Rebound effects in non-residential public service buildings

Results of an exploratory study to quantify rebound effects of thermally retrofitted non-residential buildings / Federal Real Estates on behalf of the BBSR

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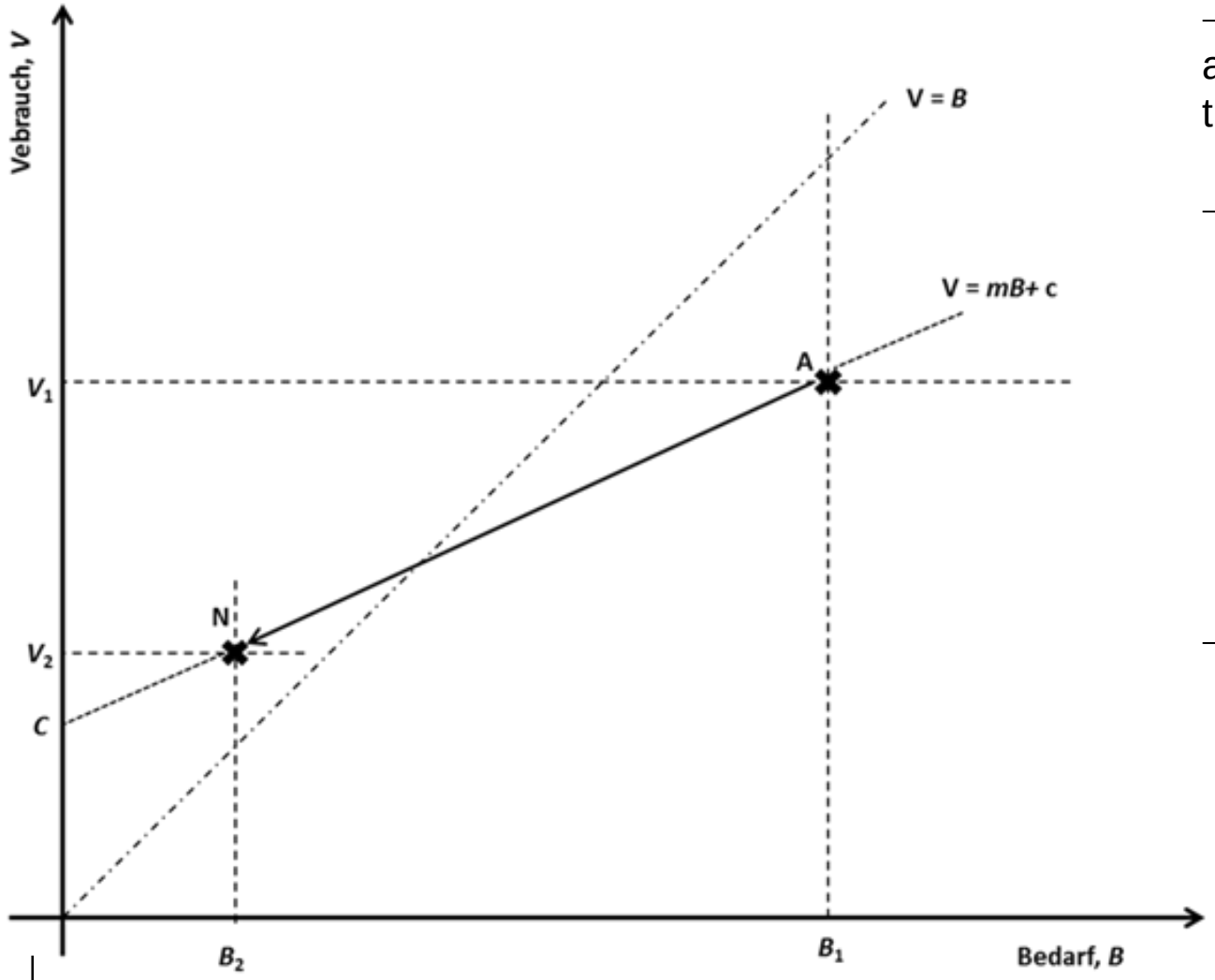
The project – objective and research questions

- **Within the project a methodology which was tested in case studies was developed to answer following research questions:**
  - Are there direct rebound effects in recently retrofitted German public service buildings? If so, what are the magnitudes?
  - What causes of rebound effects in these buildings can be identified?
  - How might these rebound effects be reduced?
  - To what extent are the results of this study transferable to other non-residential buildings?
- **Principal: BBSR**
- **Project partners: BTU Cottbus-Senftenberg; RWTH Aachen (FCN)**

Rebound effects of retrofitting: results of residential buildings



- Ideal typical curve: actual consumption = theoretical consumption

- In practice:
  - **pre-retrofit**: actual consumption often (significantly) lower than calculated consumption
  - **Post-retrofit:** actual consumption often higher than calculated consumption
- Residential buildings in Germany: rebound effects of about 36 % (estimation through data on actual and calculated consumption)

Quelle: Weiß et al. (2015)

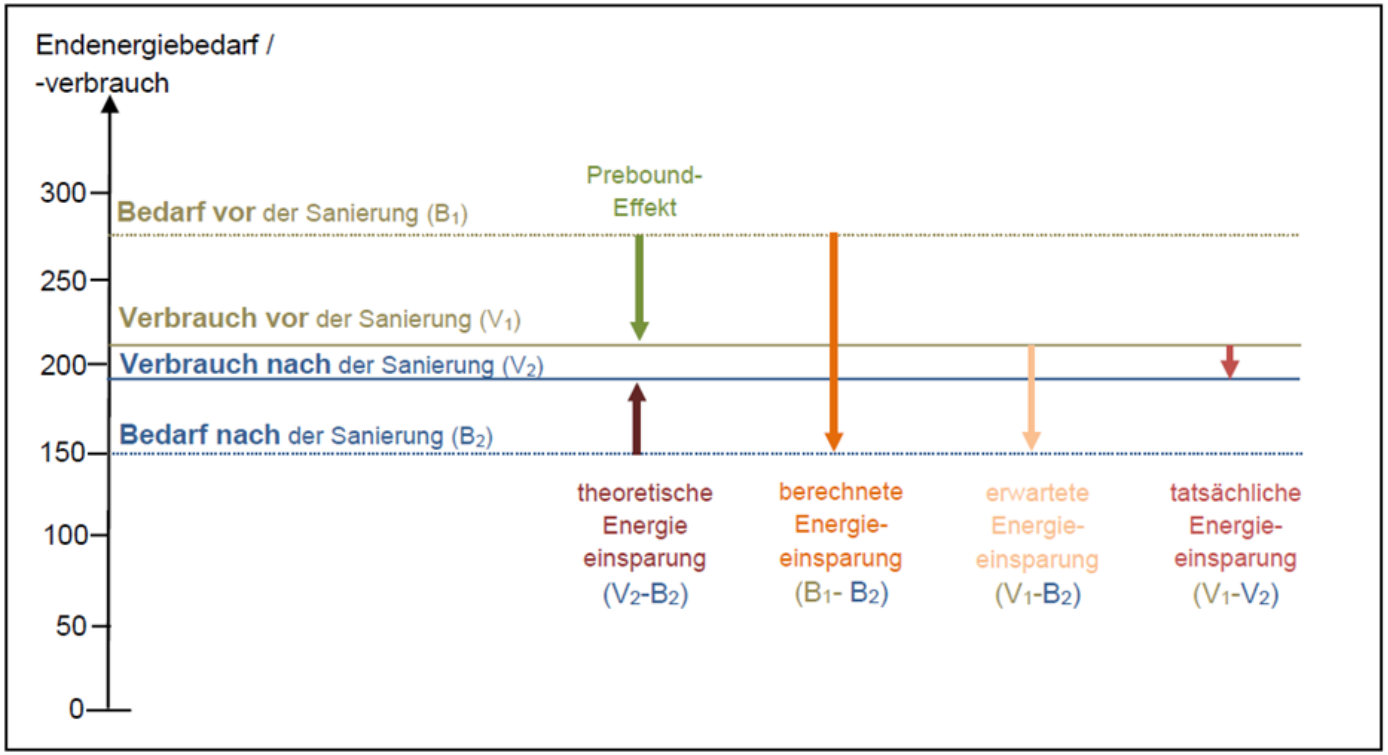
Causes of rebound effects due to thermal retrofitting

- **Increase in comfort**
  - Increase in room temperature, length of heating period, amount of heated rooms, etc.
- **Interaction between technology and user**
  - Space heating => inertness leads to high consumption, forced ventilation => higher room temperature
- **Lack of user friendly technologies**
  - Complex temperature regulation and ventilation, lack of regulation technology
- **“secondary effects”**
  - Building envelope and/or system engineering are out of standard, changes in building utilization, etc.

Rebound effects non-residential buildings

- **Results are not transferable from residential to non-residential buildings**
  - In residential buildings, users normally bear the energy costs – an important factor for the rebound effect
  - Energy consumption at the working place is based on other behavior patterns and routines than at home
  - In offices and service buildings, professional actors within the field of housing technology and building services play a more important role than in residual buildings
- **there was no detailed research on rebound effects for non-residential buildings beforehand**

Definition rebound effect



Energy saving deficit (ESD)

$$ESD = \frac{V2 - B2}{V1 - B2} \times 100\%$$

Energy performance gap (EPG)

$$EPG = \frac{V_2 - B_2}{B_2} \times 100\%$$

Mathematical definition of the elasticity rebound effect

$$R\varepsilon\,(S) = \frac{\partial S}{S} / \frac{\partial \varepsilon}{\varepsilon} = \frac{\partial S}{\partial \varepsilon} \times \frac{\in}{S}$$

Quelle: Weiß et al. (2015)

The project – method case study buildings

- **Conduction of four case studies within the project:**
  - Customs office Bremen
  - Customs office Flensburg
  - music academy Dresden Carl Maria von Weber
  - Police HQ Dresden Mitte
- **Surveys to find out energy and building characteristics (interviews of building managers and caretakers and on-site inspections)**
- **Interviews with building users and qualified personnel on-site (guideline interviews)**

Results of the Interviews

- **Little indication for higher post-retrofit energy consumption**
  - Air quality partly poor => reason for more ventilation?
  - Partly higher room temperatures („colleagues lightly dressed“)
  - No topic at all: interaction with technologies (no change!)
- **But: many respondents do not remember every day ventilation and heating behavior and pre-retrofit situation**
- **And: users consume energy more carelessly at work than at home (ventilation behavior, room temperature)**

=> expectation: high actual consumption pre- and post-retrofit and low rebound effects (if at all)

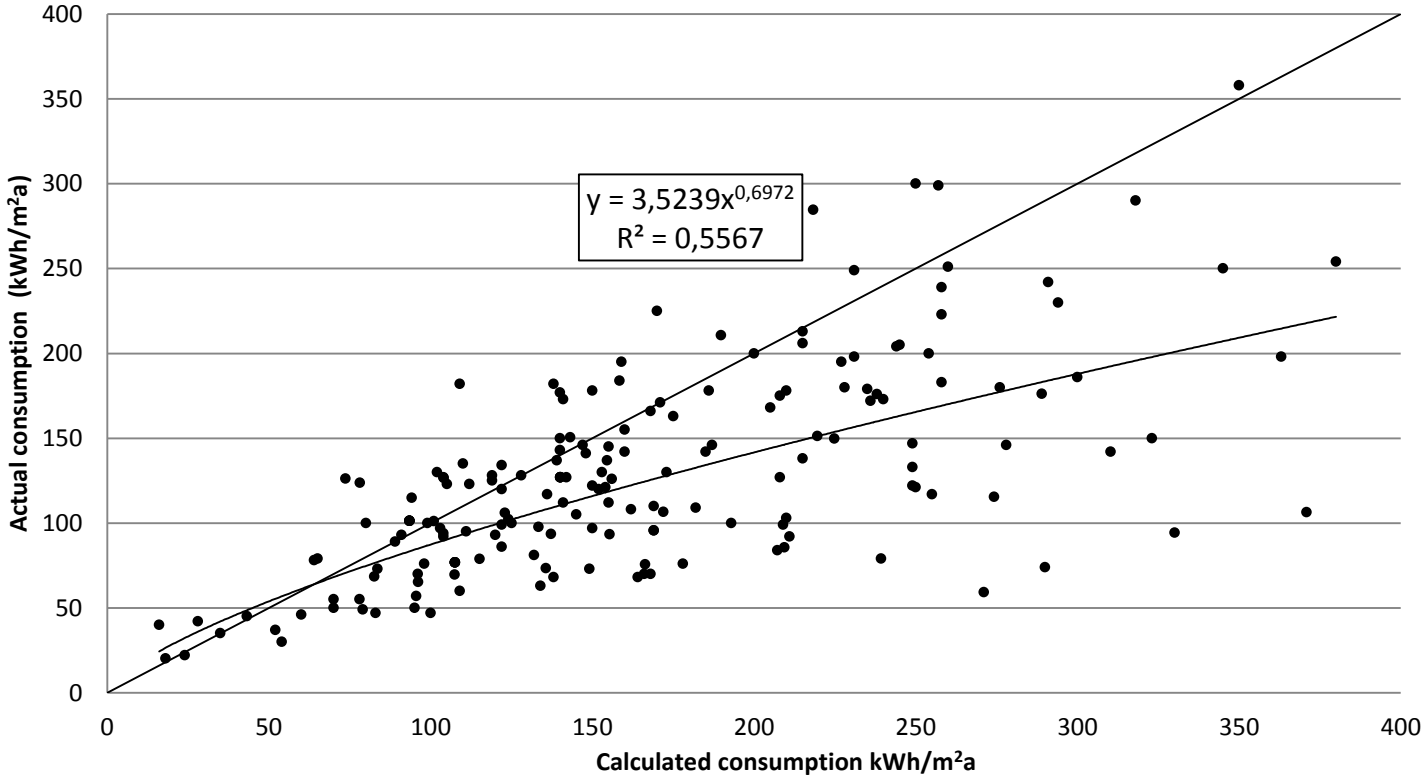
Results of the Calculations

	Pre- or post-retrofit	Theoretical energy consumption (kWh/ (m^2 a))	Actual energy consumption (kWh/(m^2 a))	Elasticity rebound effect (%)
Police HQ Dresden	pre	123	106	-1,5
	post	61	52	
Customs office Flensburg	pre	244	204	4,9
	post	136	117	
Customs office Bremen	pre	215	206	-5,5
	post	96	88	
Music academy, Dresden	pre	*140*	143	-113
	post	83	47	

ESD and EPG negative for all 4 buildings ($V_2 < B_2$)

Quelle: Weiß et al. (2015)

Results – comparison with other datasets of non-residential buildings



- 3 datasets of non-residential buildings (IWU, Oschatz et al., BBSR) – 182 points
- But: no data for pre- and post-retrofit; possibly other uses etc.
- Derived and estimated rebound effect of approximately 30 %
- case study objects show comparitively high actual consumption rates (only slightly under theoretical consumption)

Quelle: Weiß et al. (2015)

Conclusion

- **Strong deviation between theoretical and actual consumption, especially in the case of high consumption**
  - No indication for pre-retrofit energy saving behavior – but high “prebound effects“
  - Theoretical consumption high due to calculation methods and sometimes also mistakes
- **Rebound effects near to zero, nevertheless action required**
  - High potential to improve user behavior
  - Case study buildings: to reach average actual consumption post-retrofit, negative rebound effects would be necessary

Further Information:

- Weiß, J. et al. (2015): Sondierungsstudie zur Quantifizierung von Rebound-Effekten bei der energetischen Sanierung von Nichtwohngebäuden/Bundesliegenschaften. BBSR-Online-Publikation 01/2015, Bonn, Februar 2015
- Großmann, D. et al. (2016): A methodology for estimating rebound effects in non-residential public service buildings: Case study of four buildings in Germany. In: Energy and Buildings, 111. S. 455-467

Thank you for your attention!

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