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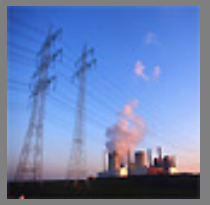




Economy-wide impacts of energy efficiency in Germany

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Overview

1. Background on modeling energy efficiency and renewable energy
2. PANTA RHEI model
3. Scenario design and results for energy efficiency
4. Conclusions and outlook

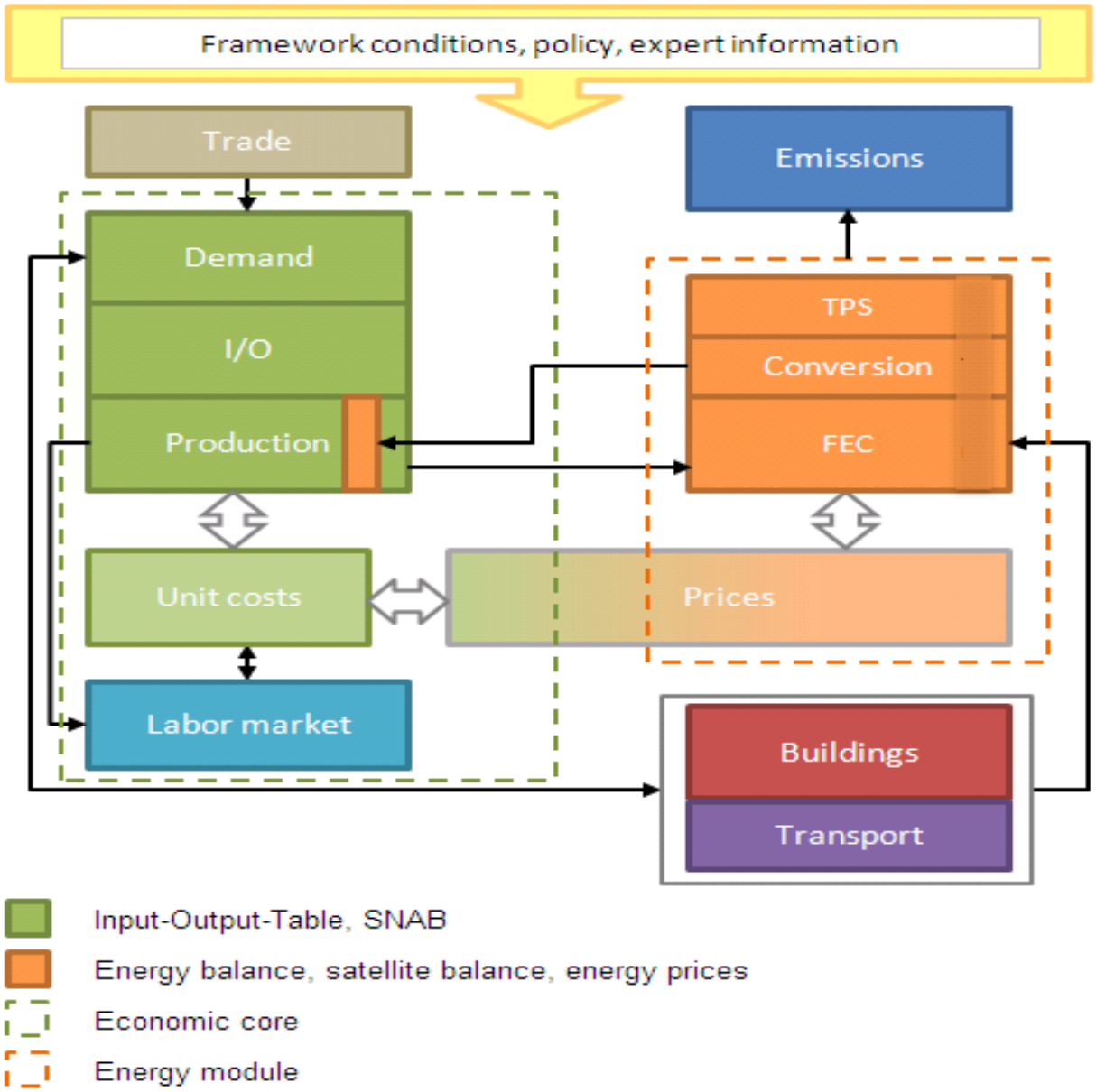
1. Background on energy efficiency

- We know that energy efficiency is extremely important – and progressing too slow
- Economics, economic modeling and economic thought face challenges when trying to capture no-regret potentials, inefficient factor use and thus energy efficiency issues
- Modeling challenges:
  - How can we define efficiency potentials and efficiency measures?
  - How are macro-indicators affected?
  - How can we capture special value chains for efficiency technologies?

The following shows how we dealt with these challenges in a case study for Germany

2. Model PANTA RHEI

- Macroeconomic energy and environmental model, INFORUM philosophy
  - Based on official statistics (SNA, time series of IOT)
  - Bottom-up (59 sectors)
  - Fully interdependent
  - Energy balance systematic
  - Parameters econometrically derived from historical time series, no neoclassical general equilibrium
  - Open for expert information
- Suitable for simulation of direct and indirect effects
  - Esp. counterbalancing effects
  - Results are net after all adaption processes
- Reference:
  Socio-economic and economic-environmental relations of the past will continue in the future

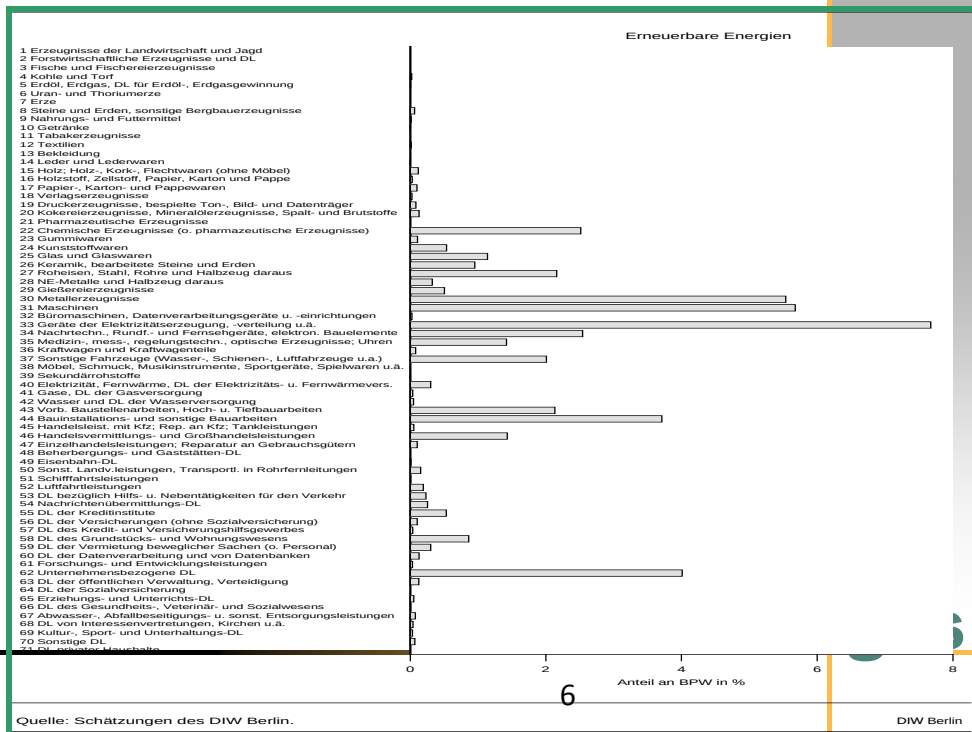

Framework conditions, policy, expert information
Trade
Emissions
Demand
I/O
Production
TPS
Conversion
FEC
Unit costs
Prices
Labor market
Buildings
Transport
Input-Output-Table, SNAB
Energy balance, satellite balance, energy prices
Economic core
Energy module

PHANTA RHEI – modeling energy, environment and economics

Sectoral focus:

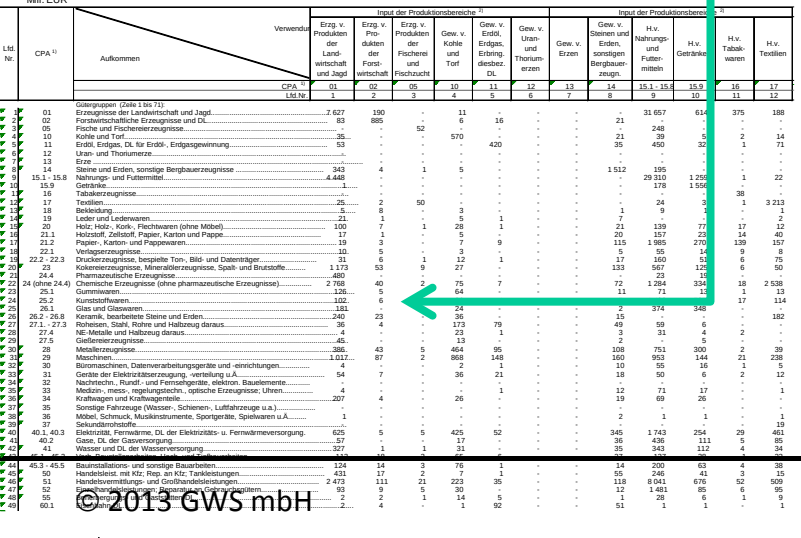
- **59 Economic sectors (WZ03):**
  - ⇨ employment, value added, production, imports, export
- **Energy consumption sectors (following EB systematic):**
  - ⇨ Households, 15 industries, transport, commerce and service
- **Special vector can be added to I/O**
  - ⇨ Done for RE
  - ⇨ Survey based
  - ⇨ Third update since 2006
  - ⇨ 13 sectors production of 13 technologies

	2011	2014	2016	2018	2020
	Value added differences in Mrd. €				
Sector 1	0,0	0,1	0,1	0,1	0,1
Sector 2	0,0	0,0	0,0	0,0	0,0
Sector 3	0,0	0,0	0,1	0,1	0,1
			≈		
Sector n-1	0,0	0,0	0,1	0,1	0,1
Sector n	**5,5**	**8,7**	**12,6**	**15,2**	**17,6**



Implementation of efficiency measures

- Energy part (other institutes):
  - Bottom-up models for energy demand (see next slide)
  - Specification of 43 (clusters of) measures
  - Differences in energy volumes and prices and related cost/investment as primary impulses
- Translation of primary impulses into the macro model
  - Find the right elements in the IO data (59 industries) and the energy balance (30 energy carriers, 68 rows)
  - Consistent linkage of IO and EB

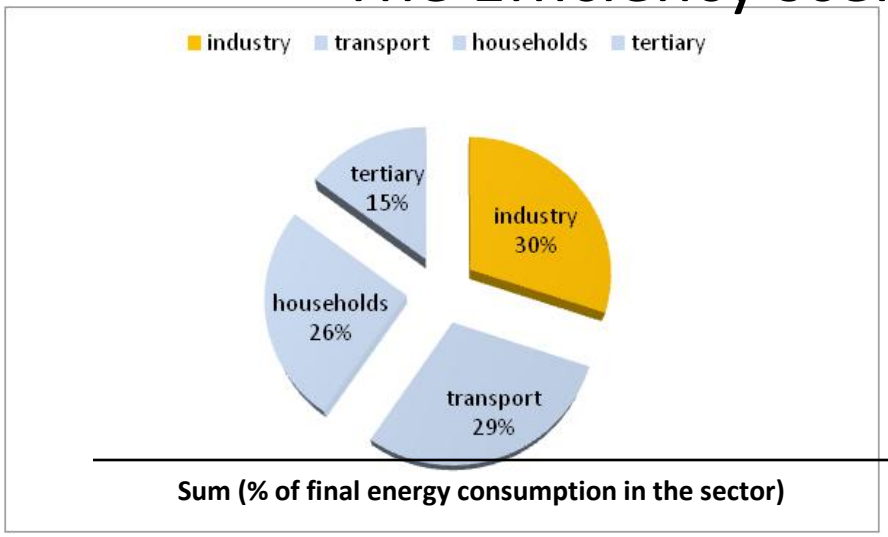


1.1 Input-Output-Tabelle 2007 zu Herstellungspreisen
Inländische Produktion und Importe
Mill. EUR

Lfd. Nr.	CPA [1]	Aufkommen / Verwendung	Input der Produktionsbereiche [2]						Input der Produktionsbereiche [2]							
			Erzg. v. Produkten der Land-wirtschaft und Jagd	Erzg. v. Pro-dukten der Forst-wirtschaft	Erzg. v. Produkten der Fischerei und Fischzucht	Gew. v. Kohle und Torf	Gew. v. Erdöl, Erdgas, Erbring. diesbez. DL	Gew. v. Uran- und Thorium-erzen	Gew. v. Erzen	Gew. v. Steinen und Erden, sonstigen Bergbauer-zeugn.	H.v. Nahrungs- und Futter-mitteln	H.v. Getränke	H.v. Tabak-waren	H.v. Textilien
		CPA [1]	01	02	05	10	11	12	13	14	15.1 - 15.8	15.9	16	17
		Lfd.Nr.	1	2	3	4	5	6	7	8	9	10	11	12
1		Gütergruppen (Zeile 1 bis 71):												
2	01	Erzeugnisse der Landwirtschaft und Jagd	7 627	190	-	11	-	-	-	-	31 657	614	375	188
3	02	Forstwirtschaftliche Erzeugnisse und DL	83	885	-	6	16	-	-	21	-	-	-	-
4	05	Fische und Fischereierzeugnisse	-	-	52	-	-	-	-	-	248	-	-	-
5	10	Kohle und Torf	35	-	-	570	-	-	-	21	39	5	2	14
6	11	Erdöl, Erdgas, DL für Erdöl-, Erdgasgewinnung	53	-	-	-	420	-	-	35	450	32	1	71
7	12	Uran- und Thoriumerze	-	-	-	-	-	-	-	-	-	-	-	-
8	13	Erze	-	-	-	-	-	-	-	-	-	-	-	-
9	14	Steine und Erden, sonstige Bergbauerzeugnisse	343	4	1	5	-	-	-	1 512	195	-	-	-
10	15.1 - 15.8	Nahrungs- und Futtermittel	4.448	-	-	-	-	-	-	-	29 310	1 256	1	22
11	15.9	Getränke	1	-	-	-	-	-	-	-	178	1 556	-	-
12	16	Tabakerzeugnisse	-	-	-	-	-	-	-	-	-	-	38	-
13	17	Textilien	25	2	50	-	-	-	-	-	24	3	1	3 213
14	18	Bekleidung	5	8	-	3	-	-	-	1	9	1	-	1
15	19	Leder und Lederwaren	21	1	-	5	1	-	-	7	1	-	-	2
16	20	Holz; Holz-, Kork-, Flechtwaren (ohne Möbel)	100	7	1	28	1	-	-	21	139	77	17	12
17	21.1	Holzstoff, Zellstoff, Papier, Karton und Pappe	17	1	-	5	-	-	-	20	157	23	14	40
18	21.2	Papier-, Karton- und Pappewaren	19	3	-	7	9	-	-	115	1 985	270	139	157
19	22.1	Verlagserzeugnisse	10	5	-	3	-	-	-	5	55	14	9	8
20	22.2 - 22.3	Druckerzeugnisse, bespielte Ton-, Bild- und Datenträger	31	6	1	12	1	-	-	17	160	53	6	75
21	23	Kokereierzeugnisse, Mineralölerzeugnisse, Spalt- und Brutstoffe	1 173	53	9	27	-	-	-	133	567	125	6	50
22	24.4	Pharmazeutische Erzeugnisse	480	-	-	-	-	-	-	-	23	16	-	-
23	24 (ohne 24.4)	Chemische Erzeugnisse (ohne pharmazeutische Erzeugnisse)	2 768	40	2	75	7	-	-	72	1 284	334	18	2 538
24	25.1	Gummiwaren	126	5	-	64	-	-	-	11	71	13	1	13
25	25.2	Kunststoffwaren	102	6	-	-	-	-	-	-	-	-	17	114
26	26.1	Glas und Glaswaren	181	-	-	24	-	-	-	2	374	348	-	-
27	26.2 - 26.8	Keramik, bearbeitete Steine und Erden	240	23	-	36	-	-	-	15	-	6	-	182
28	27.1 - 27.3	Roheisen, Stahl, Rohre und Hallzeug daraus	36	4	-	173	79	-	-	49	59	6	-	-
29	27.4	NE-Metalle und Halbzeug daraus	4	-	-	23	1	-	-	3	31	4	2	-
30	27.5	Gießereierzeugnisse	45	-	-	13	-	-	-	2	-	5	-	-
31	28	Metallerzeugnisse	386	43	5	464	95	-	-	108	751	300	2	39
32	29	Maschinen	1.017	87	2	868	148	-	-	160	953	144	21	238
33	30	Büromaschinen, Datenverarbeitungsgeräte und -einrichtungen	4	-	-	2	1	-	-	10	55	16	1	5
34	31	Geräte der Elektrizitätserzeugung, -verteilung u.Ä.	54	7	-	36	21	-	-	18	50	6	2	12
35	32	Nachrichten-, Rundf.- und Fernsehgeräte, elektron. Bauelemente	-	-	-	-	-	-	-	-	-	-	-	-
36	33	Medizin-, mess-, regelungstechn., optische Erzeugnisse; Uhren	4	-	-	-	1	-	-	12	71	17	-	1
37	34	Kraftwagen und Kraftwagenteile	207	4	-	26	-	-	-	19	69	26	-	-
38	35	Sonstige Fahrzeuge (Wasser-, Schienen-, Luftfahrzeuge u.a.)	-	-	-	-	-	-	-	-	-	-	-	-
39	36	Möbel, Schmuck, Musikinstrumente, Sportgeräte, Spielwaren u.Ä.	1	-	-	-	-	-	-	2	1	1	-	1
40	37	Sekundärrohstoffe	-	-	-	-	-	-	-	-	-	-	-	19
41	40.1, 40.3	Elektrizität, Fernwärme, DL der Elektrizitäts- u. Fernwärmeversorgung	625	5	5	425	52	-	-	345	1 743	254	29	461
42	40.2	Gase, DL der Gasversorgung	57	-	-	17	-	-	-	36	436	111	5	85
43	41	Wasser und DL der Wasserversorgung	327	1	1	31	-	-	-	35	343	112	4	34
44	45 - 45.5	Bauinstallations- und sonstige Bauarbeiten	124	14	3	76	1	-	-	14	200	63	4	38
45	50	Handelsleist. mit Kfz; Rep. an Kfz; Tankleistungen	431	17	2	7	1	-	-	55	246	41	3	15
46	51	Handelsvermittlungs- und Großhandelsleistungen	2 473	111	21	223	35	-	-	118	8 041	676	52	509
47	52	Einzelhandelsleistungen; Reparaturen Gebrauchsgütern	93	9	5	30	-	-	-	12	1 481	85	6	95
48	55	Beherbergungs- und Gaststättenleistungen	2	1	1	14	5	-	-	1	28	6	1	9
49	60.1	Eisenbahnverkehrsleistungen	2	4	-	1	92	-	-	51	1	1	-	1

Energiebilanz der Bundesrepublik Deutschland 2008 T Joule	Zeile	Steinkohlen				Braunkohlen				Mineralöle	
		Kohle	Briketts	Koks	Andere Stein-kohlen-produkte	Kohle	Briketts	Andere Braun-kohlen-produkte	Hart-braun-kohle	Erdöl (roh)	Otto-kraft stoffe
Gewinnung im Inland	1	521 002	-	-	-	1 576 414	-	-	-	131 119	-
Einfuhr	2	1 200 499	785	124 570	38 436	-	1 172	1 114	459	4 515 225	70 829
Bestandsentnahmen	3	-	-	-	-	-	352	234	-	-	18 790
Energieaufkommen im Inland	4	1 721 502	785	124 570	38 436	1 576 414	1 524	1 348	459	4 646 344	89 619
Ausfuhr	5	15 603	-	4 785	45 985	147	6 887	17 457	-	5 797	250 437
Hochseebunkerungen	6	-	-	-	-	-	-	-	-	-	-
Bestandsaufstockungen	7	17 438	-	1 318	-	909	-	-	-	28 828	-
PRIMÄRENERGIEVERBRAUCH IM INLAND	8	1 688 461	785	118 468	- 7 549	1 575 359	- 5 363	- 16 109	459	4 611 719	- 160 818
Kokereien	9	300 466	-	-	-	5 886	-	-	-	-	-
Stein- und Braunkohlenbrikettfabriken	10	-	-	-	-	118 861	-	-	-	-	-
Wärmekraftwerke der allg. Versorgung	11	997 295	-	-	-	1 378 633	117	10 497	33	-	-
Industriewärmekraftwerke (nur für Strom)	12	85 827	-	-	-	20 867	2 156	3 938	-	-	-
Kernkraftwerke	13	-	-	-	-	-	-	-	-	-	-
Wasser-, Windkraft-, Photovoltaik- u.a. Anlagen	14	-	-	-	-	-	-	-	-	-	-
Heizkraftwerke der allg. Versorgung							371	3 982	410	-	-
Fernheizwerke	16	19 575	-	229	-	2 29	20	1 270	16	-	-
Hochöfen	17	-	-	171 405	-	-	-	-	-	-	-
Raffinerien	18	-	-	-	-	-	-	-	-	4 611 719	117 859
Sonstige Energieerzeuger	19	-	-	-	7 755	-	-	-	-	-	-
Umwandlungseinsatz insgesamt	20	1 509 357	-	171 634	7 755	1 560 710	2 664	19 687	459	4 611 719	117 859
Kokereien	21	-	-	236 248	9 386	-	-	5 308	-	-	-
Stein- und Braunkohlenbrikettfabriken	22	-	-	-	-	-	32 005	89 449	-	-	-
Wärmekraftwerke der allg. Versorgung	23	-	-	-	-	-	-	-	-	-	-
Industriewärmekraftwerke (nur für Strom)	24	-	-	-	-	-	-	-	-	-	-
Kernkraftwerke	25	-	-	-	-	-	-	-	-	-	-
Wasser-, Windkraft-, Photovoltaik- u.a. Anlagen	26	-	-	-	-	-	-	-	-	-	-
Heizkraftwerke der allg. Versorgung	27	-	-	-	-	-	-	-	-	-	-
Fernheizwerke	28	-	-	-	-	-	-	-	-	-	-
Hochöfen	29	-	-	-	-	-	-	-	-	-	-
Raffinerien	30	-	-	-	-	-	-	-	-	-	1 000 552
Sonstige Energieerzeuger	31	-	-	-	7 106	-	-	-	-	-	147 166
							32 005	94 757			1 147 718
Kokereien	33	-	-	-	-	-	-	-	-	-	-
Steinkohlenzechen, -brikettfabriken	34	30	-	-	-	-	-	-	-	-	-
Braunkohlengruben, -brikettfabriken	35	-	-	-	-	9079	147	414	-	-	-
Kraftwerke	36	-	-	-	-	-	-	-	-	-	-
Erdöl- und Erdgasgewinnung	37	-	-	-	-	-	-	-	-	-	-
Raffinerien	38	-	-	-	-	-	-	-	-	-	-

The Efficiency scenario - example: industry



	13 bill. €	Savings compared to reference by 2020 PJ
Sum (% of final energy consumption in the sector)		**212 (8.1%)**
Motors		101
Optimal pneumatic systems		15
Optimal pump systems		17
Optimal vent systems		14
Optimal cooling systems		3
Optimal other systems		45
Efficient lighting		13
Efficient vapor		24
Efficient drying		29
Efficient industrial ovens		40
Efficient caloric value heat (natural gas)		5
Additional potential from specific technologies [1)]		ca. 150

[1)] Fraunhofer ISI (2001) and Prognos (2007); Source: ifeu/ISI/Prognos/GWS 2009

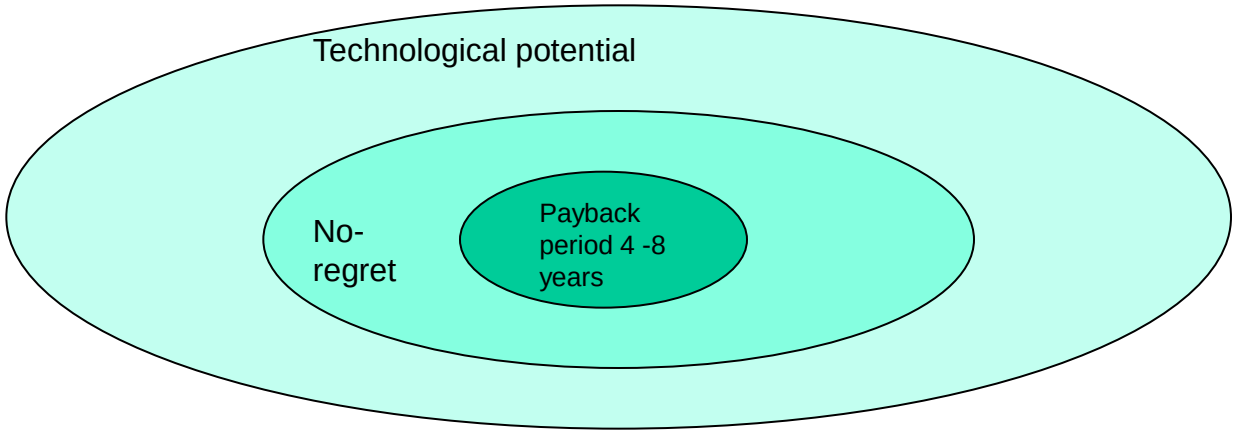
Limits and boundaries (1/2)

Technological Potential

- Potential for energy saving with market best products

Economic (no-regret potential)

- Potential for energy saving with products with payback periods within the lifespan of the product
- Much longer payback periods compared to usual calculations in companies



Limits and boundaries (2/2)

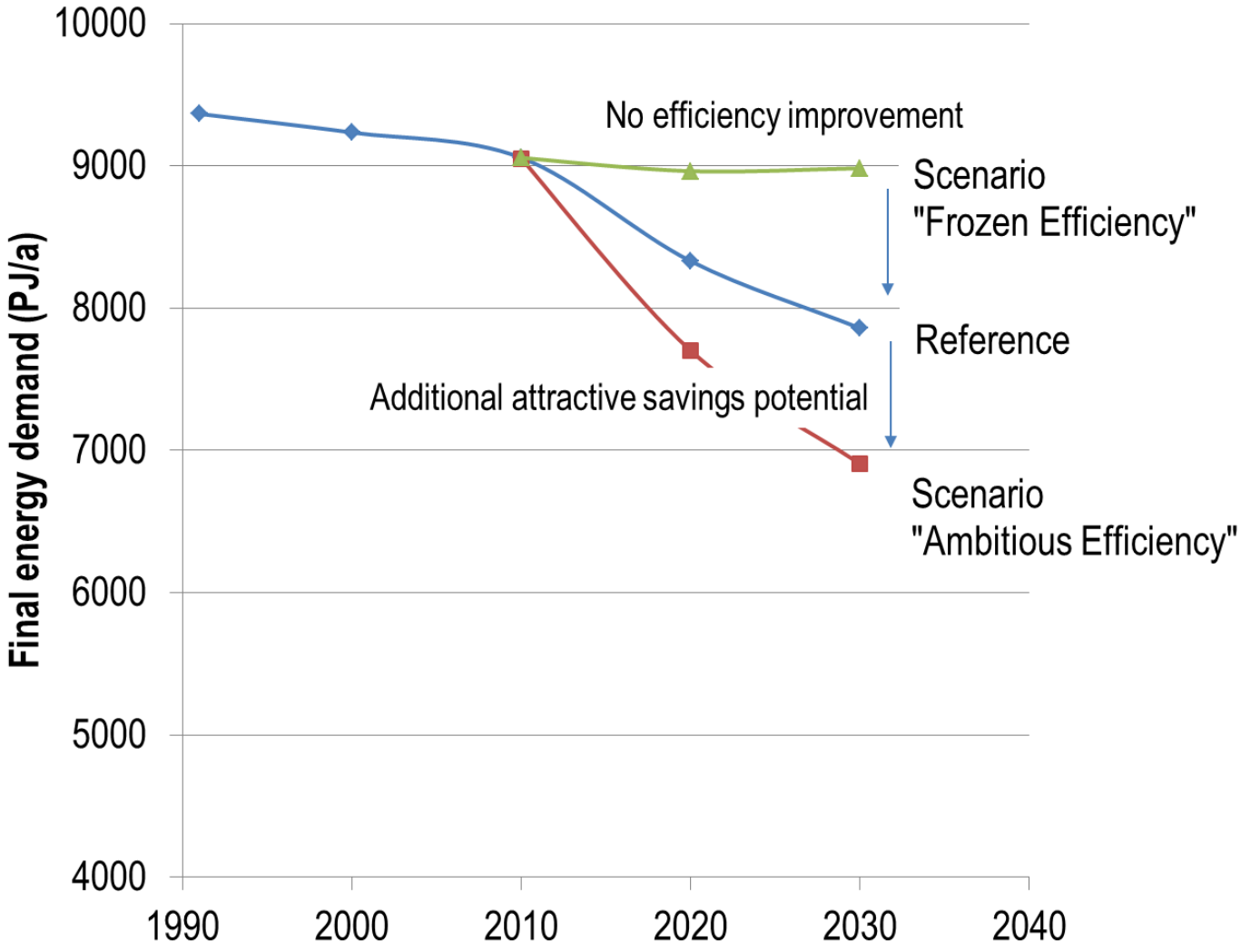
- Scenario analysis: comparison of an efficiency scenario with reference
- "Ambitious Efficiency" scenario
  - No–regret measures
  - Cost-effective over the lifetime of equipment
  - Additional investment (no crowding out)
  - Based on detailed bottom-up studies

	Investment until 2030 in billion Euro
Total	301
Private households	120
Tertiary sector	54
Industry	8
Transport	120

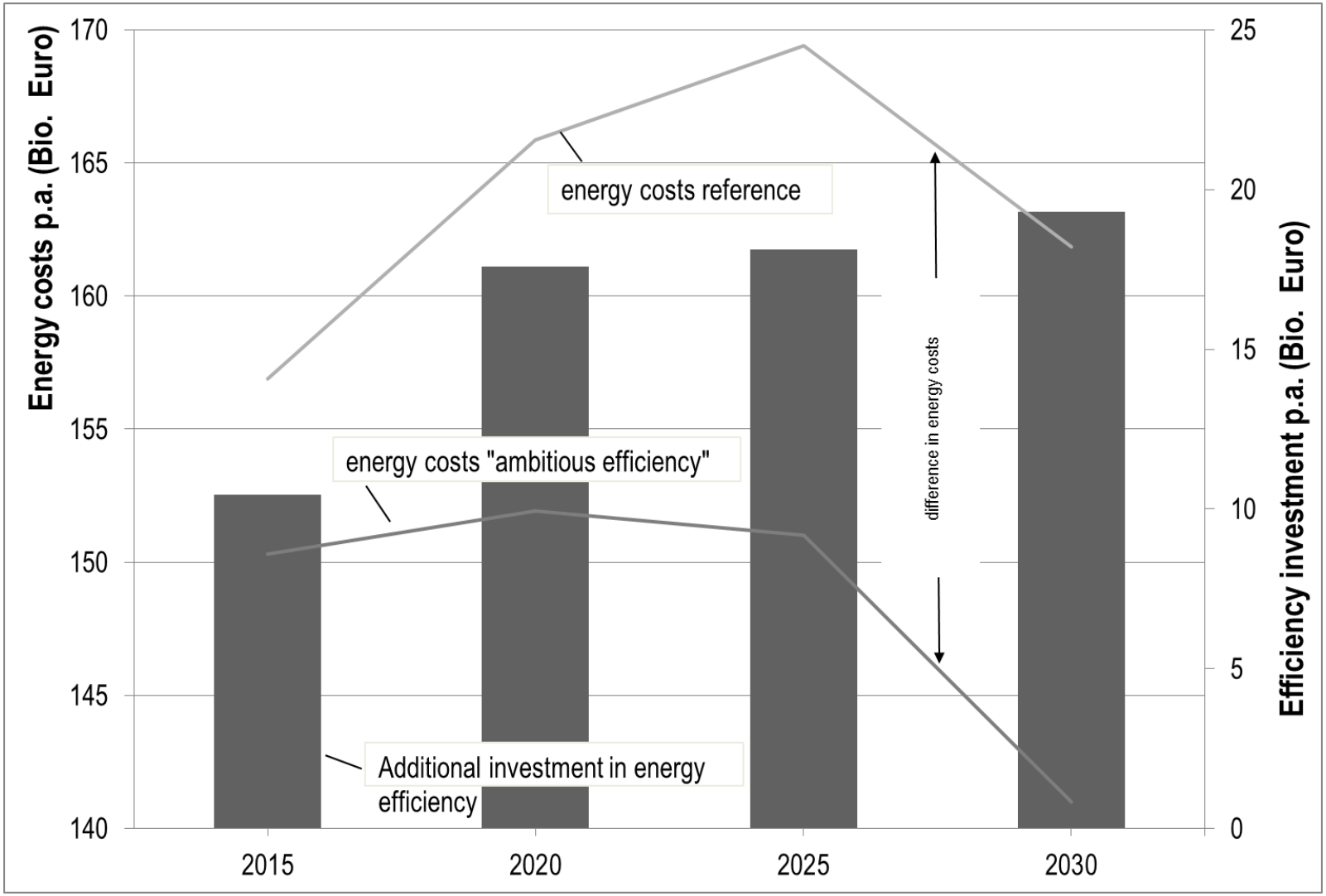
Ifeu et al. (2011, p. 22).

- depreciation, annual allowances and savings reductions to finance the investment fully included
- Energy savings fully accounted for in the model

Final energy demand in different scenarios



Additional investment and energy costs for reference and „ambitious efficiency“



Economic impacts

Efficiency- Ref	Absolute values					Percentage difference				
	2011	2014	2016	2018	2020	2011	2014	2016	2018	2020
GDP components	Difference in bil. Euro									
GDP	6,4	8,8	12,8	15,2	17,8	0,3	0,4	0,5	0,6	0,7
Private consumption	2,0	4,7	6,6	8,5	10,6	0,2	0,4	0,5	0,7	0,8
Gov't consumption	0,1	-0,1	0,0	-0,1	-0,1	0,0	0,0	0,0	0,0	0,0
Investment	3,6	3,6	4,2	4,7	5,7	1,4	1,3	1,5	1,7	1,9
Buildings	3,0	3,1	5,1	5,2	5,1	1,4	1,4	2,4	2,5	2,5
Exports	0,1	0,3	0,4	0,4	0,5	0,0	0,0	0,0	0,0	0,0
Imports	2,4	2,7	3,3	3,5	3,9	0,2	0,2	0,3	0,3	0,3
Prices	Difference in percentage points									
Private consumption	-0,04	-0,10	-0,14	-0,18	-0,22	-0,04	-0,08	-0,12	-0,15	-0,18
Production	-0,05	-0,06	-0,07	-0,07	-0,07	-0,05	-0,05	-0,06	-0,06	-0,06
Imports	-0,07	-0,16	-0,23	-0,30	-0,39	-0,07	-0,16	-0,22	-0,29	-0,36
Labor market	Absolute difference									
Employment	67	79	110	120	128	0,2	0,2	0,3	0,3	0,3

Macroeconomic results (ambitious efficiency against reference)

- **Higher GDP and more jobs (+127.000 in 2030)**
  - Additional investment yields additional production and therefore additional employment,
  - Energy is replaced by capital,
  - Imports (e.g. crude oil, gas) are replaced by domestic value added,
  - Construction, trade and services are more labor intensive than the energy industry (industry structure matters),
  - Energy efficiency improves economic productivity and thus competitiveness on fast growing markets,
  - Rebound effects are small

Energy savings, emissions and rebound

		2010	2015	2020	Rebound
FEC		**108**	**418**	**693**	
Private households	[PJ]	25	115	219	13%
Tertiary sector	[PJ]	8	32	59	13%
Industry	[PJ]	19	123	197	11%
Transport	[PJ]	57	148	219	27%
TPES	**[PJ]**	**162**	**629**	**1.027**	
Electricity production	**[PJ]**	**39**	**151**	**245**	
CO_2-Emissions	**[Mio. t]**	**13,9**	**49,8**	**76,6**	
Oil	[TJ]	67	189	287	
Natural gas	[TJ]	26	165	321	
Import savings	[Bill. €]	0,8	3,2	6,2	

Source: Own Calcuations by GWSmbH

4. Conclusions

Implementation of “no-regret” energy efficiency measures will yield a double dividend of less emissions / energy use and more jobs:

- Positive macroeconomic net impacts
- Additional potential for exports
- How to overcome barriers for efficiency improvement?

Important for results:

- Interdependent modeling of economy and energy, based on observed behavior
- Specification of efficiency measures (based on expert judgment or bottom-up model)
- Existence of no-regret options contradicts assumptions of microeconomic optimization and (ideal) general equilibrium

Thank you for your attention!

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References

- **More on PANTA RHEI:**
- **More on the development / extension of I/O vector:**
- **More on efficiency:**