

The background of the slide is a faded, light-colored image of a wind farm. Several white wind turbines are visible against a pale sky, with a flat landscape in the foreground. A large teal horizontal bar is overlaid on the top half of the image, containing the title text.

CLIMATE CHANGE ADAPTATION– RESULTS FROM AN ECONOMIC MODEL FOR GERMANY

Ulrike Lehr
Markus Flaute
Lara Ahmann

- **“Detailed economic analysis of individual policy instruments and measures for climate change adaptation”**
- Funded by: German Environment Agency
- Partner: Institute for Ecological Economy Research
- **Part I: Extreme weather events: Storm, Heavy rain, Heatwave**
 - What are the macroeconomic effects?
 - How can we adapt?

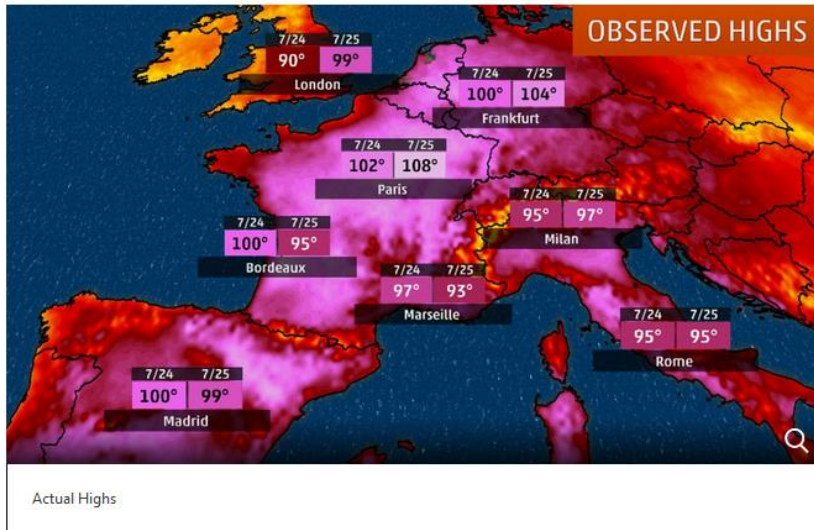


Storm 'Friederike' caused €1 billion in damages in Germany

The deadly winter storm "Friederike" that swept through western Europe is estimated to have caused around €1 billion in damages in Germany. It was the second-most expensive storm to strike Germany in the past 20 years. [dw.com](https://www.dw.com), 25.01.18

May and April 2018 hottest in Germany since 1881

Germany has experienced its hottest May and April since the late 1800s. The German Weather Service said the blazing temperatures could only be understood in relation to climate change. [dw.com](https://www.dw.com), 04.06.18



Can Germany's supposedly crumbling infrastructure hold up against extreme heat?

This week, a runway at Hanover airport cracked because of unusually hot temperatures while some German roads have also buckled this summer. In an age of rising temperatures, can the country's concrete hold up?



[dw.com](https://www.dw.com), 27.07.18

After the drought, the storm: German weather chaos continues

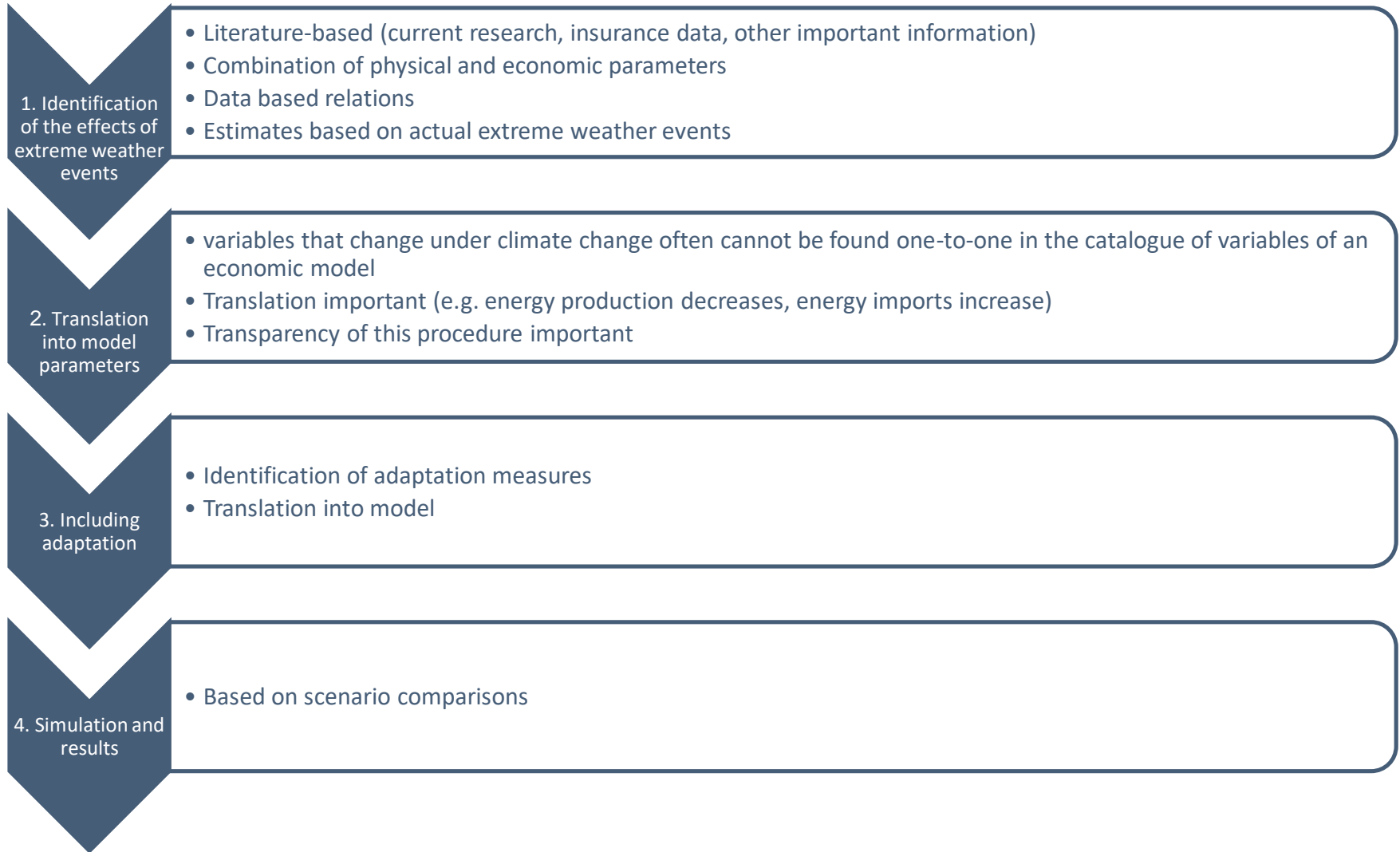
After days of exceptional heat, the rains came in dramatic fashion across northern Germany. Several people were injured by falling trees and travel was severely disrupted. [dw.com](https://www.dw.com), 10.08.18

→ Focus on storm, heavy rain and heat waves

By [weather.com](https://www.weather.com) meteorologists, July 26, 2019 08:50 PM EDT

Modeling of climate damages and adaptation

Proceeding in 4 steps

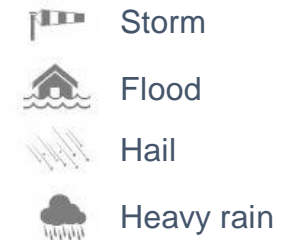


1. Identification of the effects of extreme weather events

– Data insurance industry: property insurance (only insured damages)

The ten most devastating natural disasters in Germany (simplified)

Year	Name	Date	Hazard	Number of damages	Claims expenditure property insurance (Million €)
2007	Kyrill	18.01.–19.01.		2.060.000	2.060
2002	August-Hochwasser	31.07.–02.09.		107.000	1.800
2013	Juni-Hochwasser	25.05.–15.06.		120.000	1.650
2013	Andreas	27.07.–28.07.		245.000	1.600
1999	Lothar	25.12.–26.12.		550.000	800
2016 ²	Elvira, Friederike, Gisela	27.05.–09.06.			800
2002	Jeanett	27.10.–28.10.		995.000	760
2015 ¹	Niklas	30.03.–01.04.		590.000	590
2010	Xynthia	28.02.		580.000	510
2014	Ela	09.06.		270.000	450

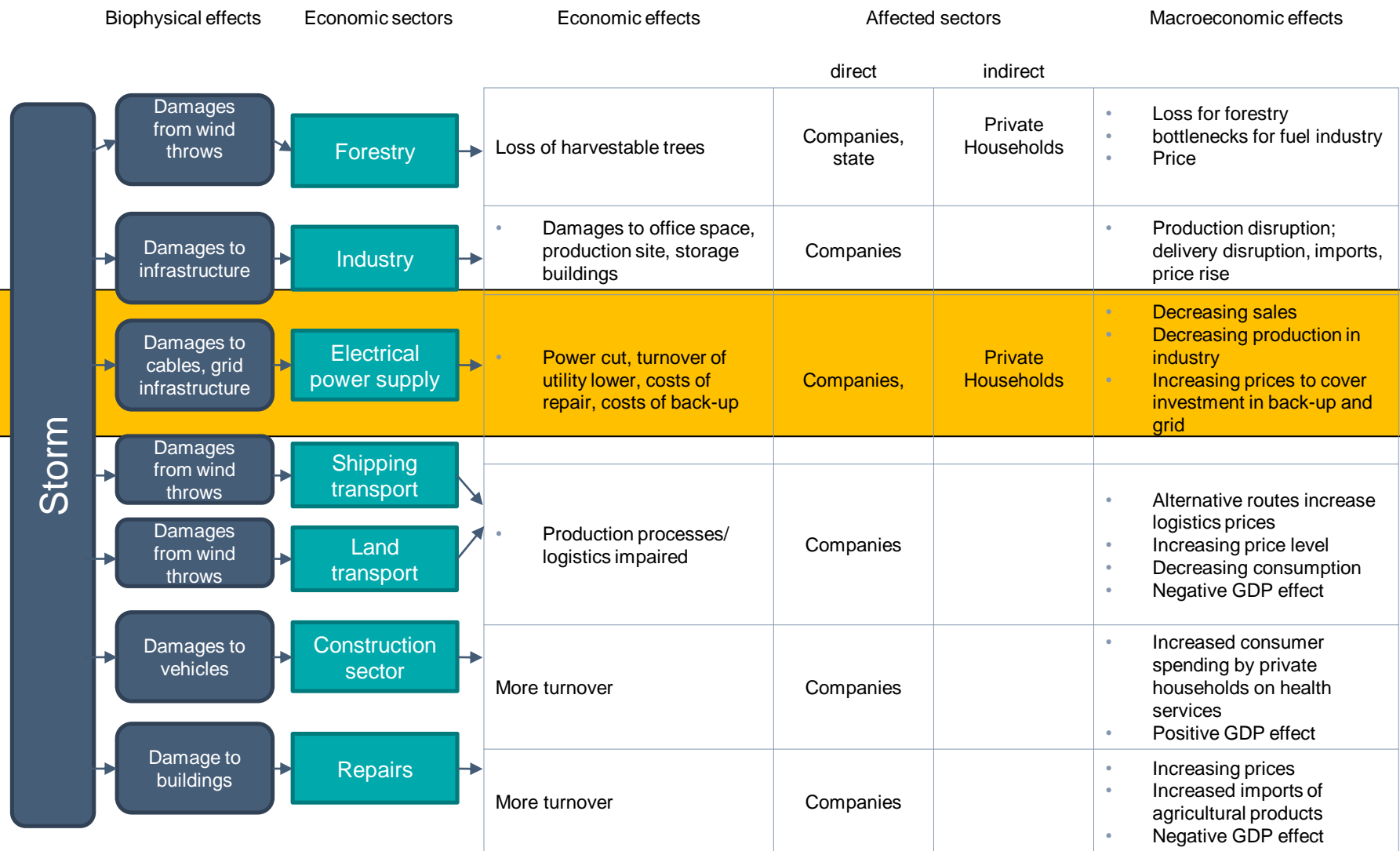


Source: GDV

2. Translation of climate change into model parameters


- The **macro-econometric PANTA RHEI** depicts macroeconomic relations and long-term structural changes on an **annual basis for Germany**.
- **Macroeconomic variables** as well as **individual economic sectors (63 sectors)** can be analyzed.
- **Important to remember** while implementing extreme weather events in the model:
 - Not every damage is insured
 - Some damages can be shifted (insurance)
 - Some losses are not monetary
- Complete chains of action were analyzed for the economic damages; **in the following results for the example of storms on the grid and electricity generation**
- **Full study includes 26 adaptation measures and instruments**

2. Translation of climate change into model parameters




3. Including adaptation measures & instruments

- **Adaptation to climate change:**
 - anticipating the adverse effects of climate change
 - taking appropriate action to prevent or lessen the damage or taking advantage of opportunities that may arise

 - **Selection of adaptation measures:**
 - Extreme weather event: storm, heavy rainfall, heat wave
 - Need for action: medium or high
 - Extent of decrease in damage
 - Can be simulated with an economic model
 - Economic instrument, CC instrument, voluntary agreements
- 

Taxes, subsidies, financial support, also: public investment



Cooperation
Voluntary agreements
Regulatory instruments

3. Storm: implementation of adaption measures in the model

Sector	Measure	Instrument	Implementation	Adaptation effect
Wald- und Forstwirtschaft	g2 Angepasster Waldumbau		Veränderung der Vorleistungsstruktur der Forstwirtschaft; 100 Mio €/a	Änderung der Produktion
Utilities	i1 stabilizing the grid		Investing in grid infrastructure Straßen werden	Reduction of production losses Reduktion Produktionsausfall
Verkehr, Verkehrsinfrastruktur	k1 Technische Maßnahmen Verkehrsinfrastruktur Straße	z.B. Förderung von Mehrinvestitionen BVWP	Kinnament gebaut, erneuert und instandgehalten; 100 Mio. €/a	Reduktion Schäden Infrastruktur in Sturmjahren, Reduktion der Kfz-Schäden in Sturmjahren
Verkehr, Verkehrsinfrastruktur	k2 Anpassung der Wartungsarbeiten Eisenbahninfrastruktur		Vermehrte Wartungs- und Reparaturarbeiten Eisenbahn; 50 Mio. €/a	Reduktion Produktionsausfall, Reduktion Schäden Infrastruktur Eisenbahn in Sturmjahren
Verkehr, Verkehrsinfrastruktur	k3 Technische Lösungen für Hitzebelastung, Überschwemmung, Sturm an Eisenbahnschienen	z.B. Finanzierungsprogramm Schiene; Förderung intramodaler Strukturen	z.B. vermehrte Wartungsarbeiten zur Reaktivierung und Instandhaltung von Ausweichrouten; 200 Mio. €/a	Reduktion Produktionsausfall, Reduktion Schäden Infrastruktur Eisenbahn in Sturmjahren
Verkehr, Verkehrsinfrastruktur	k5 Angepasste Hafeninfrastruktur		Bauinvestitionen für eine verbesserte Hafeninfrastruktur; 50 Mio. €/a	Reduktion Produktionsausfall, Reduktion Schäden Infrastruktur Hafen in Sturmjahren
Verkehr, Verkehrsinfrastruktur	k7 Angepasstes Design und Wartung von Brücken und Tunneln	z.B. Förderung von Mehrinvestitionen BVWP	s.o. k1	s.o. k1
Industrie und Gewerbe	i6 Erhöhung der Anlagensicherheit	z.B. Finanzielle Unterstützung bei Betriebsoptimierung zur Integration von Klimaanpassung	Bauinvestitionen und Investitionen in zusätzliche technische Ausrüstung; 100 Mio. €/a	Reduktion Produktionsausfall

4. Simulation and results: Storm; Production cuts from power outages

Economic effects in years with a storm and without adaptation:

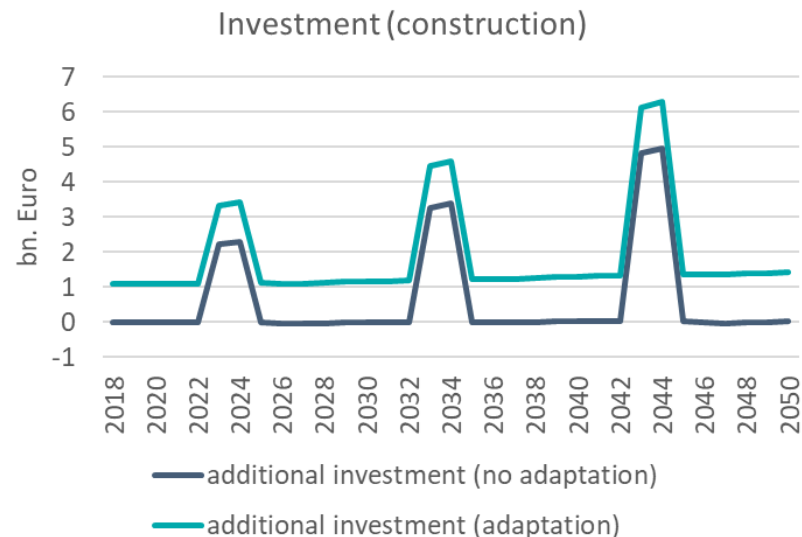
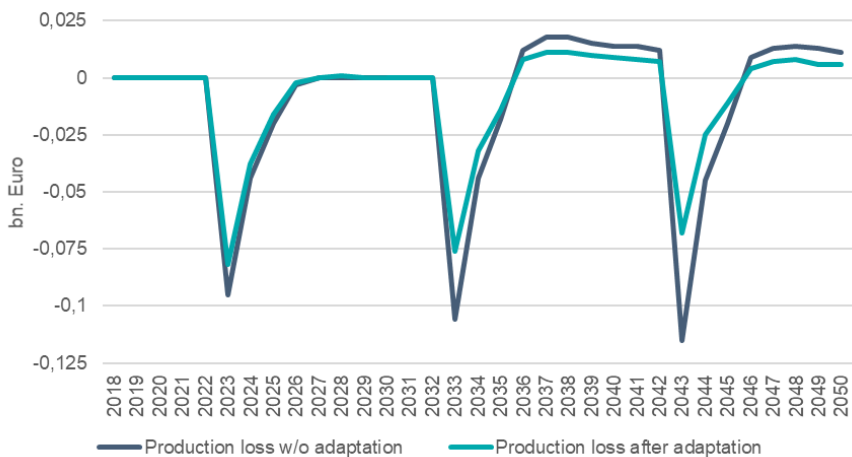
- **Production cuts due to power outs have the following effects:**
 - Higher unit costs → higher prices
 - Lower productivity → Lower wages → lower income → lower consumption
 - Repairs replace /crowd out other
 - higher imports

Adaptation: Stabilizing the grid

Operationalize:

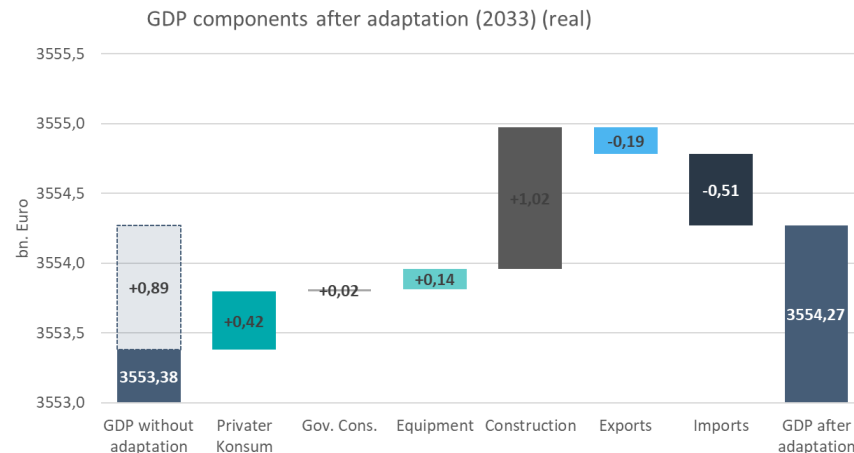
- Increase grid capacity (redundancy), increase storage as back-up
- **Translation into modeling parameters:**
 - Utilities invest (construction) (1 bn. € / a)
 - Less production losses (reduction by half)

Details: Stabilizing the grid



Economic effects from adaptation:

- Higher depreciation → higher unit costs → higher electricity prices
- Higher prices
- Investment leads to positive additional demand in all sectors
- Higher wages, higher income, higher consumption → positive GDP



- Extreme weather events can lead to **increased economic activity** (especially in the construction sector), as **the damage has to be repaired**.
- Adaptation measures can shift the impact on GDP from "**bad GDP**" with **defensive expenditures** to "**good GDP**":
Investments have a positive impact in non-loss years, while the damage can be reduced in years with extreme weather event.
- The **reduction of GDP** in years with extreme weather event can be **assessed negatively**, but from a **social (and ecological) point of view the adaptation measures may be preferable**
- Over all simulated measures, the effects were small!
- The results will be used to support the development of the German adaptation strategy.

CONTACT**Markus Flaute**

T +49 (0) 541 40933 - 295

E flaute@gws-os.com

Researcher Energy and Climate

**Ulrike Lehr**

T +49 (0) 541 40933 - 280

E lehr@gws-os.com

Head of Energy and Climate

**Lara Ahmann**

T +49 (0) 541 40933 - 288

E ahmann@gws-os.com

Researcher Energy and Climate



SPECIALISTS IN
EMPIRICAL ECONOMIC
RESEARCH

www.gws-os.com

Gesellschaft für Wirtschaftliche Strukturforschung mbH

Heinrichstr. 30

49080 Osnabrück

Tel + 49 (0) 541 40933-295

Fax + 49 (0) 541 40933-110

flaute@gws-os.com

4. Simulation and results: Cooling and facades

Adaptation measure: Efficient building cooling and facade design

Implementation:

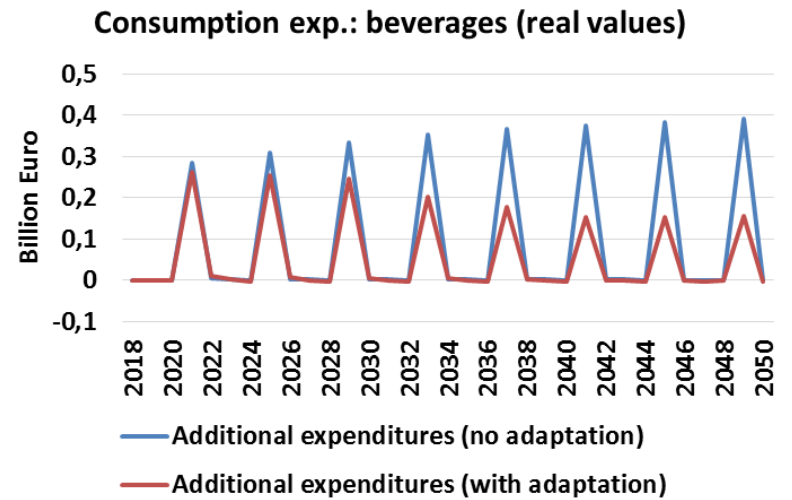
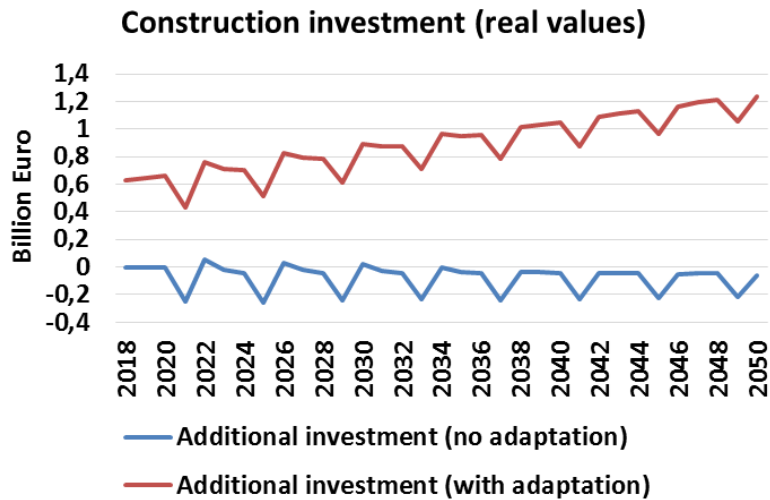
- Shading, green roofs, ventilation

Translation into the model PANTA RHEI:

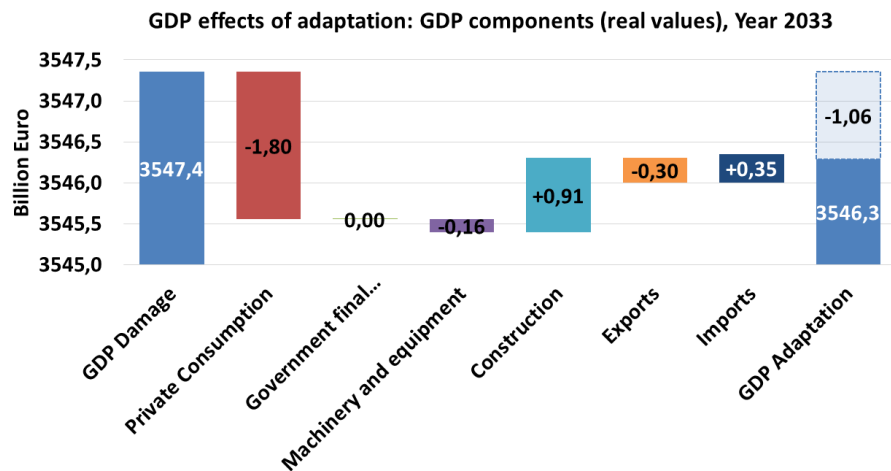
- **annual:** Investment in residential and public buildings (0.6 - 1.3 billion € / a)
- **In heat wave years:**
 - Improved labor productivity
 - Reduction of increased beverage consumption
 - Reduction of increased demand for healthcare services
 - Reduction of increased power consumption for air conditioning systems

4. Simulation and results: Cooling and facades

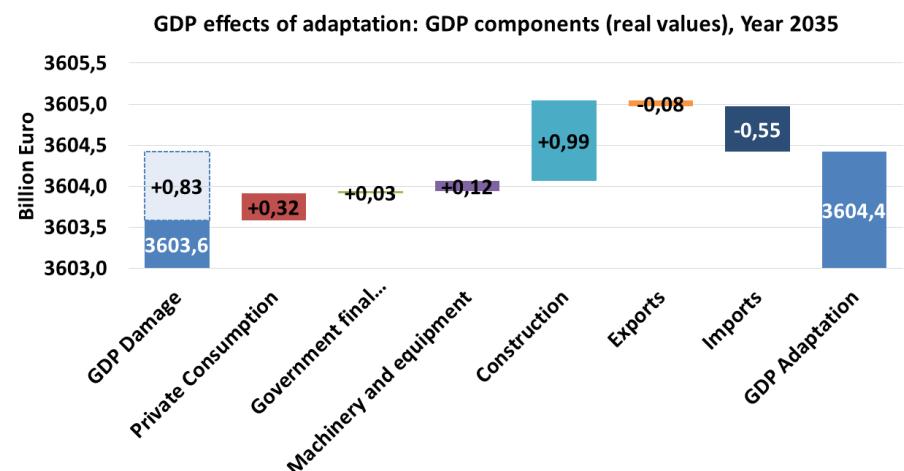
Reduction of higher consumption of beverages:



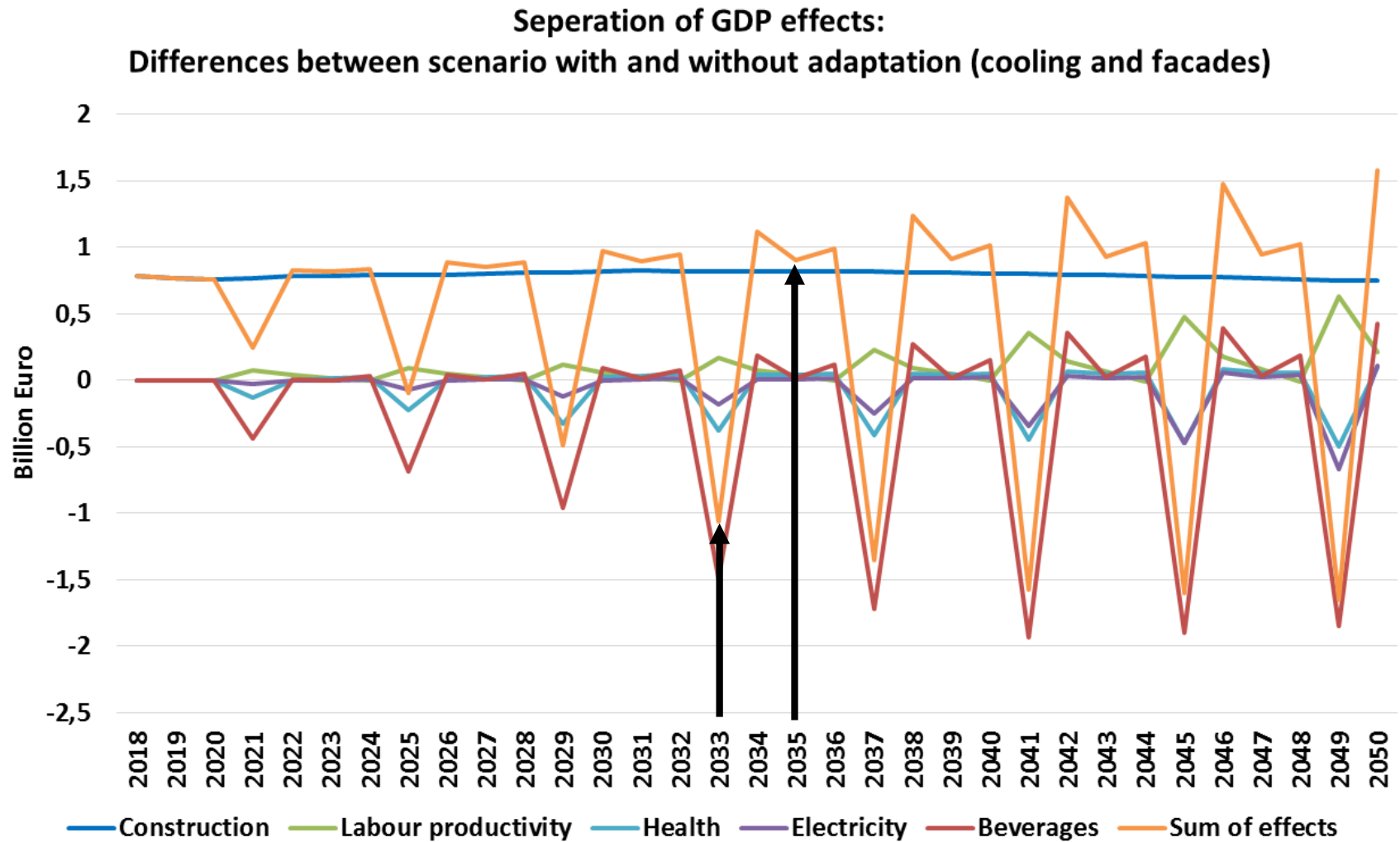
2033: heat wave plus adaptation



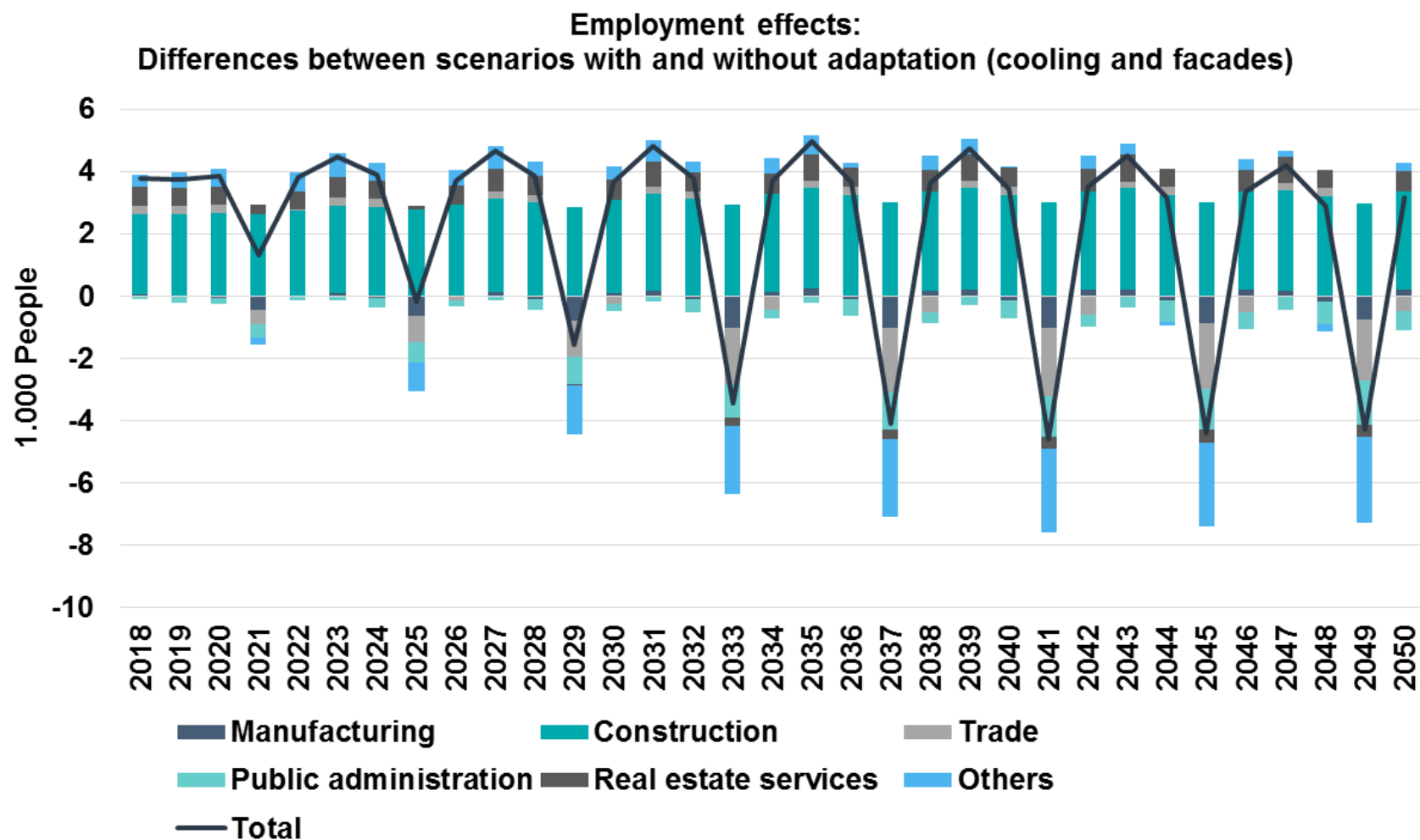
2035: no heat wave, but adaptation



4. Simulation and results: Cooling and facades



4. Simulation and results: Cooling and facades



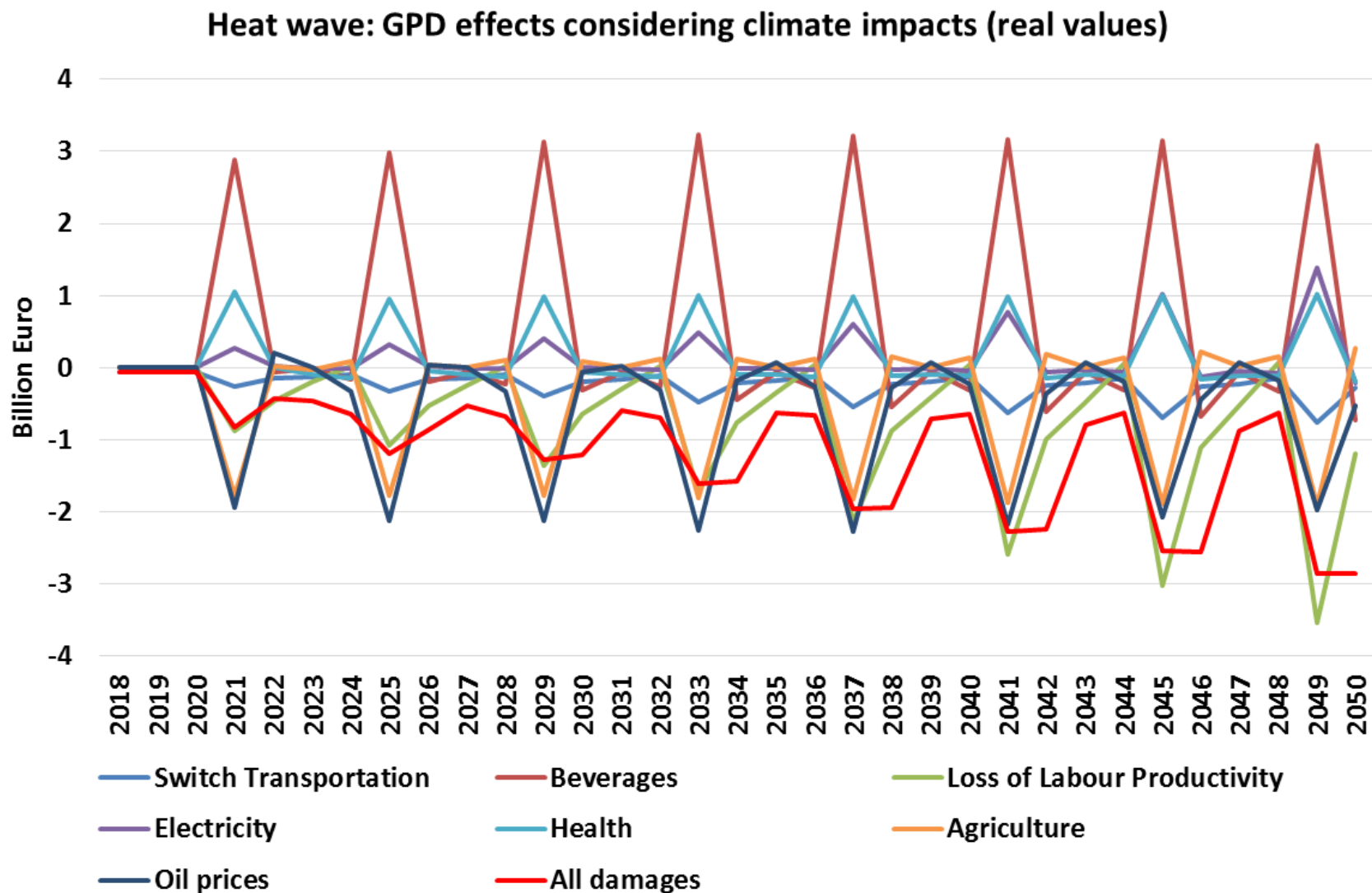
2. Translation of climate change into model parameters

- **Translation of the effects of heat waves into the model:**
 - **Transport:** Switching from water to road
 - **Reduced labor productivity:** Reduction in production
 - **Increased electricity consumption for air conditioning systems and decreased capacity of the grid:** pressure on the electricity system
 - **Increased consumption of non-alcoholic beverages**
 - **Increased demand for health services**
 - **Crop failures Agriculture:** Increased imports
 - **Higher oil prices due to restrictions in shipping:** Adjustment of prices for petrol, diesel and fuel oil
 - **Baseline scenario**, describing the economic development **with** climate change impacts, but **without any adaptation** to climate change

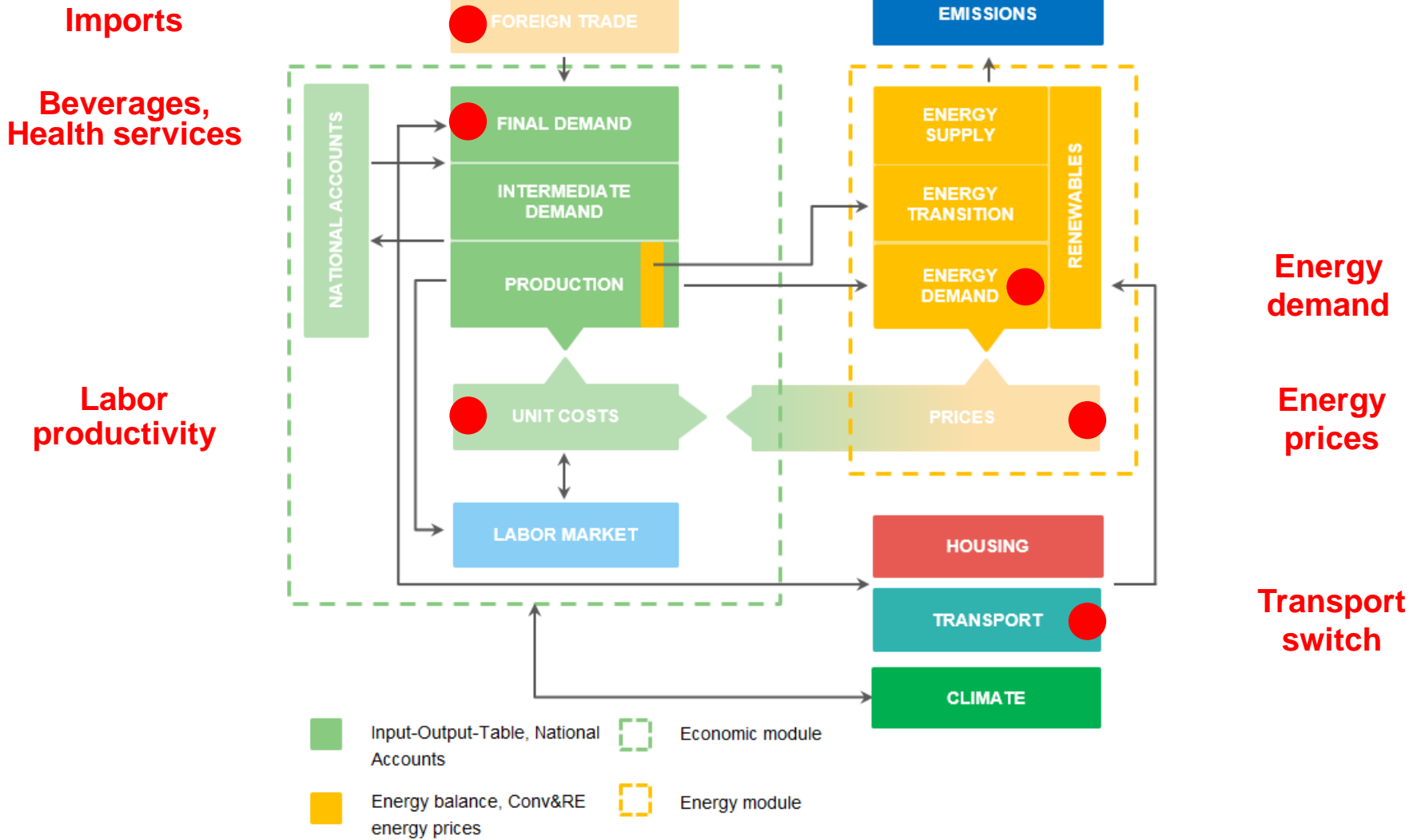
- **Selection of adaptation measures (and instruments)** to influence the aforementioned climate change impacts



2. Translation of climate change into model parameters

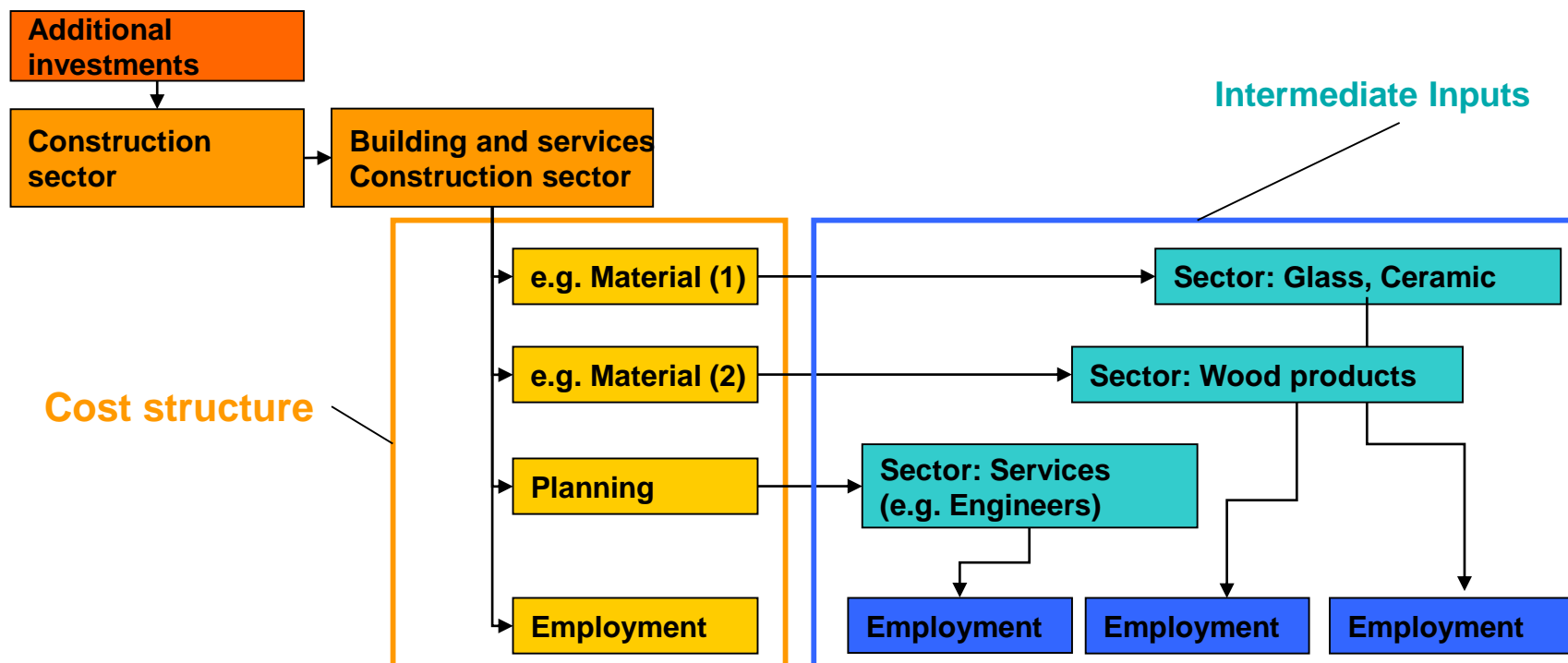


BACKUP: Structure of PANTA RHEI



BACKUP: Example: Intermediate Inputs

- Many extreme weather events destroy buildings
- Construction sector benefits from the need for construction work to repair the damages
- Adaptation measures often contain construction work



- **Time series** of extreme weather events
 - **Storm every 10 years, damage equaling to Kyrill 2007**
 - Kyrill was expensive for the insurance companies (€2.4 Billion)
 - Lots of data available
 - First storm event in the simulation: year 2023
 - **Heavy rain every 3 years**, damage amounting to an average of the most expensive heavy rain events of the last decades in Germany
 - In 2006-2016, there were four years of heavy rainfall events that caused insured losses of €150 Million or more (→ average)
 - First heavy rain event in the simulation: year 2018
 - **Heatwave every 4 years**, , literature-based information on damages
 - First heat wave event in the simulation: year 2021

BACKUP: Including measures and instruments

Type of instrument	Map into economic model
Command and control	The regulation is treated as binding
Planning	If this results in a physical/monetary change, it is mapped.
Price instrument	Prices are implemented
Direct subsidy	Subsidy is regarded as successful
Voluntary agreement	The agreement is considered to have been fulfilled
Management of information and knowledge	If this results in a physical/monetary change, it is mapped.
Provision of basic data	If this results in a physical/monetary change, it is mapped.
Inspection	If this results in a physical/monetary change, it is mapped.