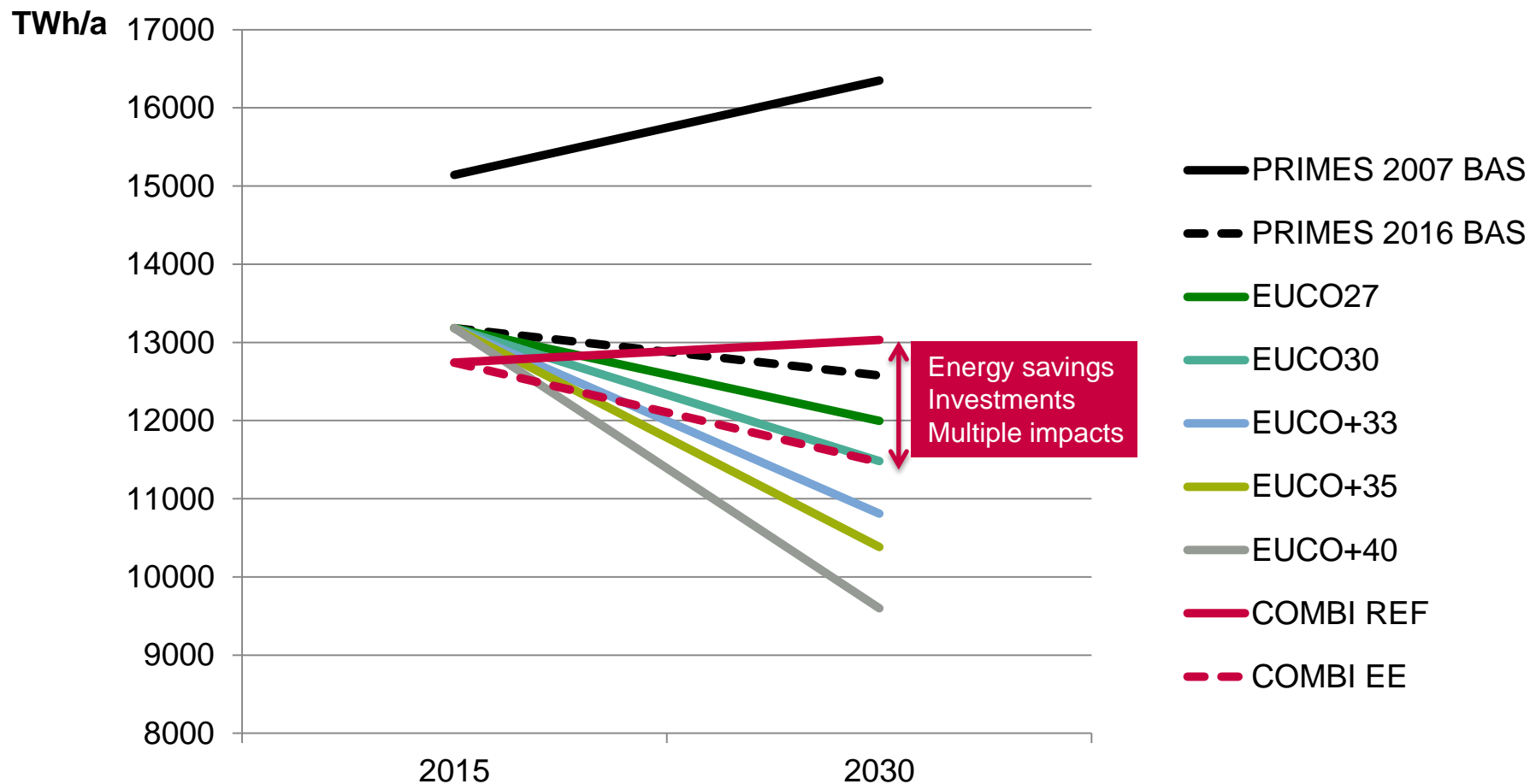
# COMBI input data 2

## Comparison of COMBI and EED IA (PRIMES 2016) scenarios



# COMBI quantifications

*Additional savings and impacts*



# Multiple impact modelling

## Overview









### Impacts modelling

#### Input data

- energy savings

additional data:  
stocks, scenario  
levels etc.

- investment costs

Impact category	Modelling approach	Impacts covered (additional savings)
Air pollution 	GAINS model (IIASA)	Air pollutants (NOx, PM10, PM2.5, SO2, VOC) Affected ecosystem area (acidification, eutrophication) Human health (through air pollution)
Resources 	Life-Cycle modelling (Material Input per service unit/MIPS)	Ecological footprint (Biotic materials, fossil fuels, metal ores, minerals, unused extraction)
Social welfare  	Socio-economic modelling	Health from indoor pollution Health from building conditions (asthma, excess winter deaths) Labour productivity (residential/tertiary buildings, transport)
Economy  <b>CE</b>	Short-term: Input- Output modelling	Employment GDP Public budget
Economy  <b>CE</b>	Long-term: CGE modelling	Fossil fuel prices EUA prices Structural effects
Energy system 	LEAP modelling	Avoided combustion/investment in combustion plants De-rated capacity margin
Energy security 	LEAP modelling	Energy intensity Fossil fuel imports Energy security index

COMBI online tool



# Access to project results

## COMBI online tool

User mode

Standard

Expert

1. Physical

2. Monetary

3. Cost-Benefit Analysis

Calculation

per capita

per GDP

Total

(select one)

Impact

Countries

Actions

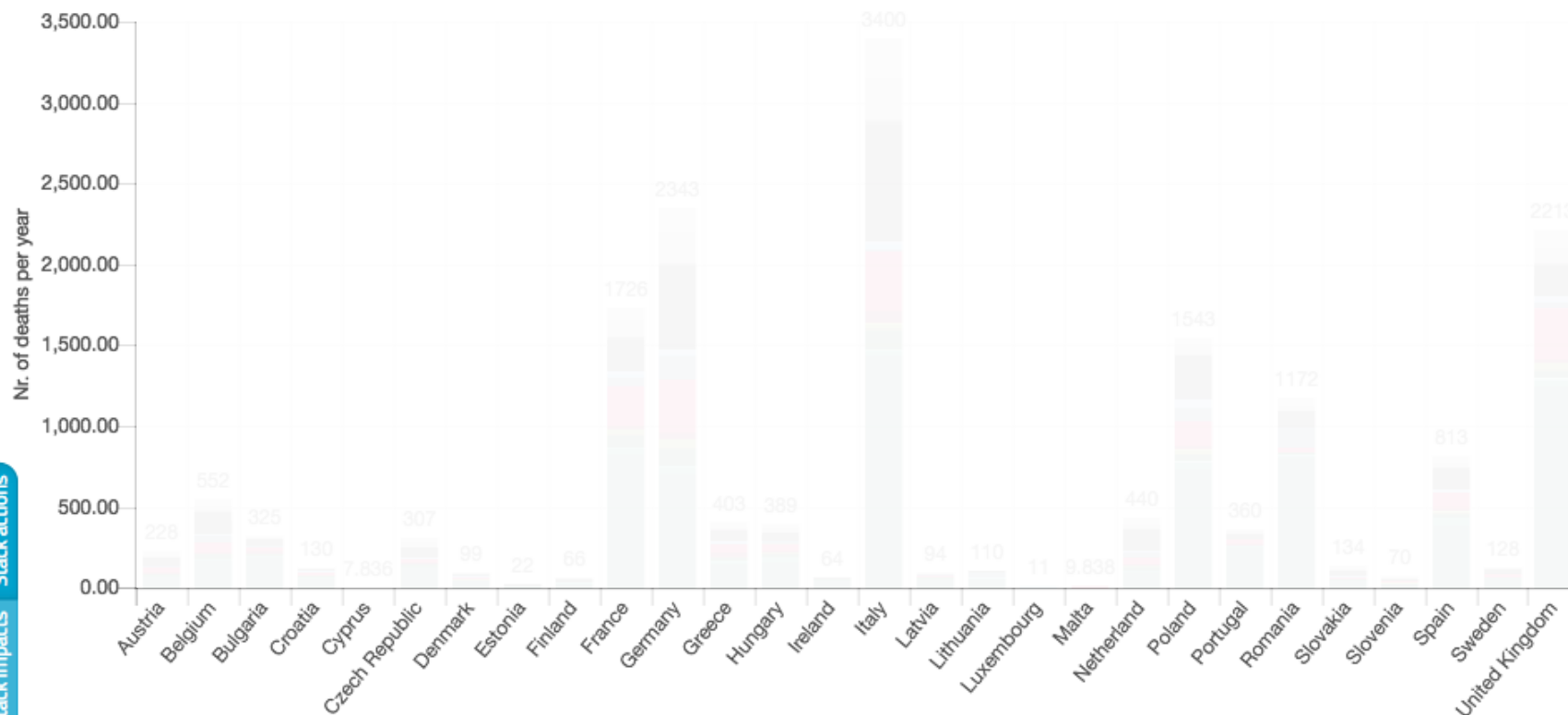
### Avoided mortality (total)

Avoided mortality (nr. of deaths per year) due to lower levels of air pollution (ozone and PM2.5) and avoided excess winter mortality due to improved indoor conditions and lower health risks.

► [Details on avoided excess winter mortality calculation](#)

► [Details on mortality from air pollution](#)

sensitivity: energy prices, discount rates, impact selection



# Results: avoided mortality

Tool standard mode (pre-aggregated)

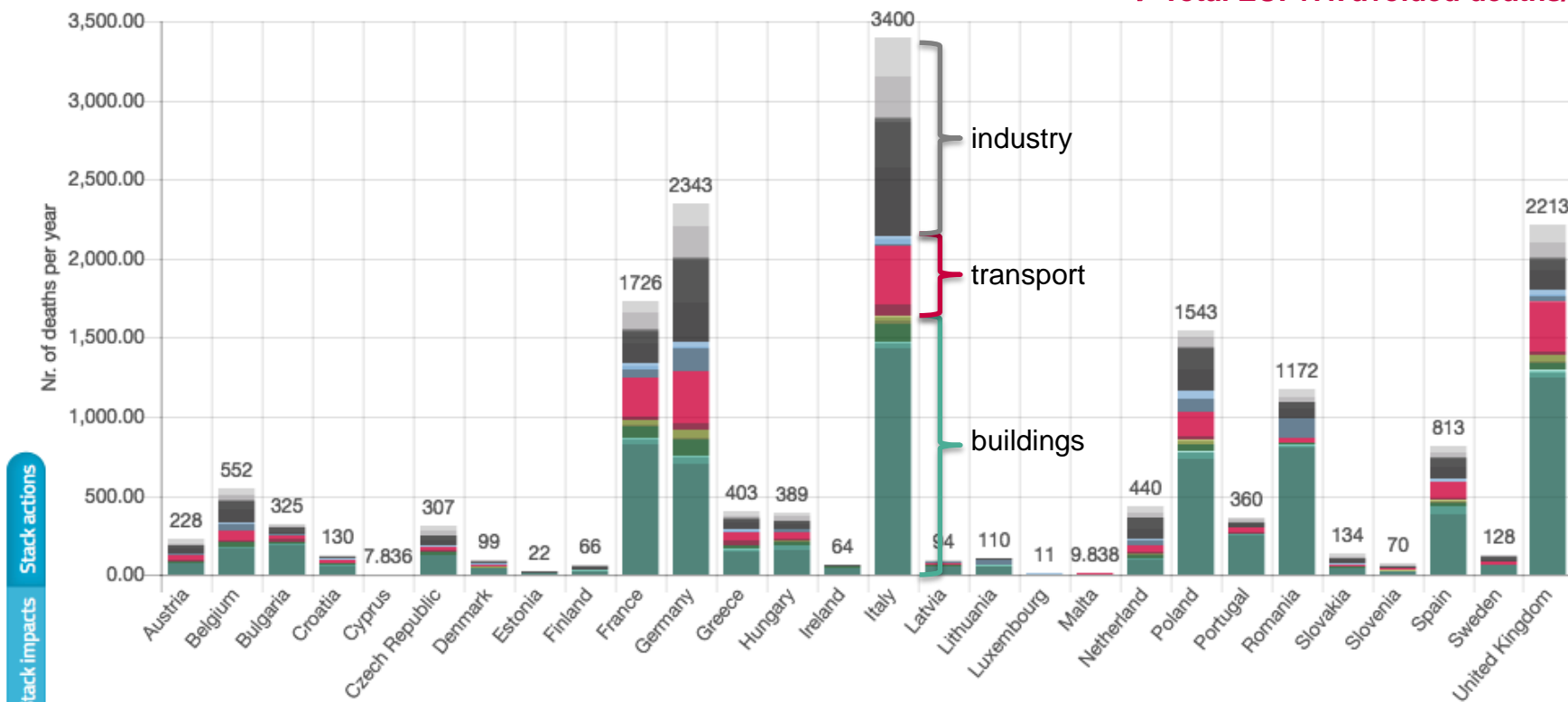
User mode		Standard	Expert	1. Physical		2. Monetary	3. Cost-Benefit Analysis
Calculation	per capita	per GDP	Total	(select one)	Impact ▾	Countries ▾	Actions ▾

**Avoided mortality (total)**

Avoided mortality (nr. of deaths per year) due to lower levels of air pollution (ozone and PM2.5) and avoided excess winter mortality due to improved indoor conditions and lower health risks.

- [Details on avoided excess winter mortality calculation](#)
- [Details on mortality from air pollution](#)

→ Total EU: 17k avoided deaths/year



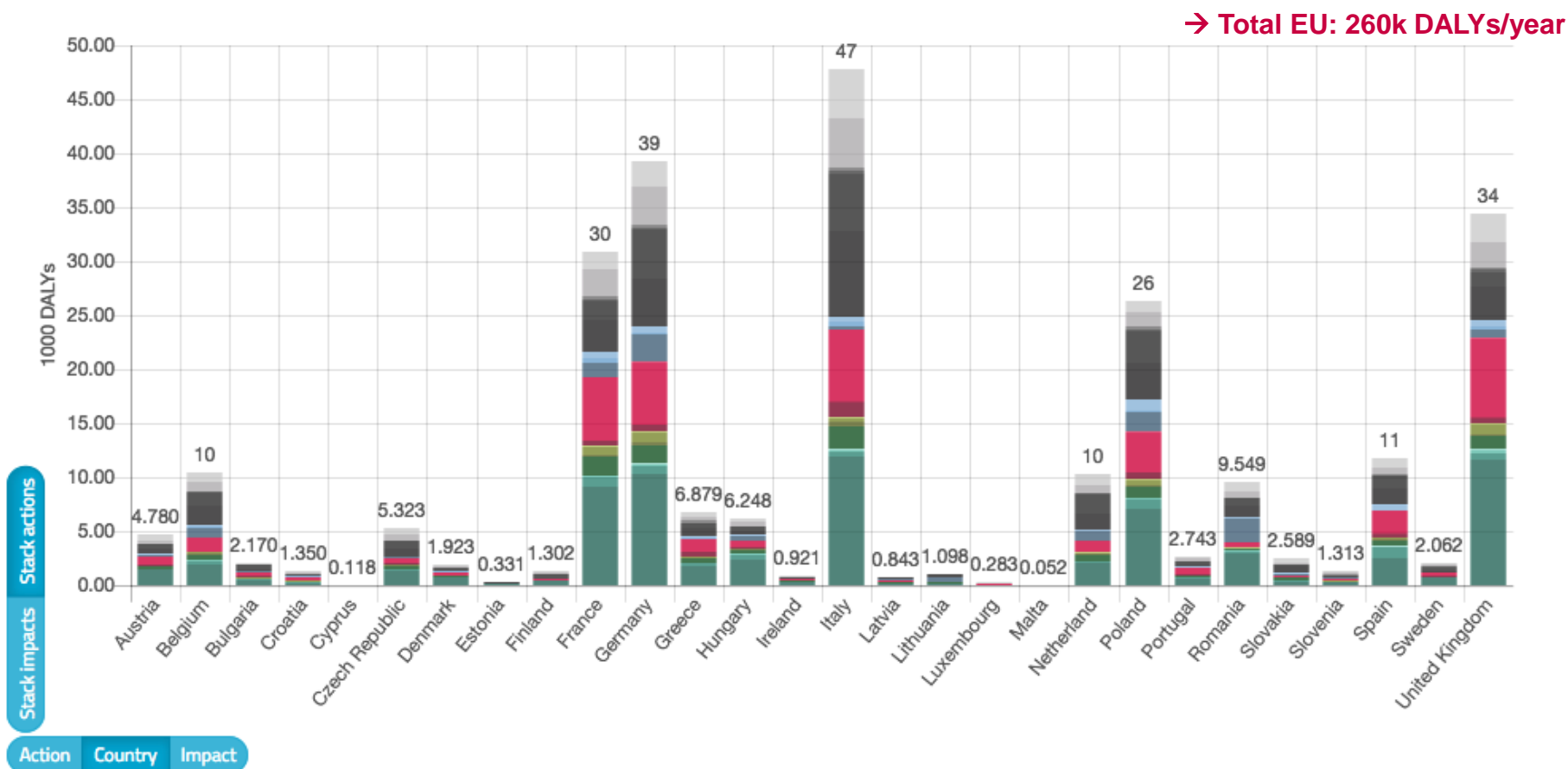
# Results: avoided health impacts (DALY)

Tool standard mode (pre-aggregated)

User mode	Standard	Expert	1. Physical		2. Monetary	3. Cost-Benefit Analysis
Calculation	per capita	per GDP	Total	(select one) Impact	Countries	Actions

Health impacts (DALY) (total)

Overall health impacts measured in gains of healthy life years (DALY) from several causal chains (building refurbishment, indoor/outdoor air pollution). For details explore sub-impacts in expert mode.



# Results: Labour productivity (mn workdays)

Tool standard mode (pre-aggregated)

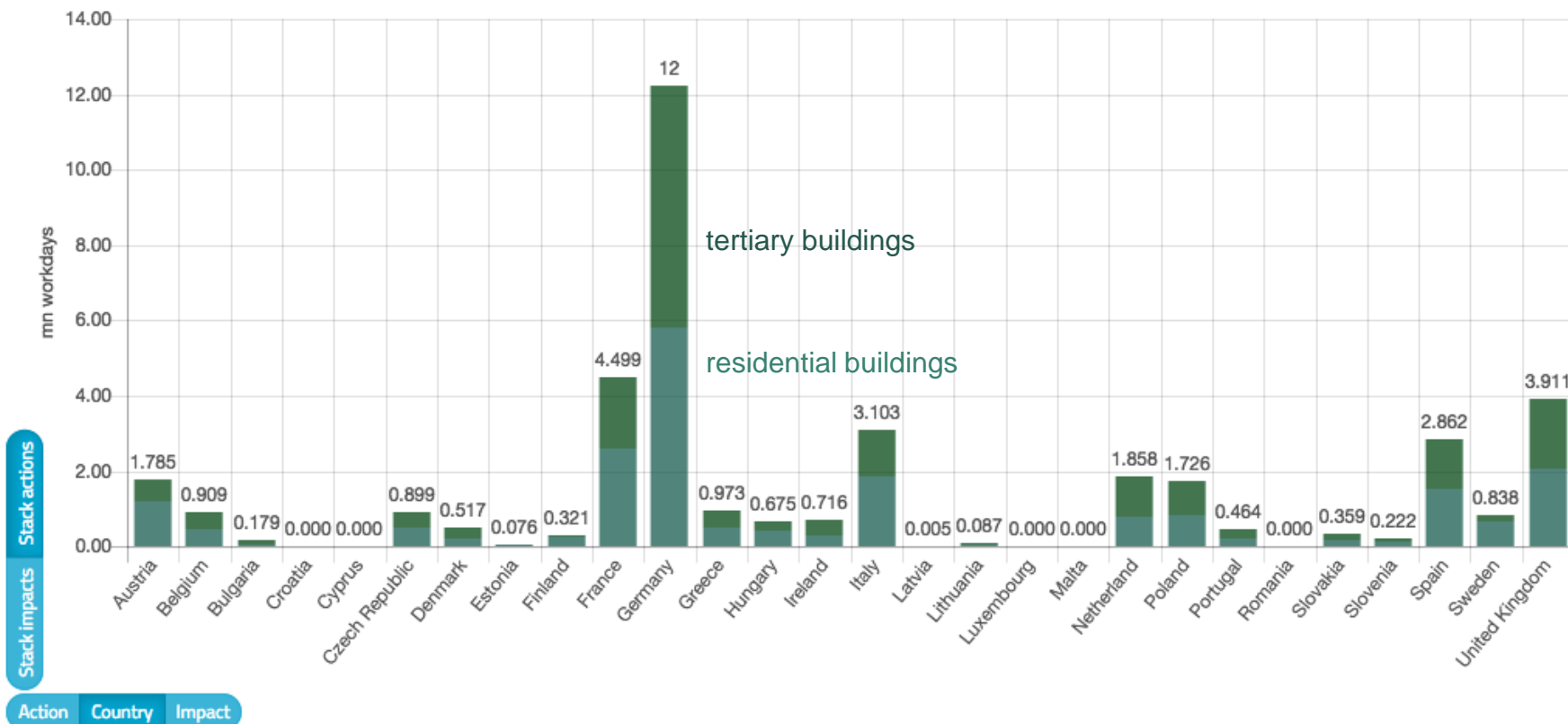
User mode		Standard	Expert
Calculation	per capita	per GDP	Total
		(select one)	
1. Physical		2. Monetary	
Impact		Countries	
		Actions	

Labour productivity in mn workdays (total)

- improved building conditions (refurbishment/new built) leading to better health and thus more available time
- Improved tertiary building conditions leading to higher workforce productivity
- Reduced road congestion leading to less time loss

[Details on productivity quantifications](#)

→ Total EU: 39mn days/year



# Results: Avoided investments in combustibles plants

Tool standard/expert mode

User mode	Standard		Expert	1. Physical		2. Monetary		3. Cost-Benefit Analysis	
Calculation	per capita	per GDP	Total	(select multiple)Impacts		Countries		Actions	
Energy prices	Low	Mid	High						

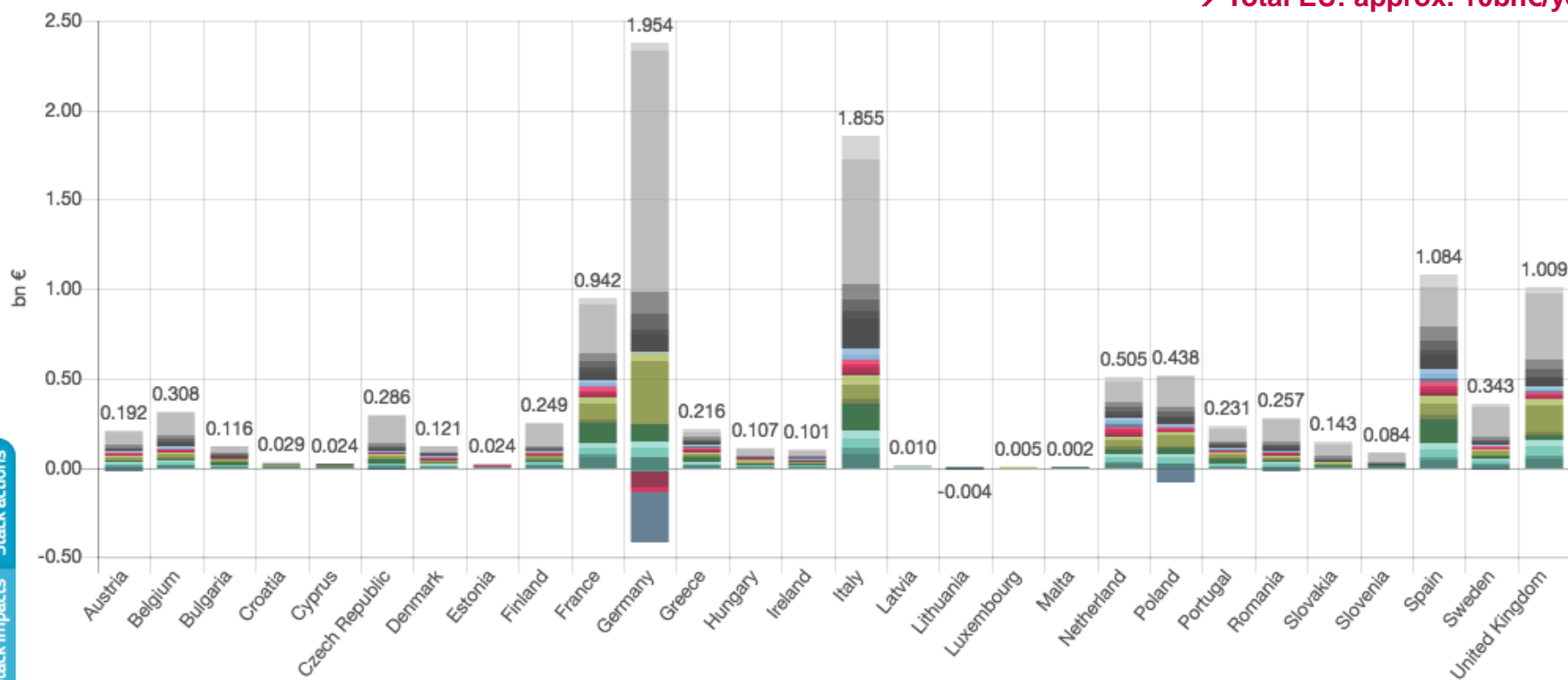
Avoided investments in combustibles plants (total)

Avoided investment costs in combustibles-based power plants and CHP incl. fossil, waste and solid biomass-fuelled plants

## Avoided investments in combustibles plants (total)

Avoided investment costs in combustibles-based power plants and CHP incl. fossil, waste and solid biomass-fuelled plants

→ Total EU: approx. 10bn€/year



Stack impacts Stack actions

Action Country Impact

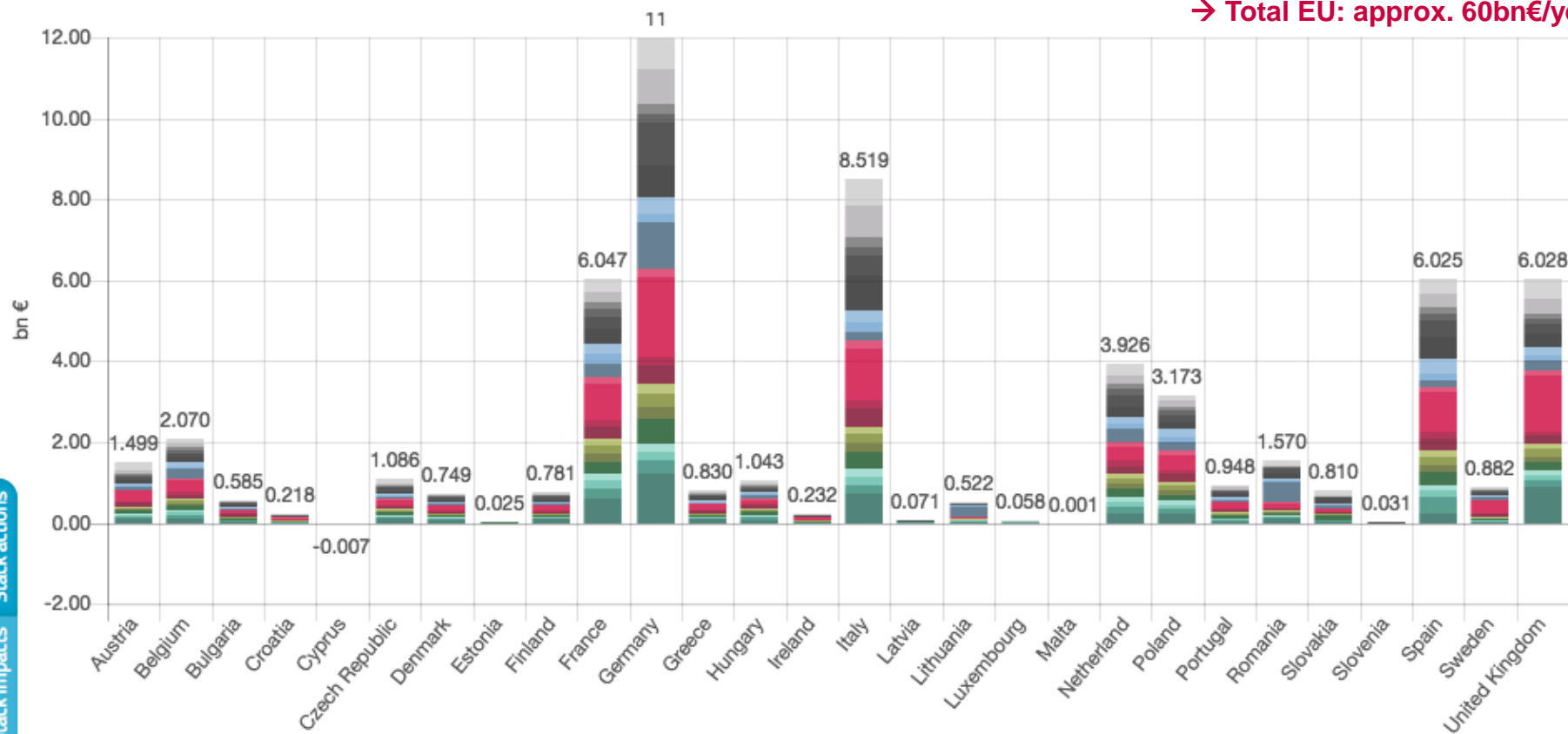
# Results: Fossil fuel import reduction

Tool expert mode

User mode	Standard		Expert	1. Physical			2. Monetary		3. Cost-Benefit Analysis	
Calculation	per capita	per GDP	Total	(select multiple) Impacts			Countries		Actions	
Energy prices	Low		Mid	High						

Selected monetary impacts by bn € and country

→ Total EU: approx. 60bn€/year



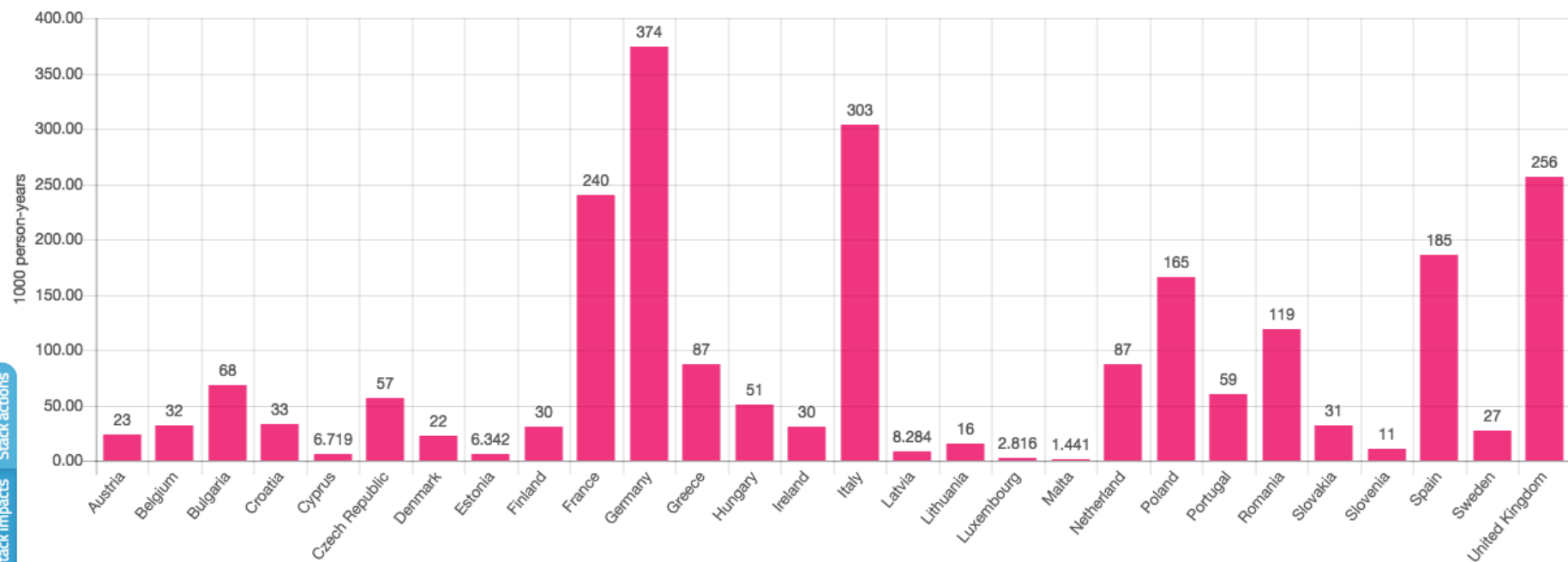
Stack actions  
Stack impacts

Action Country Impact

# Results: Employment effect

## Tool expert mode

User mode	Standard		Expert	1. Physical		2. Monetary		3. Cost-Benefit Analysis	
Calculation	per capita	per GDP	Total	(select one)	Impact ▾		Countries ▾		Actions ▾
				Employment effect <small>(total)</small>					
				Direct (short-term) employment effect in 1000 person-years. Note: based on assumption of existence of output gap in 2030.					

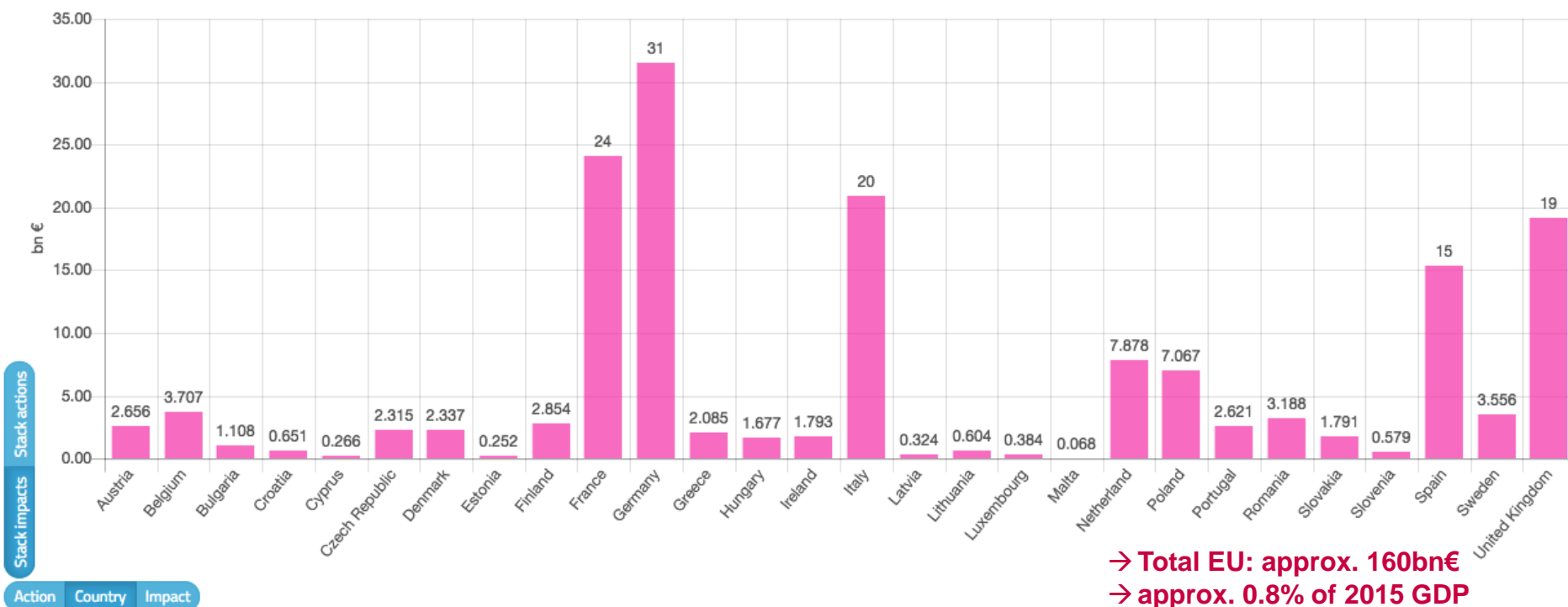


→ Total EU: approx. 2.3 mn job-years

# Results: GDP effect

## Tool expert mode

User mode	Standard	Expert	1. Physical	2. Monetary	3. Cost-Benefit Analysis
Calculation	per capita	per GDP	Total	(select one) Impact ▾	Countries ▾
			Increase in Gross Domestic Product (total) Short-term increase in GDP in bn€. Note: based on assumption of existence of output gap in 2030.		



→ Total EU: approx. 160bn€  
→ approx. 0.8% of 2015 GDP



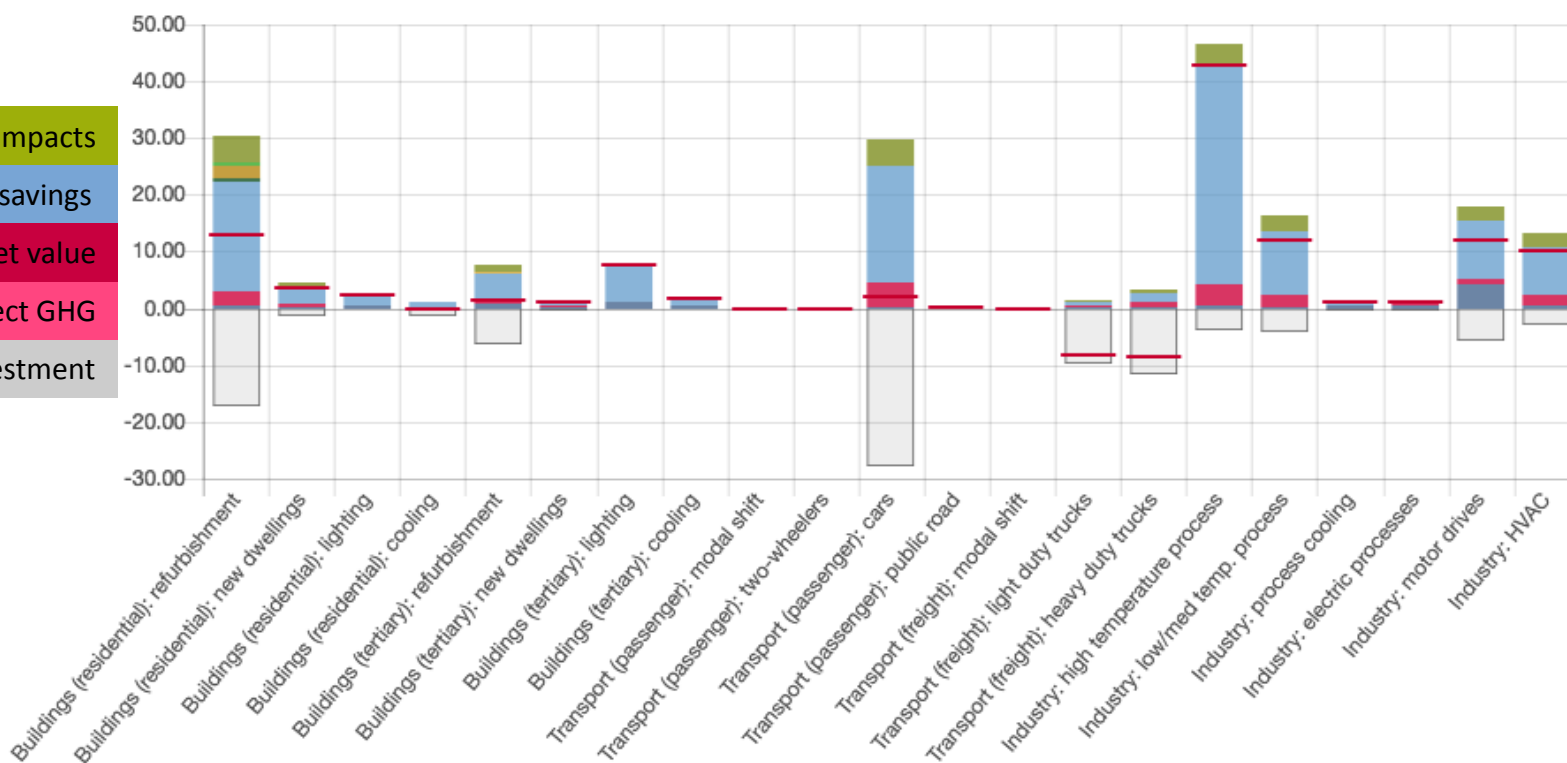
# Cost-benefit analysis

## Example from expert mode (total EU)

User mode	Standard		Expert		1. Physical		2. Monetary		3. Cost-Benefit Analysis	
Calculation	per capita	per GDP	Total		(select multiple)	Impacts	Countries		Actions	
CBA mode	Life-Time	Annualised								
	Levelized	MCC	BCR	CBR						
Energy prices	Low	Mid	High							
Discount rate			3							

### Annualised net present value (bn€ per year in 2030) (total)

Annualised net value of actions. Calculated based on selected actions and countries, annualised investments (annuisation based on selected discount rate), selected annual impacts. Negative values imply costs of EEI actions, positive values gains of EEI actions. Note: modal shift actions not possible to display as infrastructure investments not quantified in COMBI



→ MI inclusion improves NPV

→ Public budget (not included here) approx. amount of energy savings

# COMBI online tool

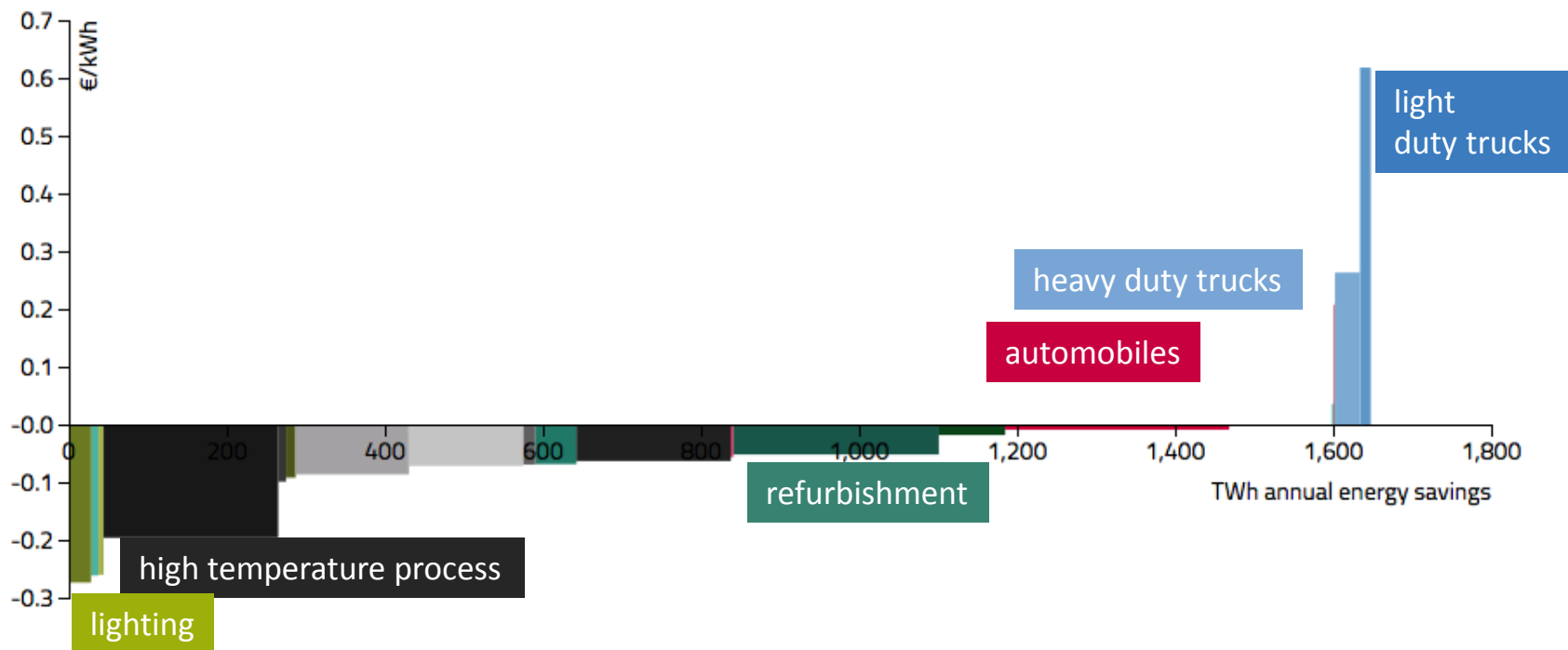
## Marginal energy savings cost curve (excl./incl.\* MIs)

User mode	Standard	Expert	
Calculation	per capita	per GDP	Total
CBA mode	Life-Time	Annualised	
	Levelized	MCC	BCR CBR
Energy prices	Low	Mid	High
Levelization by	Energy savings		
	GHG emissions		
Discount rate	3		

1. Physical	2. Monetary	3. Cost-Benefit Analysis
(select multiple) Impacts	Countries	Actions

### Marginal energy savings cost curve (total)

Levelized cost of energy savings (based on selected impacts) by TWh annual energy savings in 2030. Positive values imply net costs, negative values net gains. Note: modal shift actions net value not possible to display as infrastructure investments not quantified in COMBI. Savings potential included with net value 0.



\* MIs included for this display: avoided costs of combustibles generation, health & mortality from air pollution & building conditions, productivity, direct GHG emissions. Public budget effect excluded.

# Caveats & interpretation

## Room for improvements

- COMBI far from complete:
  - sectoral & EEI action coverage
  - many impacts could not/not comprehensively be estimated
  - estimation techniques: model improvements & Integrated Assessment (for feedback loops, overlaps & interactions)
  - impact values level-dependent (non-linear) → applicable only for COMBI scenarios
  - impact aggregation issues: inclusion to CBA
- Knowledge base issues
  - more data & research needed
  - Evolving: BAS/EE/BAT technologies → Continuous model improvements necessary

# COMBI conclusions & insights

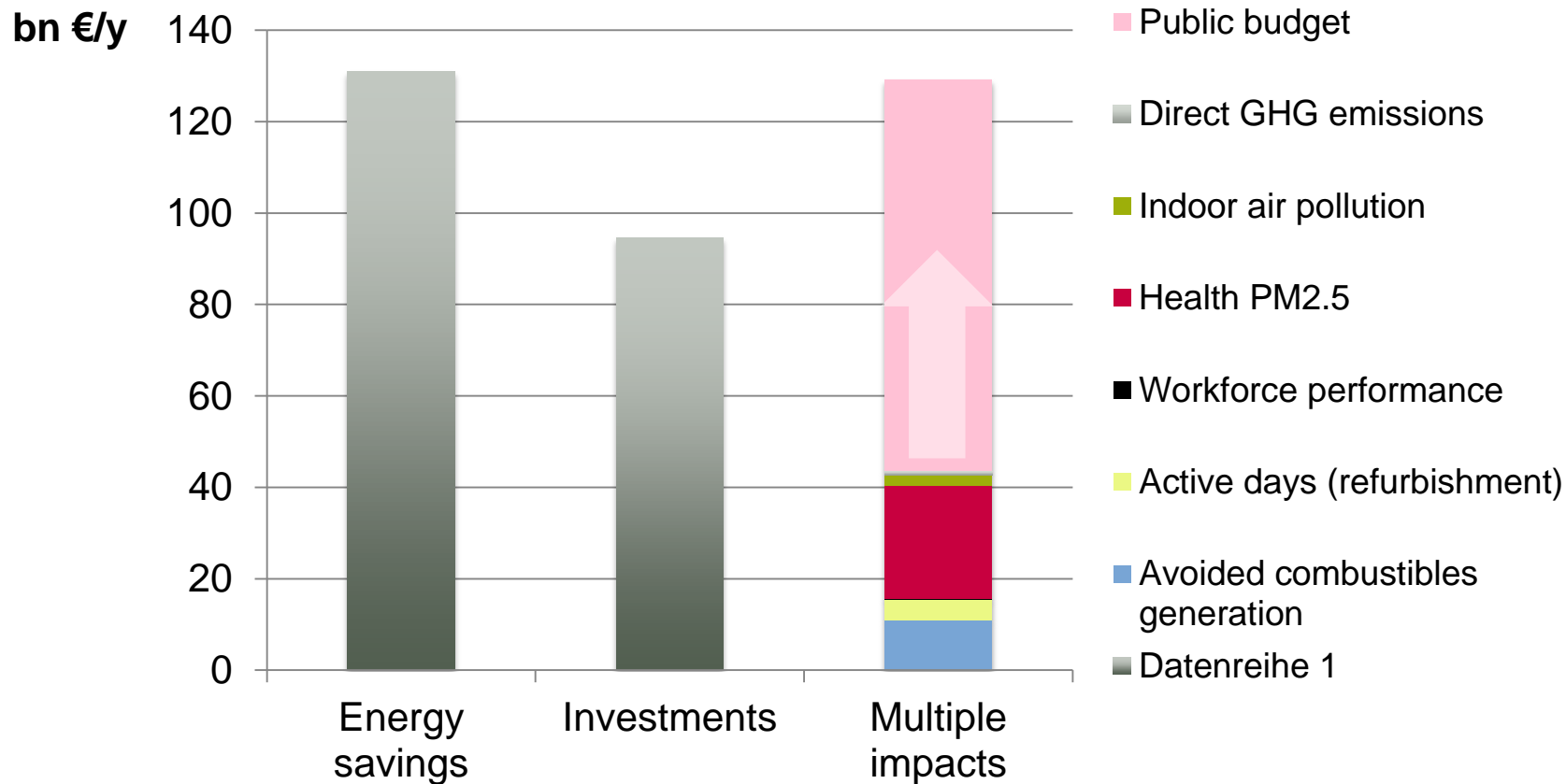
## Wrap-up of impacts

Pursuing a more ambitious EE policy that leads to achieving the 33% target (instead of 27% target) will lead to **at least** (conservative estimation):  
(selected impacts, per year)

- **Avoided health problems:** 260k DALYs/year, 17k deaths/year
- **Additional labour productivity:** 39mn workdays/year
- **Lower material footprint:** 845 Mt resource savings (production phase not accounted for in most cases)
- **Avoided investment in electricity generation:** 10bn€/year
- **Lower fossil fuel import costs:** 60bn€/year
- Up to 160bn€ **additional GDP** (in case of negative output gap)
- Up to 85bn€ **public budget effect** (in case of negative output gap)
- Up to 2.3mn person-years **additional employment** (in case of negative output gap)

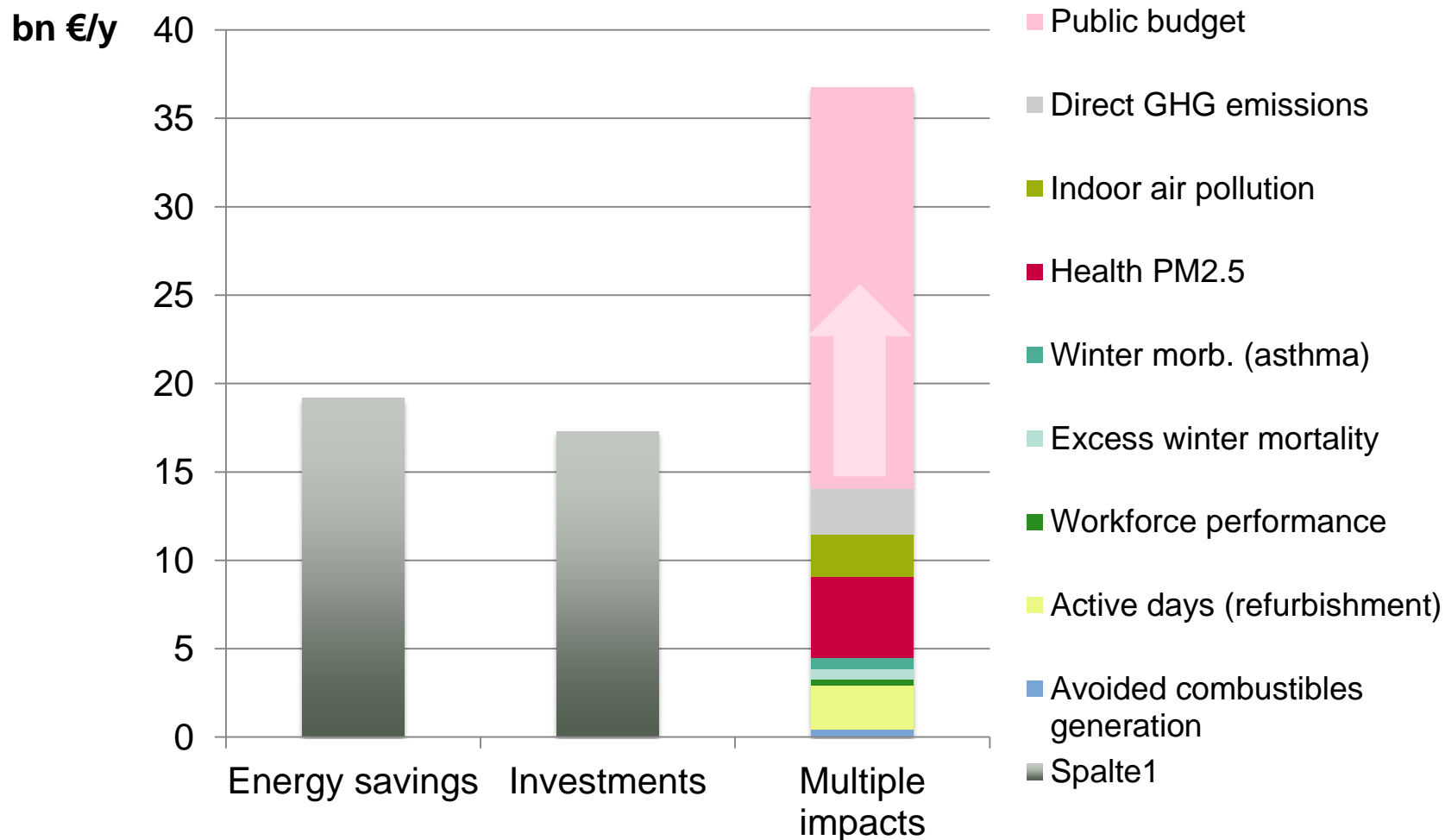
# COMBI conclusions & insights

## All EEI actions



# COMBI conclusions & insights

## Residential refurbishment



# COMBI conclusions & insights

## Primary and multiple impacts of EE in the EU

- only monetized MIs quantified in COMBI amount to 1/3 (up to 100% incl. public budget) of energy cost savings
  - Res. buildings: MI amount to 2/3 of energy savings (close to 200% incl. public budget)
  - Cost-effectiveness of EEI actions improves substantially from a societal perspective when including MIs
- EE is a case not only for GHG Mitigation but also for
- human health, environment, agriculture, economy, public budgets
- **Key to involve respective policy departments!**

# Thank you

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Wuppertal Institute for Climate, Environment and  
Energy



**Wuppertal  
Institut**

and Transport Policy



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→ **launch on 17 May 2018**



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**online tool**

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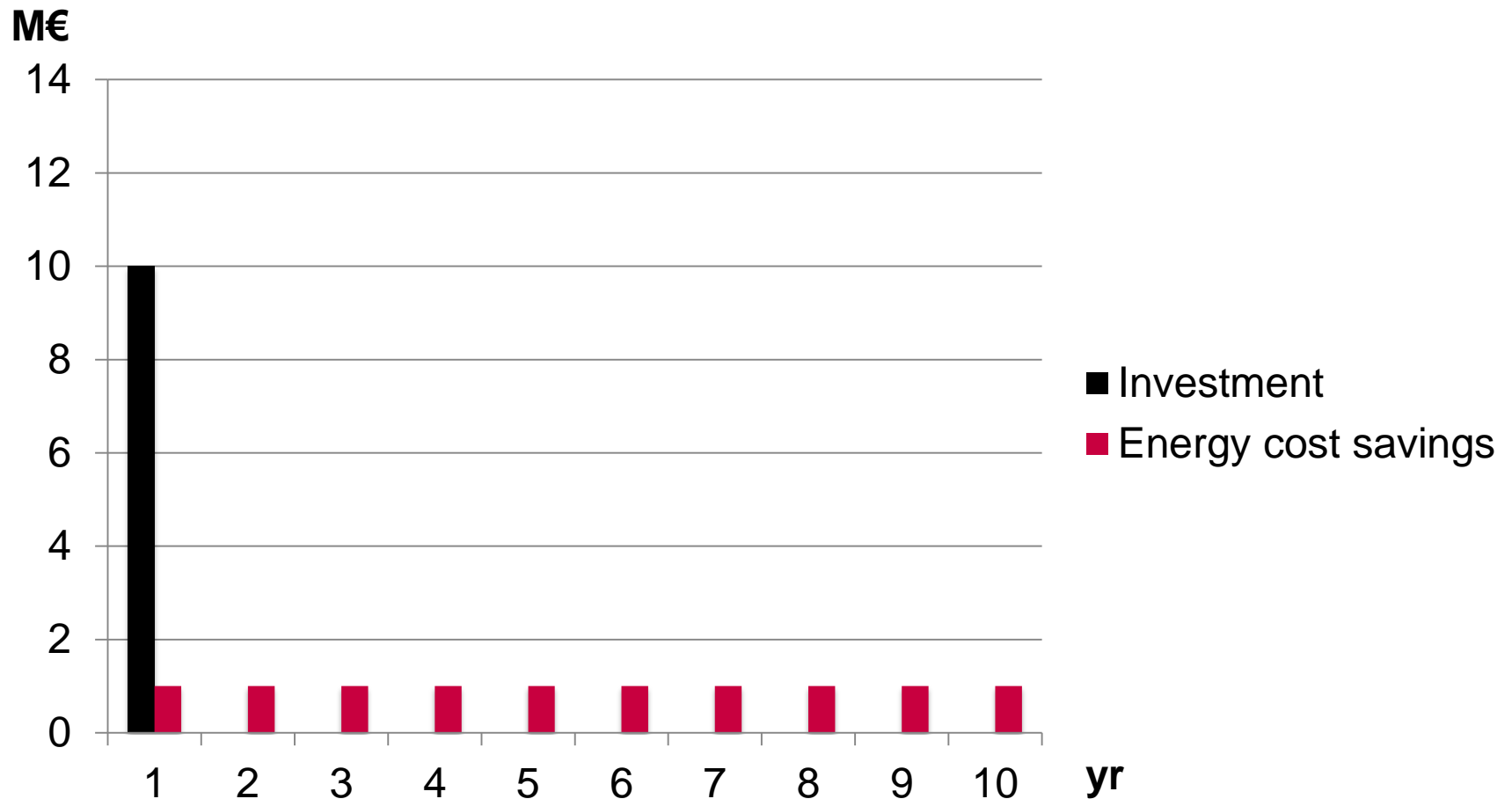
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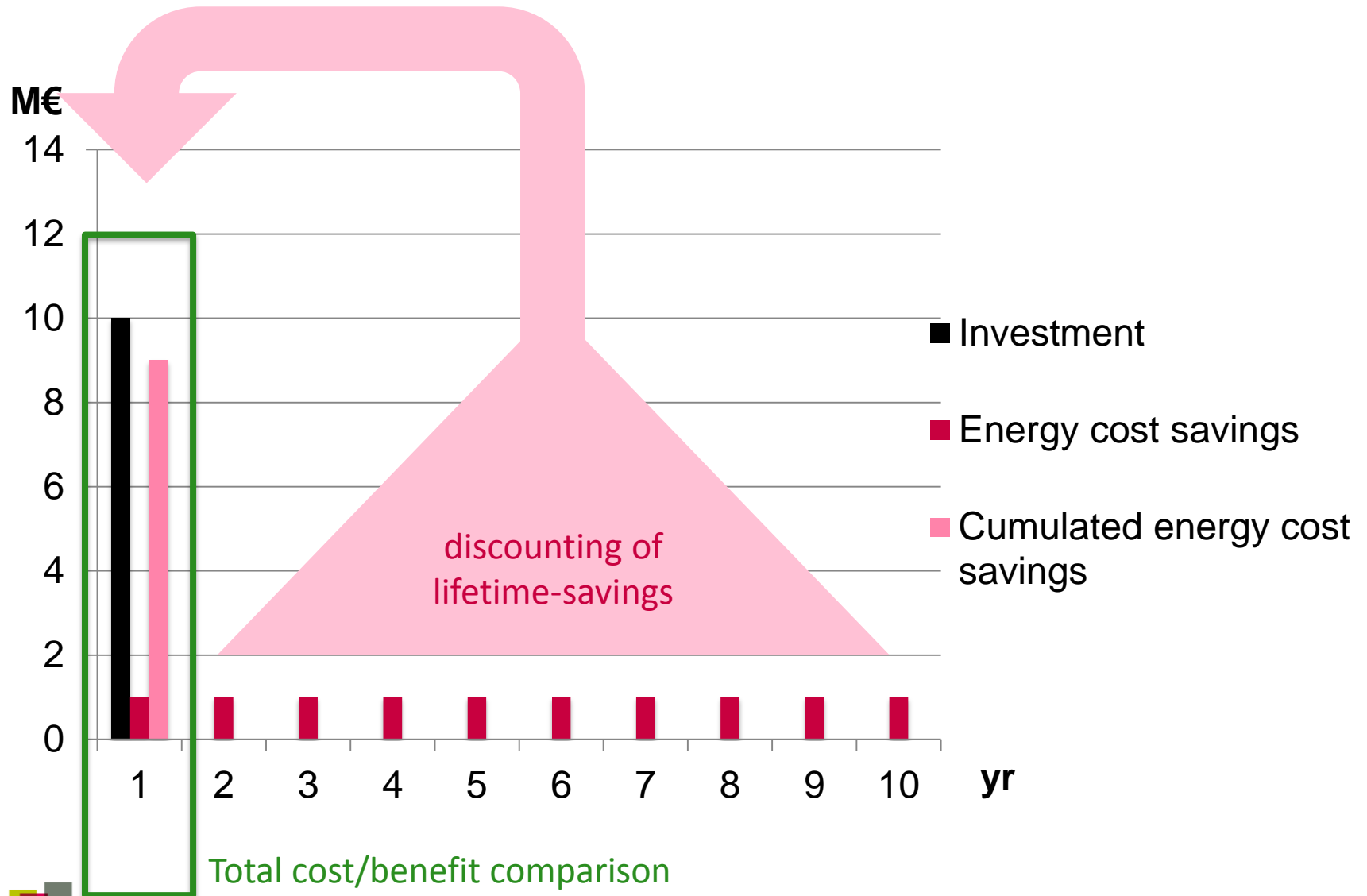
# Traditional cost-benefit analysis

Example: CBA of total values

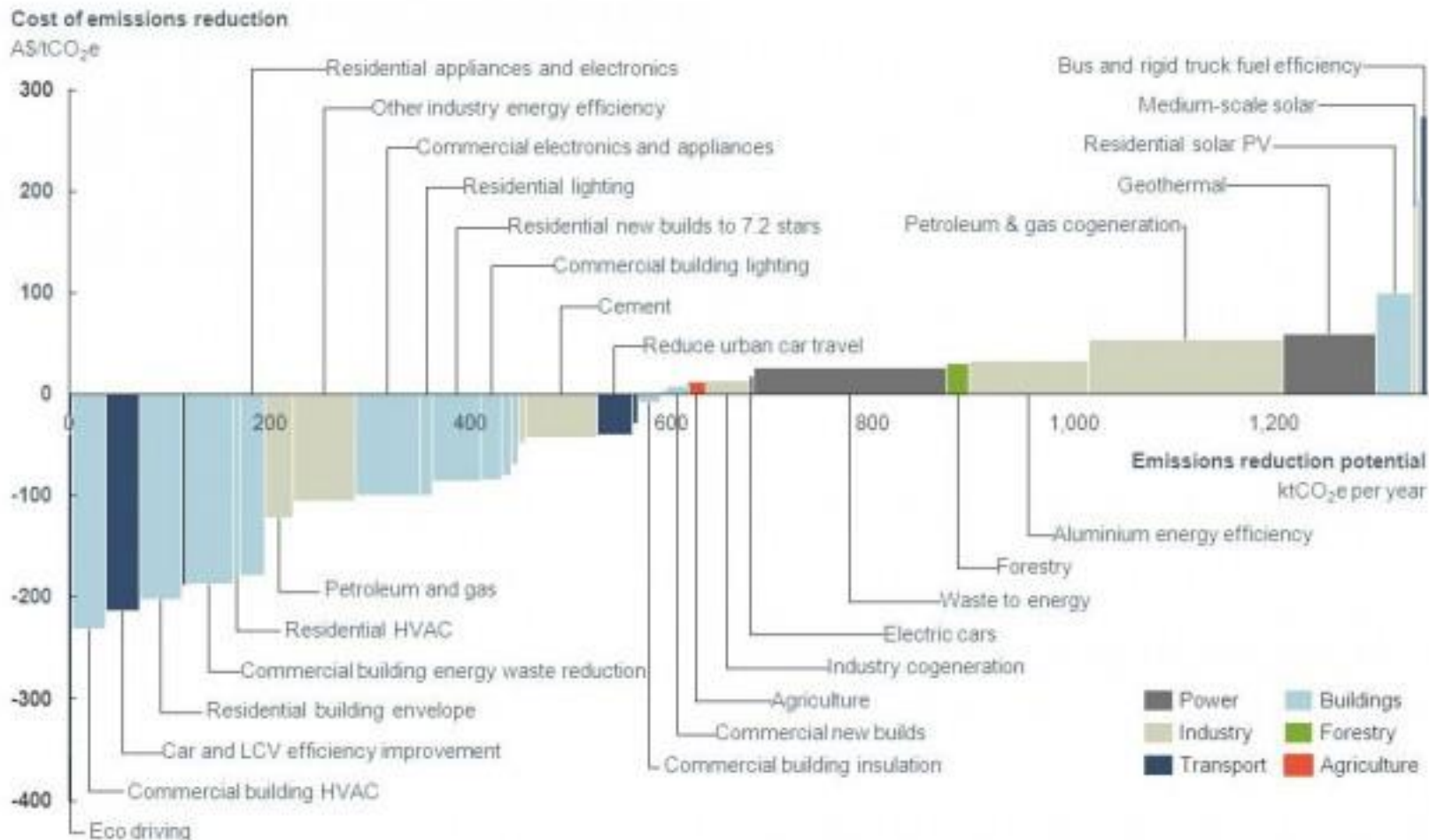


# Traditional cost-benefit analysis

Example: CBA of total values



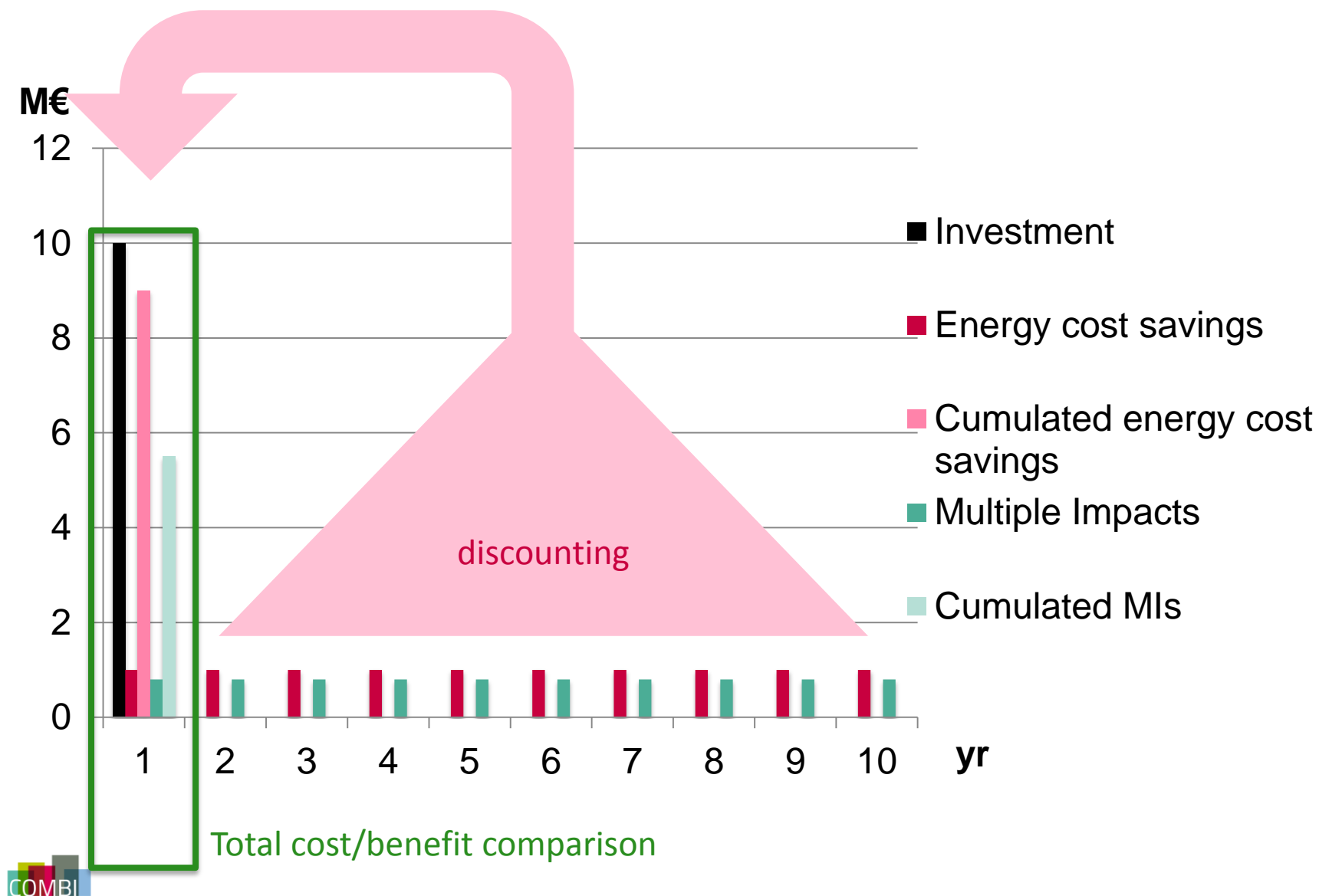
# Cost-benefit analysis of Energy Efficiency



Source: Ecofys/WI 2014, Climateworks

# Expanded Cost-benefit analysis

CBA including Multiple Impacts of Energy Efficiency



# Cost-benefit analysis of Energy Efficiency



Source: Ecofys/WI 2014



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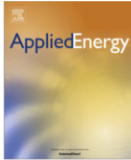
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## Measuring multiple impacts of low-carbon energy options in a green economy context



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