Projections of Energy Demand in Germany: Different Approaches and their Synthesis

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Introduction

- Study of the energy demand for different purposes
  - **Sectoral Approach:**
    - Demand site of the residential, tertiary and industry sector incl. creation of sub-sectors and classes in order to calculate the present and **future potential of decentral energy systems**
  - **Climatological Approach**
    - Influence of rising temperatures upon the electricity demand. Sectoral approach as an input for the climatological approach
- Combination of both approaches within System Dynamics

Sectoral approach

- A detailed description of the energy needs in the three German sectors: Industry, Residential and Tertiary as an input of primary importance for computing the DG potential in Germany.

- The energy demand is analysed by detailed literature reviews and recalculations in terms of useful energy demand in an energy planning tool - PlaNet MESAP (linear network model)

The PlaNet MESAP models enable us to:

- assess the demand in terms of useful energy consumption
- assess the heat and cooling demand per temperature level as technical input for the DG-potential analysis.

Heat applications divided by sectors in Germany in 2003

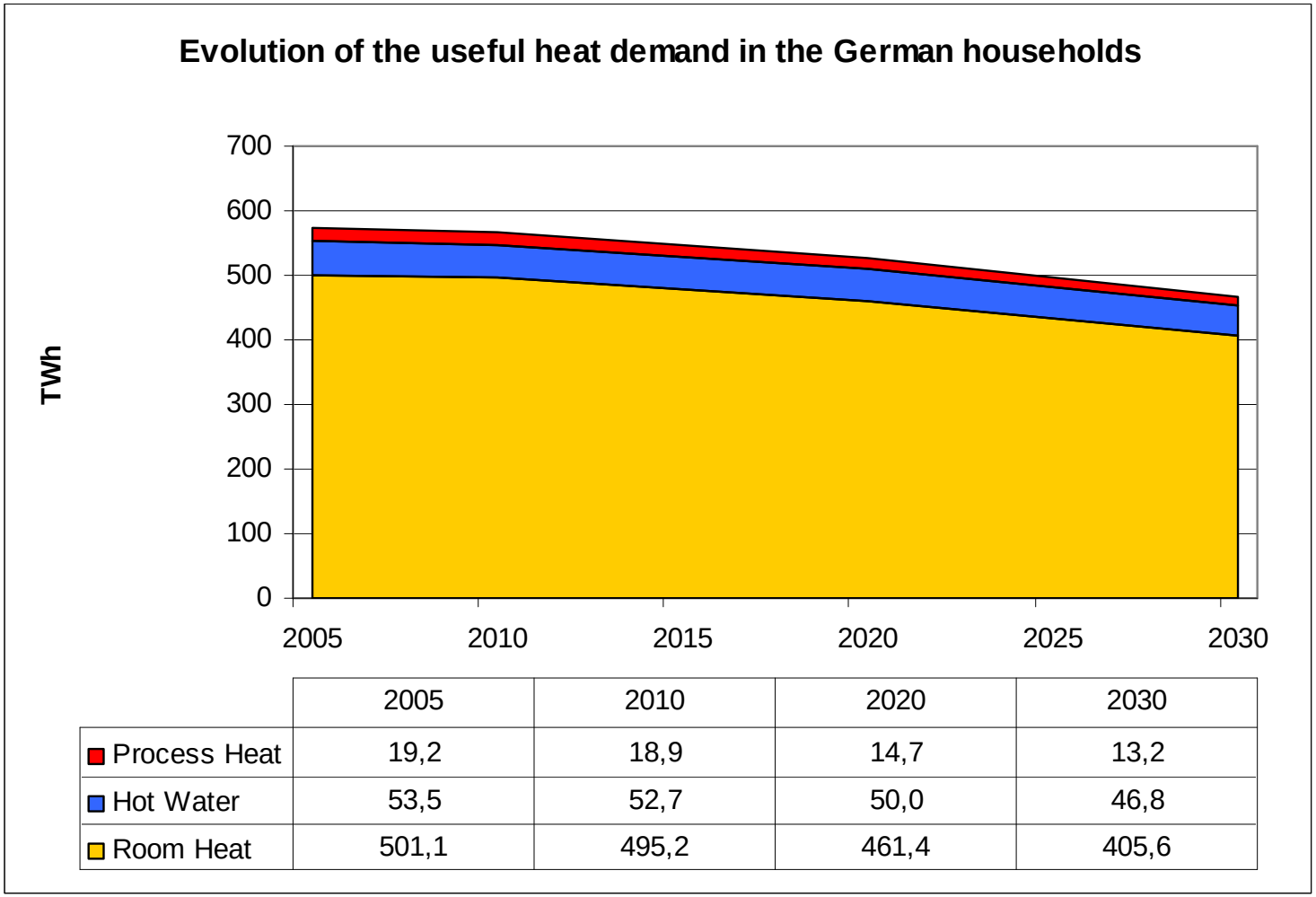
Heat applications divided by sectors in Germany in 2003

Application	Residential	Industry	Tertiary
Room heat	82.9%	12,6%	64,2%
Warm water	12,5%	1,0%	14,3%
Process heat	4,6%	86,4%	21,6%
Total	**100%**	**100%**	**100%**

Source: Bremer Energieinstitut

Label	years	spezific heat demand	Average size of accommodation unit	number of housing units in 2005	number of accommodations in 2005
		[kWh/m² a]	[m²/AU]		
SFH	until 1980	204,2	112,0	6.849.742	8.286.322
SFH	1981-2001	129,2	134,7	2.447.143	2.920.401
SFH	2002 - 2030	85,0	125,3	518.230	616.693
RDH	until 1980	168,7	86,9	2.109.129	4.003.910
RDH	1981-2001	118,3	100,0	901.791	1.700.161
RDH	2002 - 2030	85,0	125,3	326.752	455.950
SMFH	until 1980	162,3	69,0	1.271.459	5.805.218
SMFH	1981-2001	97,6	76,2	389.952	1.755.579
SMFH	2002 - 2030	65,0	70,0	103.703	178.637
LMFH	until 1980	143,6	62,2	728.749	6.305.293
LMFH	1981-2001	89,5	66,8	218.393	1.856.862
LMFH	2002 - 2030	65,0	70,0	58.451	179.645
HRB	until 1980	125,9	57,9	128.885	2.884.863
HRB	1981-2001	85,0	61,7	36.744	808.466
HRB	2002 - 2030	65,0	70,0	10.257	82.490
			total	**17.013.841**	**37.719.528**

Evolution of the useful heat demand in the German residential sector



	2005	2010	2020	2030
Process Heat	19,2	18,9	14,7	13,2
Hot Water	53,5	52,7	50,0	46,8
Room Heat	501,1	495,2	461,4	405,6

~19% reduction of room heat demand from 2005 to 2030

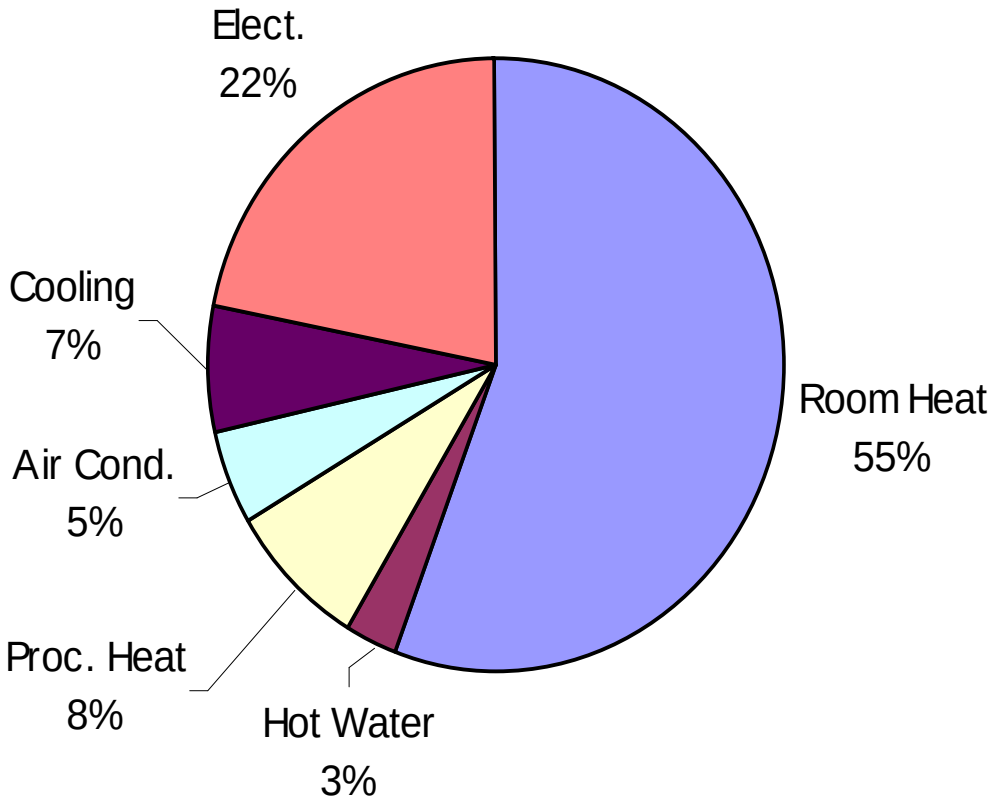
Evolution of the useful heat demand in the German tertiary sector

Complex and heterogeneous sector:
5 PlaNet MESAP models were necessary

The models provide the useful energy demand for:

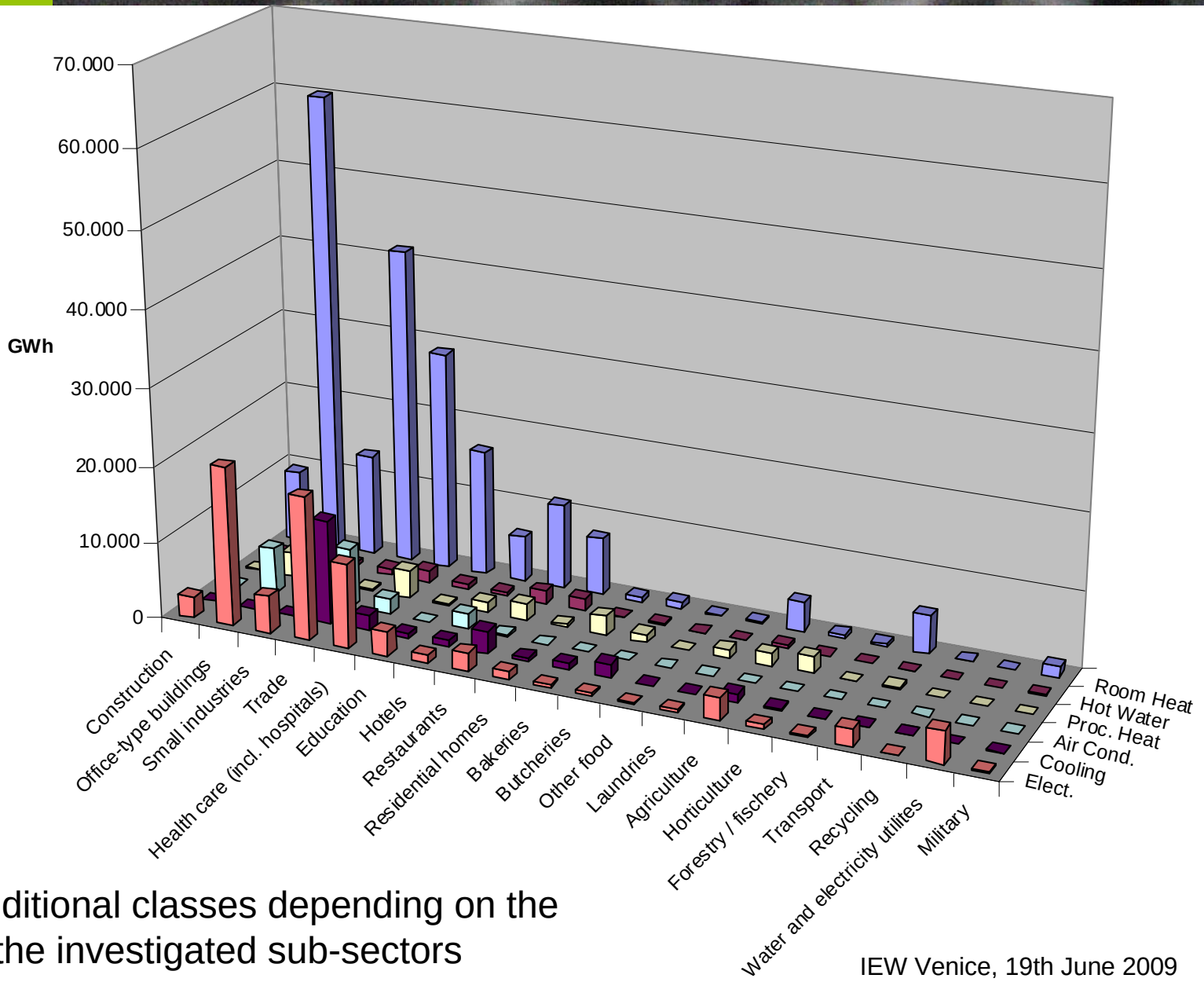
- room heat
- hot water
- process heat
- air conditioning
- cooling (0-5℃)
- refrigeration (below 0℃)
- Electricity

Share of the final energy demand per segment, 2005



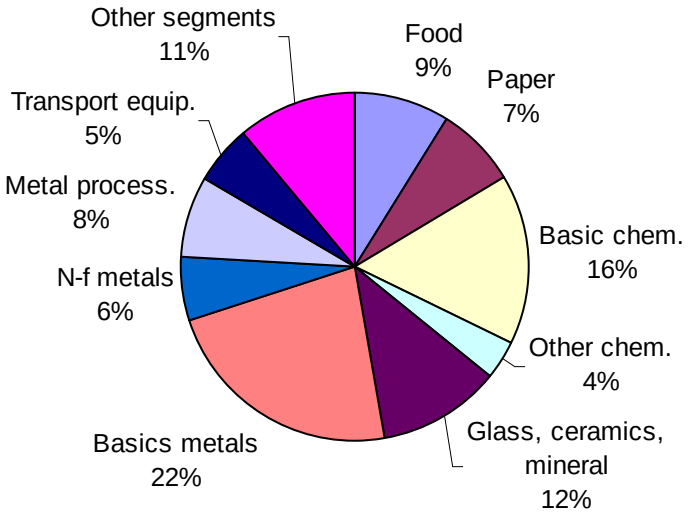
~22% reduction of the total final energy demand from 2005 to 2030

Heterogeneity of the Tertiary Sector

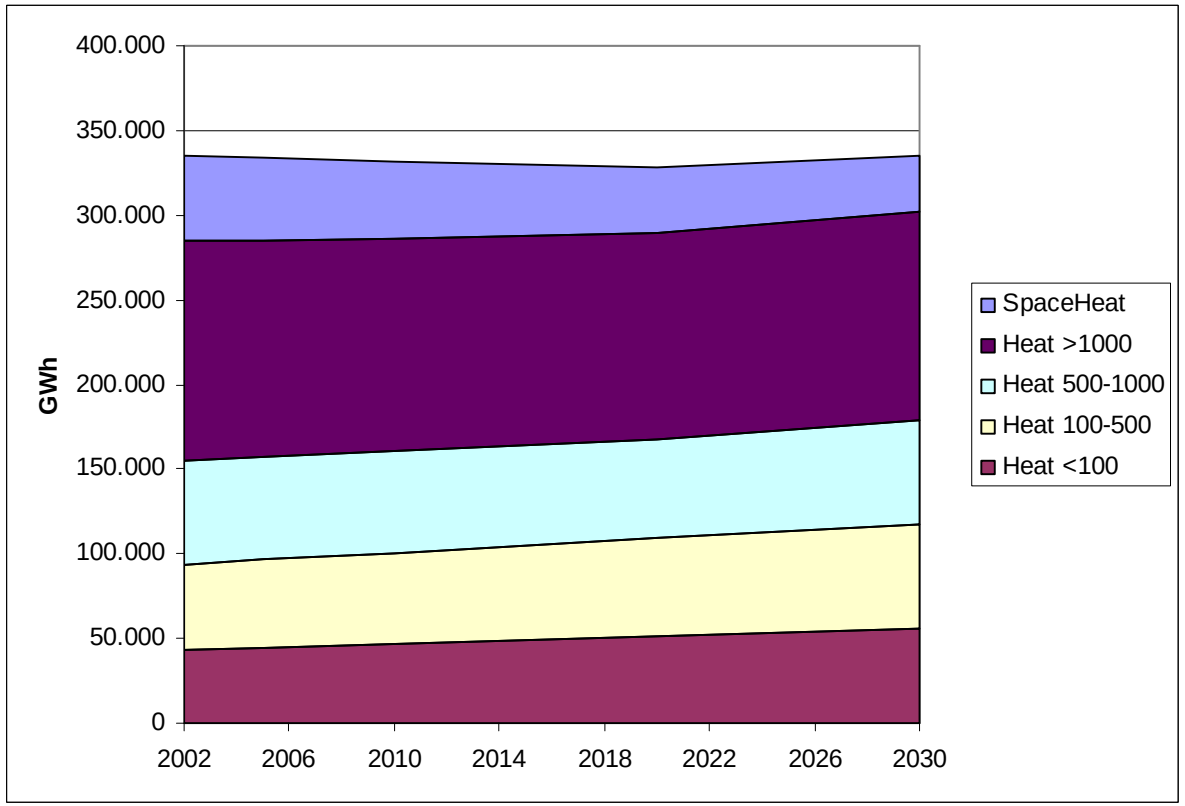


- With additional classes depending on the size of the investigated sub-sectors

Evolution of the useful heat demand in the German industry sector



Industry sector –share of final energy demand per segment, 2005



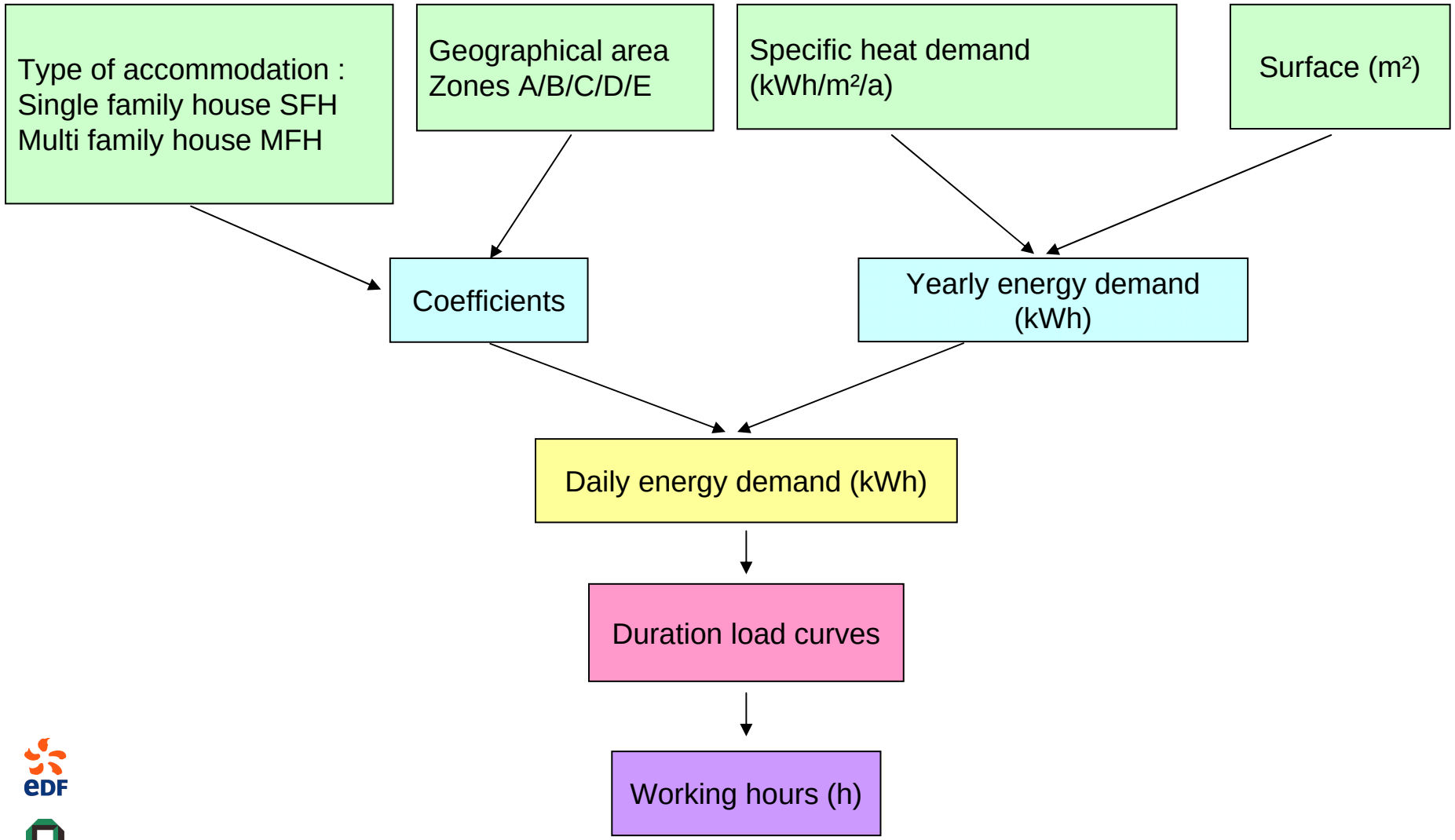
Industry: total demand almost constant, process heat increase of 6%
Space heat demand decrease of 33%.

Industry sector – energy demands

#	Segment	Units	Employees	Space heat	Proc. heat <100	Proc. heat 100-500	Proc. heat 500-1000	Proc. heat >1000	Air Cond	Cooling	Total Elec
1	Food	5 890	542 921	8 269	12 703	12 893	-	-	1 517	25 651	14 705
2	Pulp & Paper	1 014	140 669	3 530	5 763	12 983	-	-	387	-	18 879
3	Basic Chemicals	541	189 209	3 428	8 287	10 465	20 166	4 778	453	1 966	53 038
4	Other Chemicals	1 329	293 456	886	2 415	3 093	5 353	1 268	802	-	8 153
5	Glass, Ceramic, mineral processing	3 425	217 798	1 948	649	930	13 103	26 034	581	-	12 083
6	Basics metals	94	79 720	2 651	515	1 500	17 101	80 803	223	-	24 454
7	nf-metals	662	133 757	383	170	242	2 186	8 239	361	-	26 470
8	Metal processing & machinery and equip.	18 379	1 591 970	10 179	3 820	2 765	1 344	3 376	4 538	-	21 481
9	Transport equip.	1 731	939 027	6 318	2 277	1 528	675	1 832	273	141	18 389
10	Other Industries	17 527	2 023 490	10 482	8 212	5 136	736	2 086	5 450	3 638	37 498
	Total	**50 592**	**6 152 018**	**48 073**	**44 810**	**51 534**	**60 663**	**128 416**	**14 586**	**31 396**	**235 148**

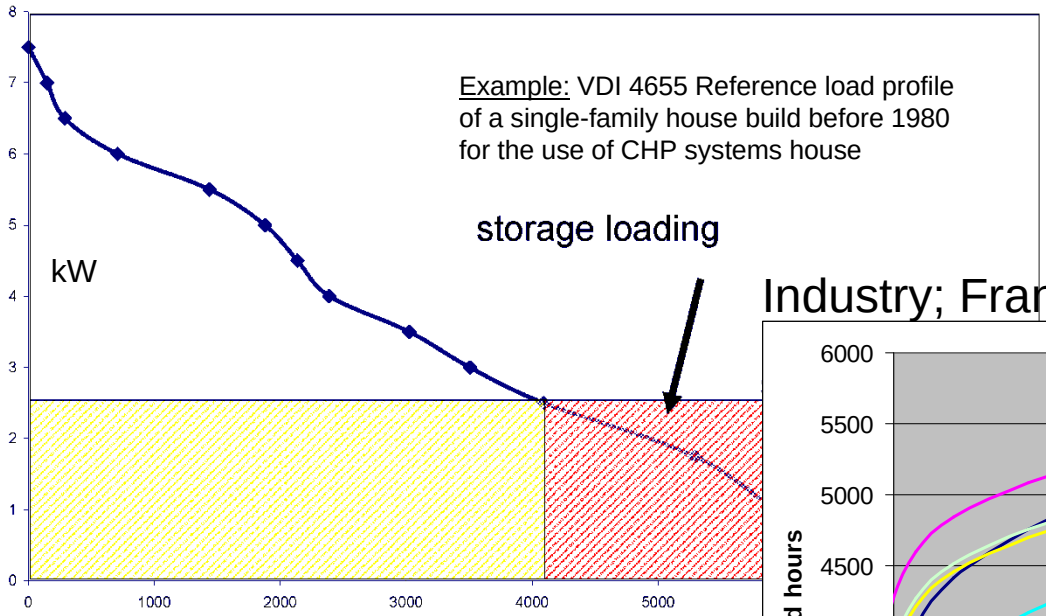
Useful energy demands per segment and uses, GWh, 2005

Functioning of the VDI 4655 – residential and tertiary sector

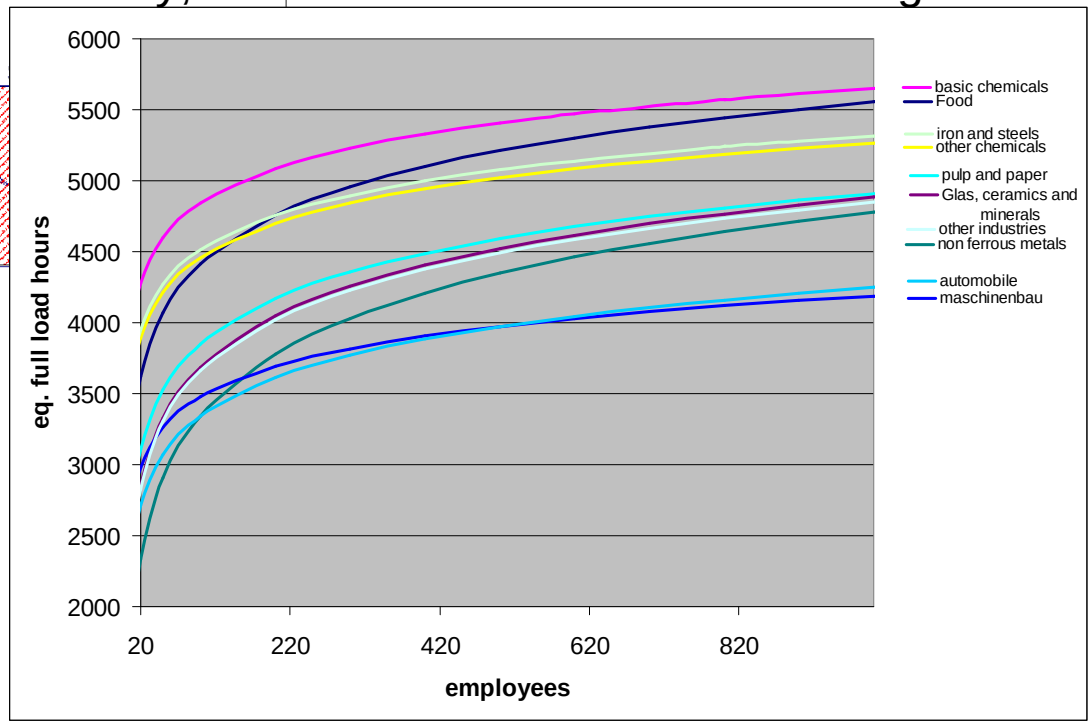


Estimation of operating hours in different sectors

Residential: VDI 4655 method

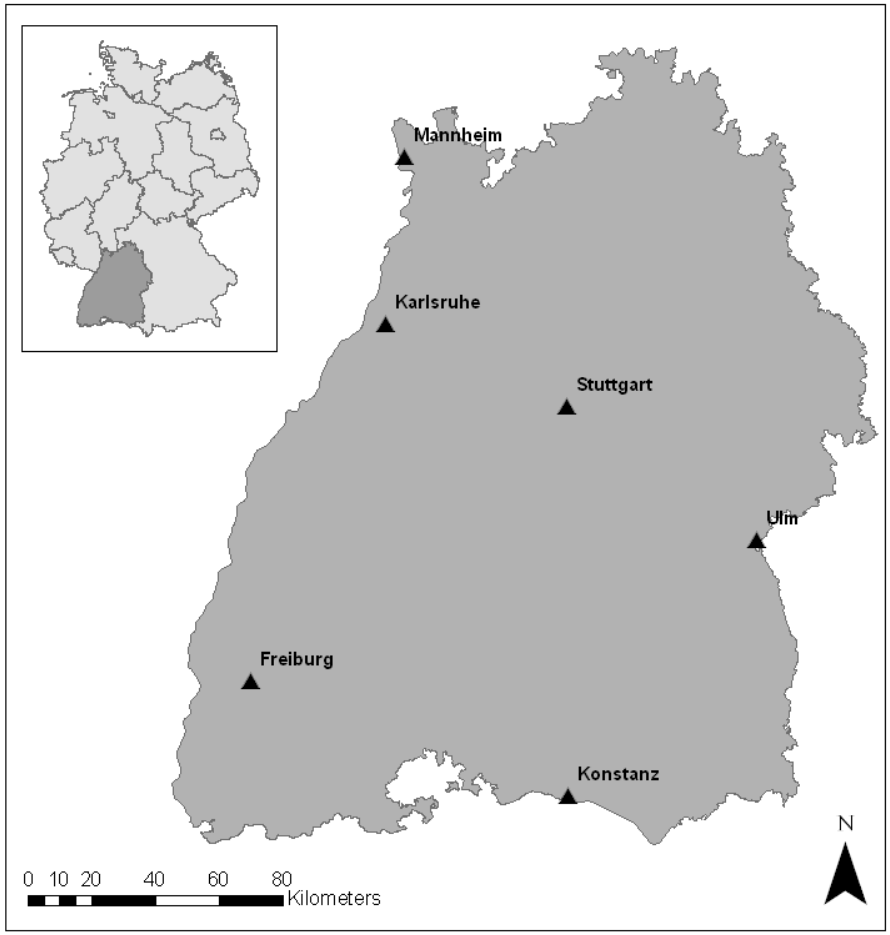


Industry; France: 20.000 industries investigated

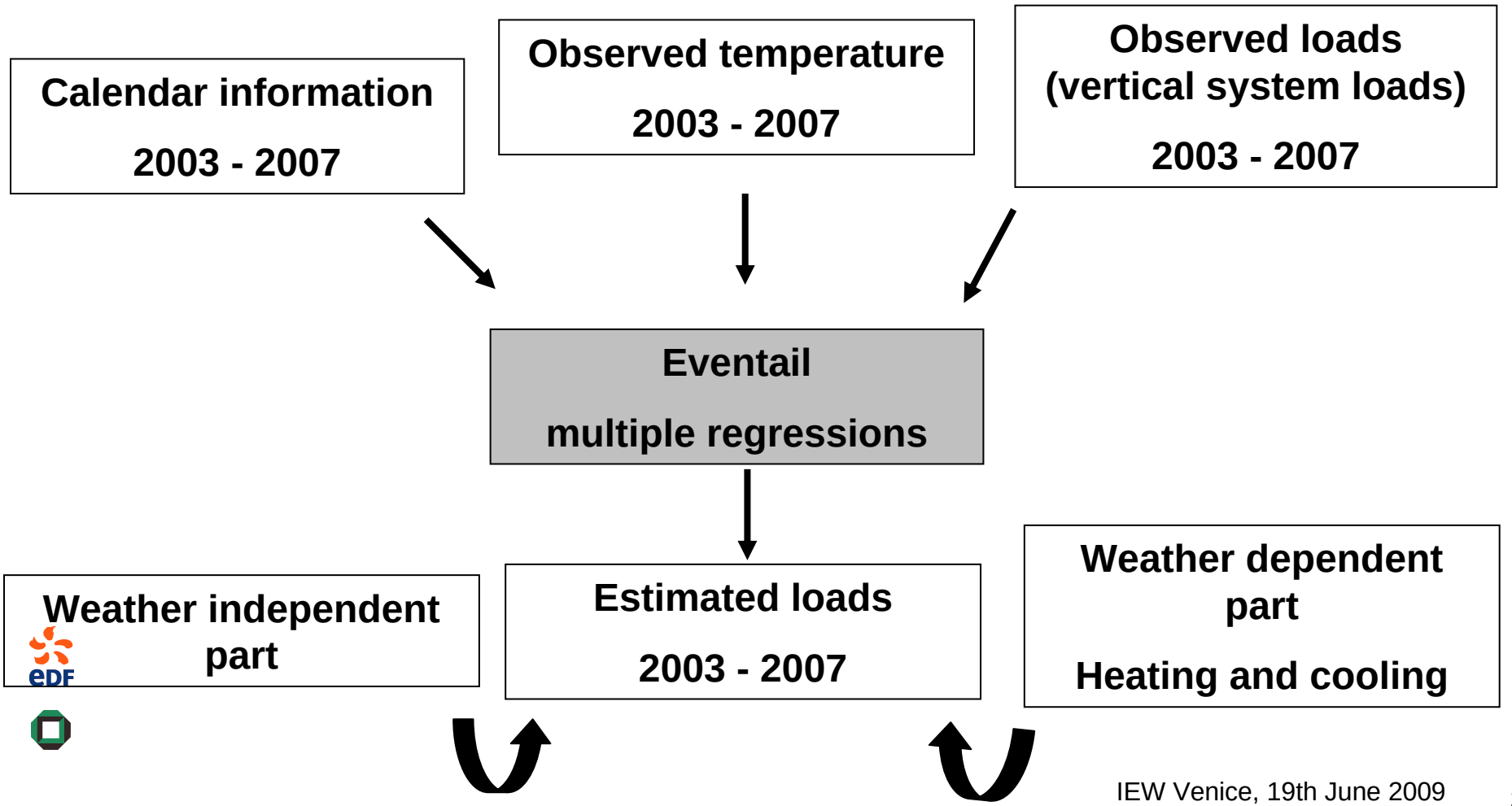


Climatological Projection

Objective: Identification of the temperature effect on the electricity demand in Baden-Württemberg (BW) by fixing all other load influencing factors.



Calibration of the load forecast model „Eventail“ on the EnBW supply region



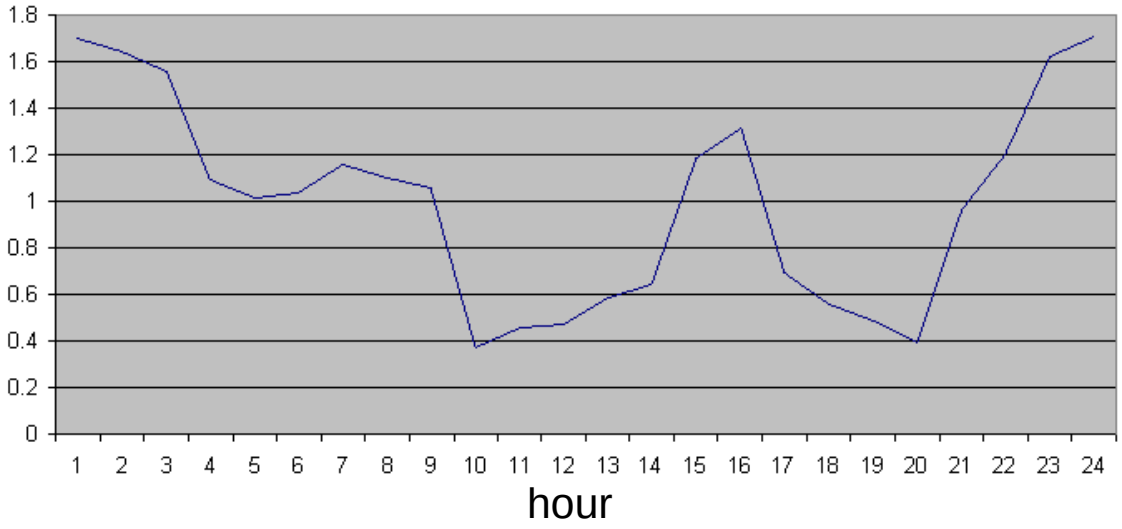
Results of the „Eventail“-calibration

MAPE: 4.6 %

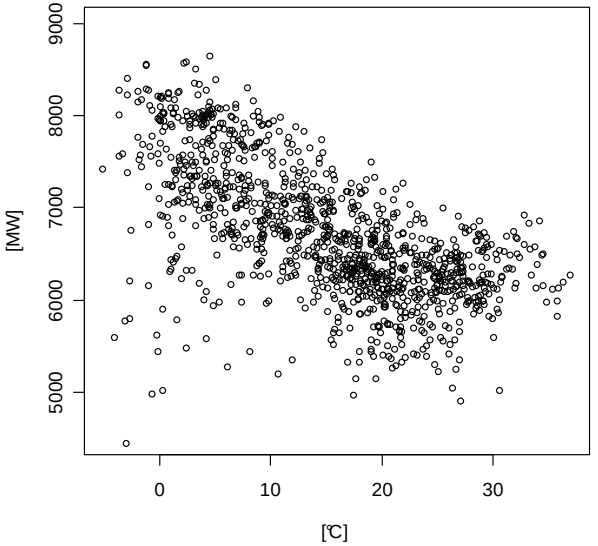
The temperature-dependent part is 0.05 % of the total load in average!

Heating gradient: -59 MW/℃
Cooling gradient: 84 MW/℃

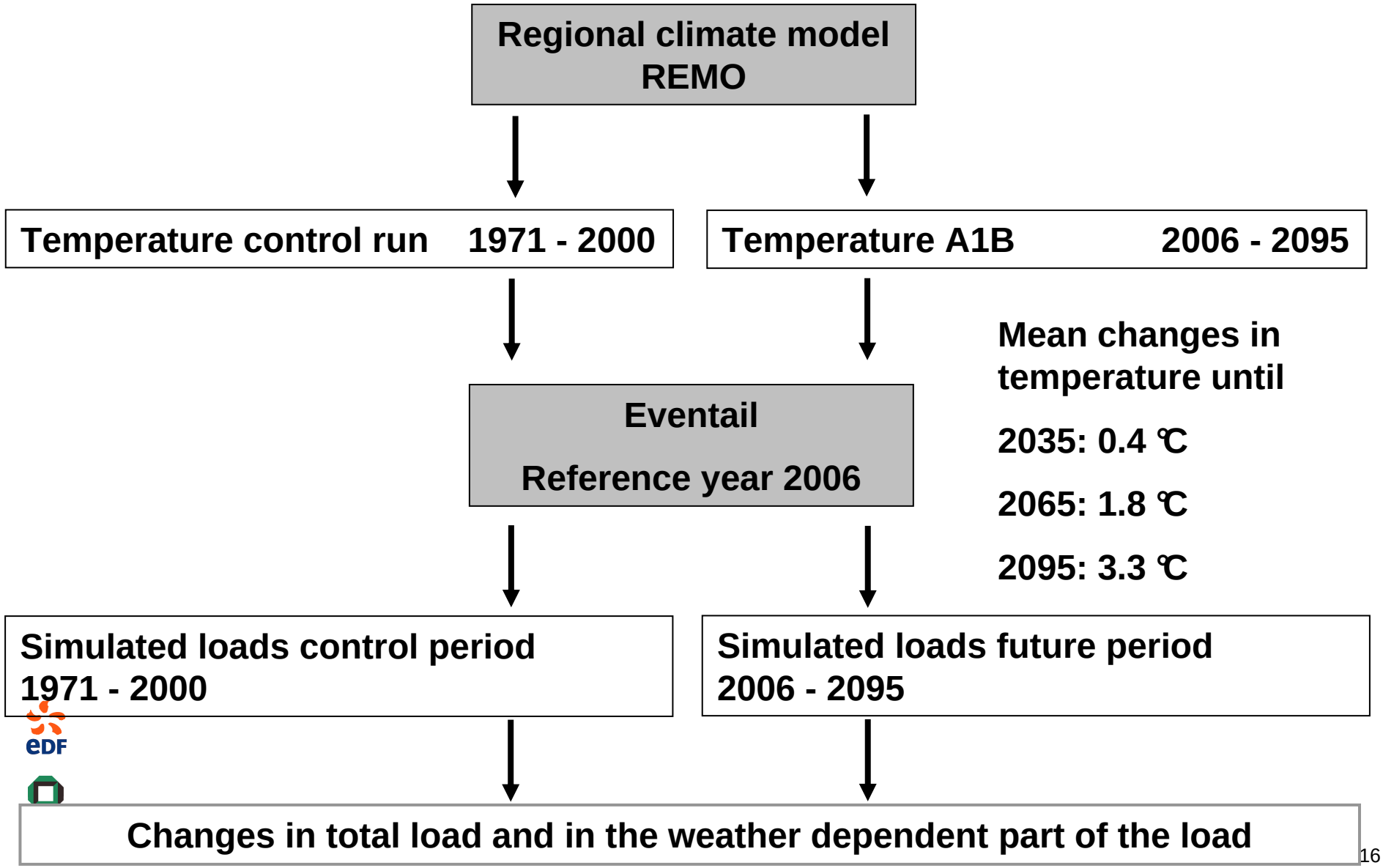
Calibration weakness in the cooling gradient curve



Daily average temperature and average load, workdays 2003-07, EnBW supply region



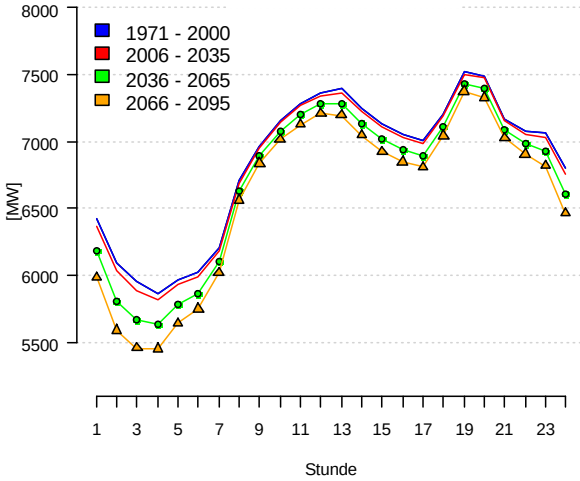
The impact of long-term temperature variations on the electricity demand until 2095



The impact of long-term temperature variations on the electricity demand until 2095

Mean load curves total load, significant values (α = 95%) indicated by symbol

JanFeb



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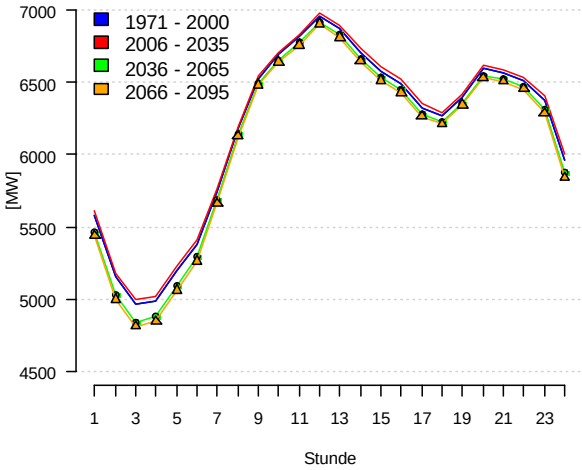
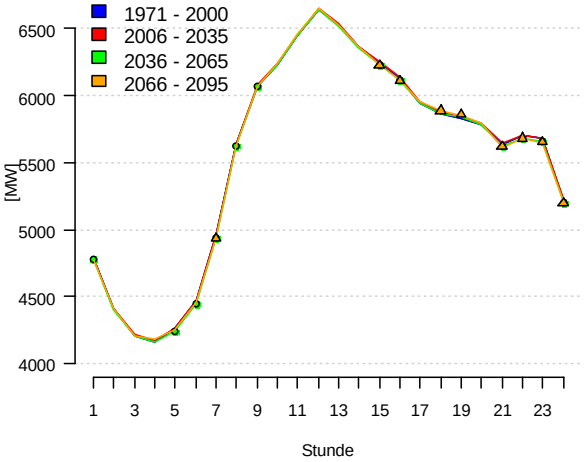


MayJun



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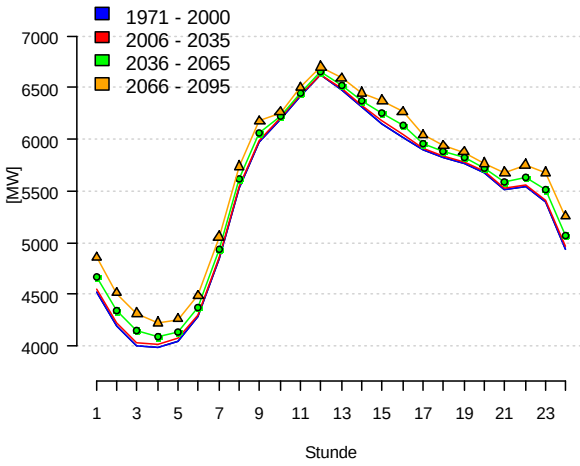

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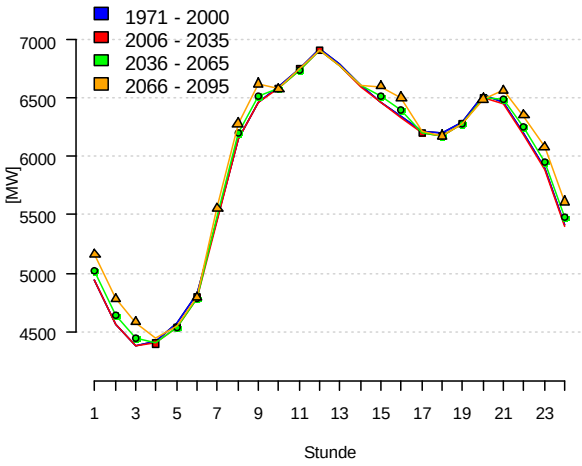

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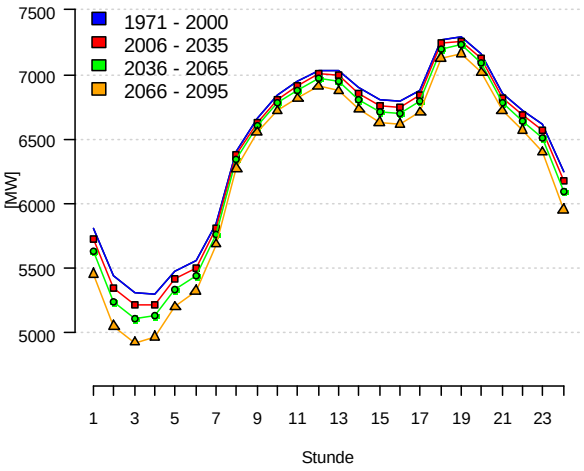
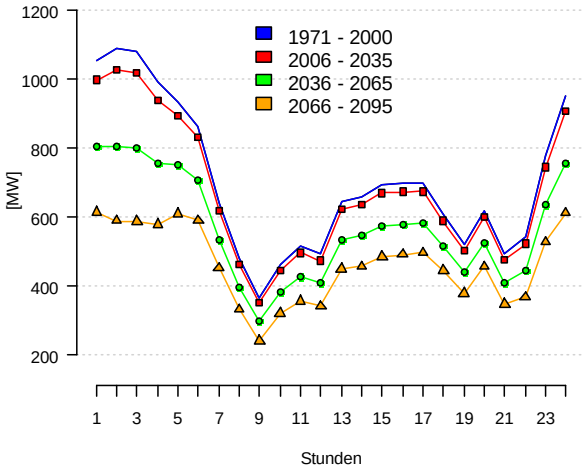


The impact of long-term temperature variations on the electricity demand until 2095

Mean load curves heating load, significant values (α = 95%) indicated by symbol

JanFeb



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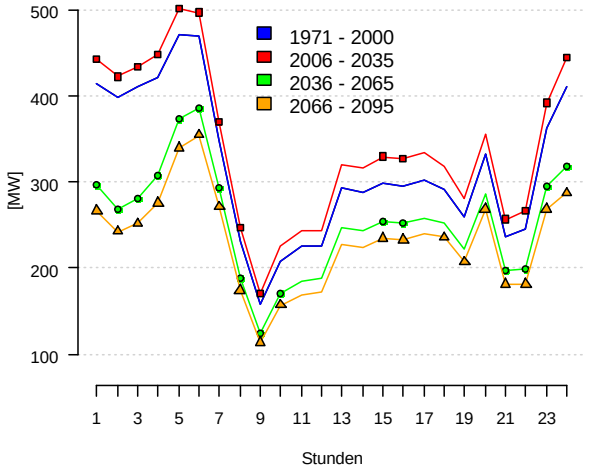

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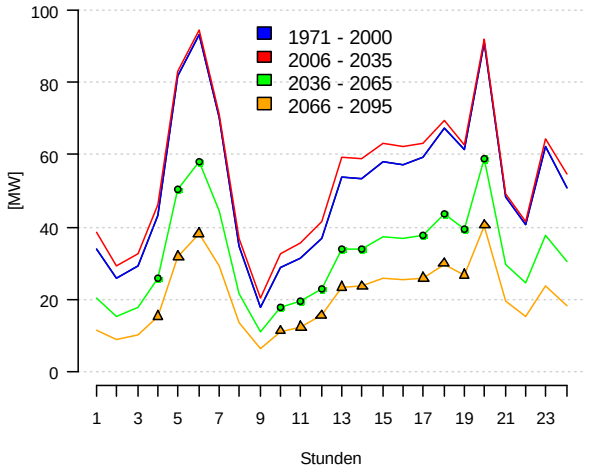

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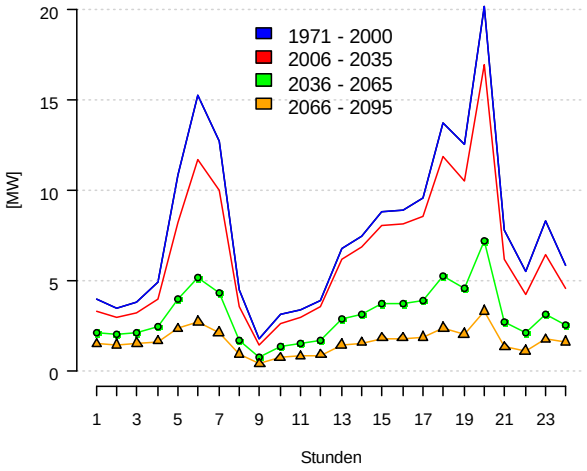

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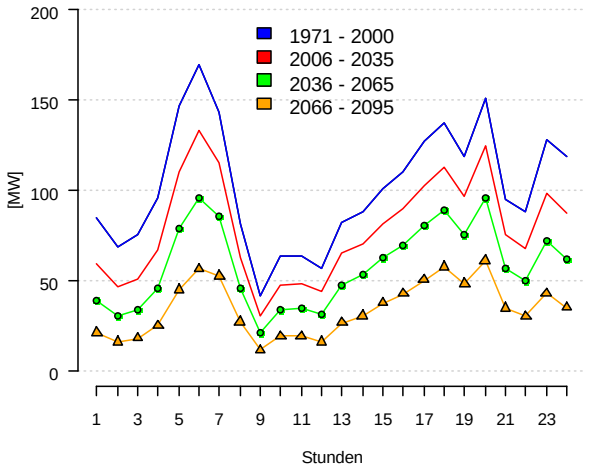

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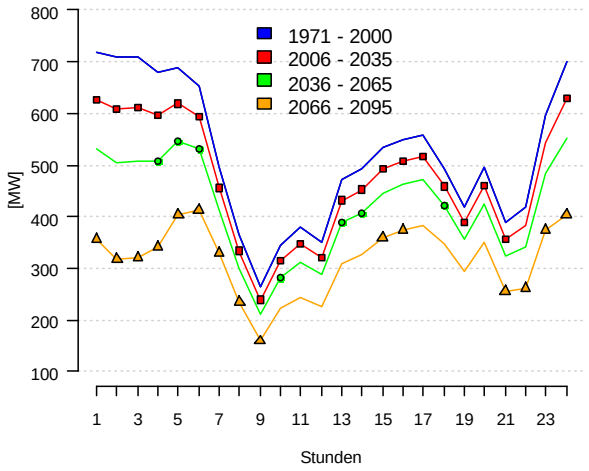

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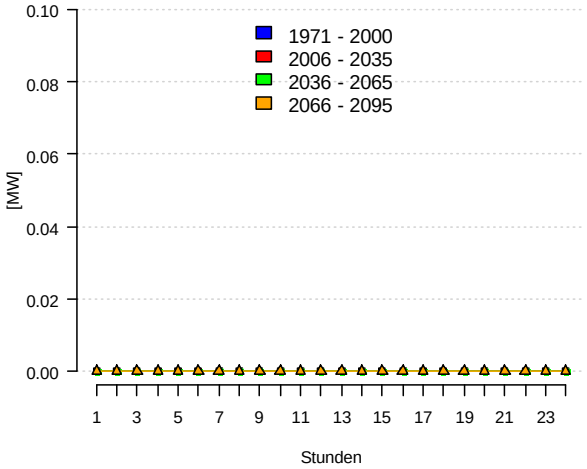
The impact of long-term temperature variations on the electricity demand until 2095

Mean load curves cooling load, significant values (α = 95%) indicated by symbol

JanFeb



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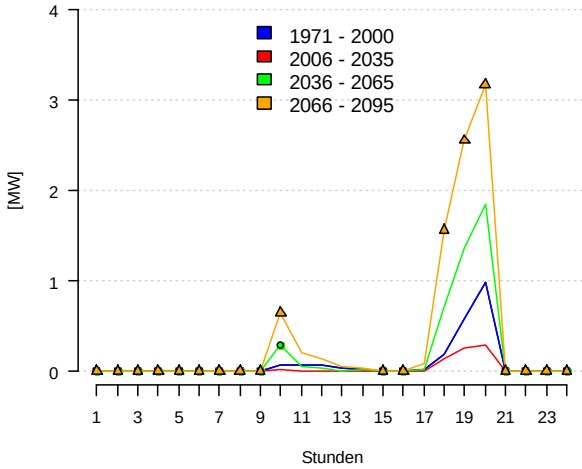

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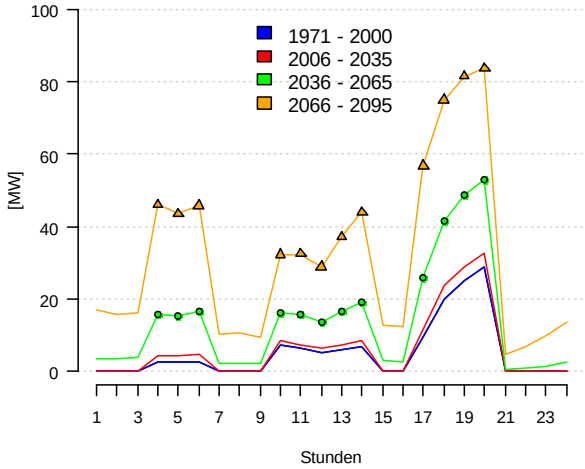

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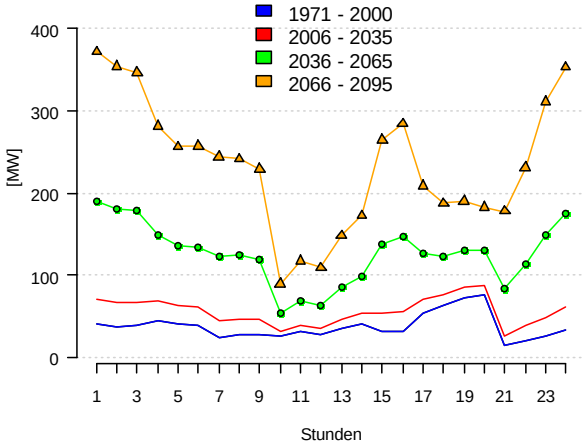

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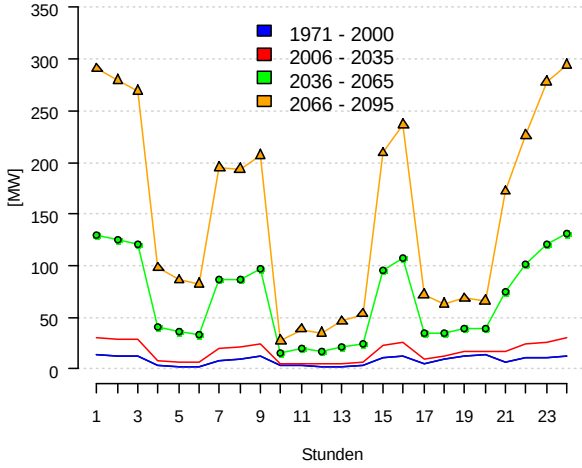

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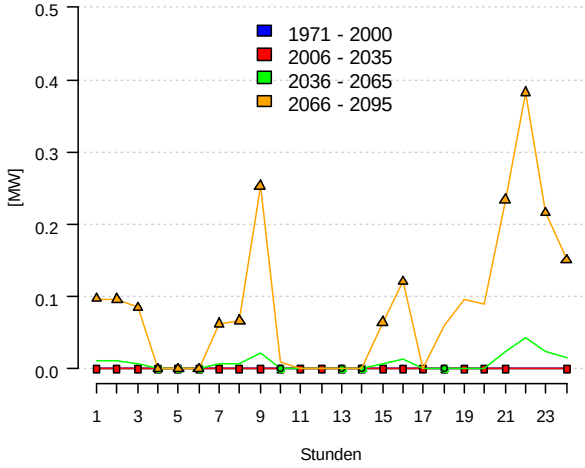


Conclusions:

- The thermo-sensitive part of the loads is very small in average (0.05%)
- The mean changes in the temperature result in
  - a net decrease in the total load of 8 MW until 2035, 35 MW until 2065 and 44 MW until 2095
  - a decrease in the heating load of 12 MW (4.3%) until 2035, 61 MW (21.7%) until 2065 and 104 MW (37.0%) until 2095
  - an increase in the cooling load of 4 MW (44.4%) until 2035, 26 MW (288.9%) until 2065 and 61 MW (677.8%) until 2095

BUT: The stated changes only represent the temperature effect.

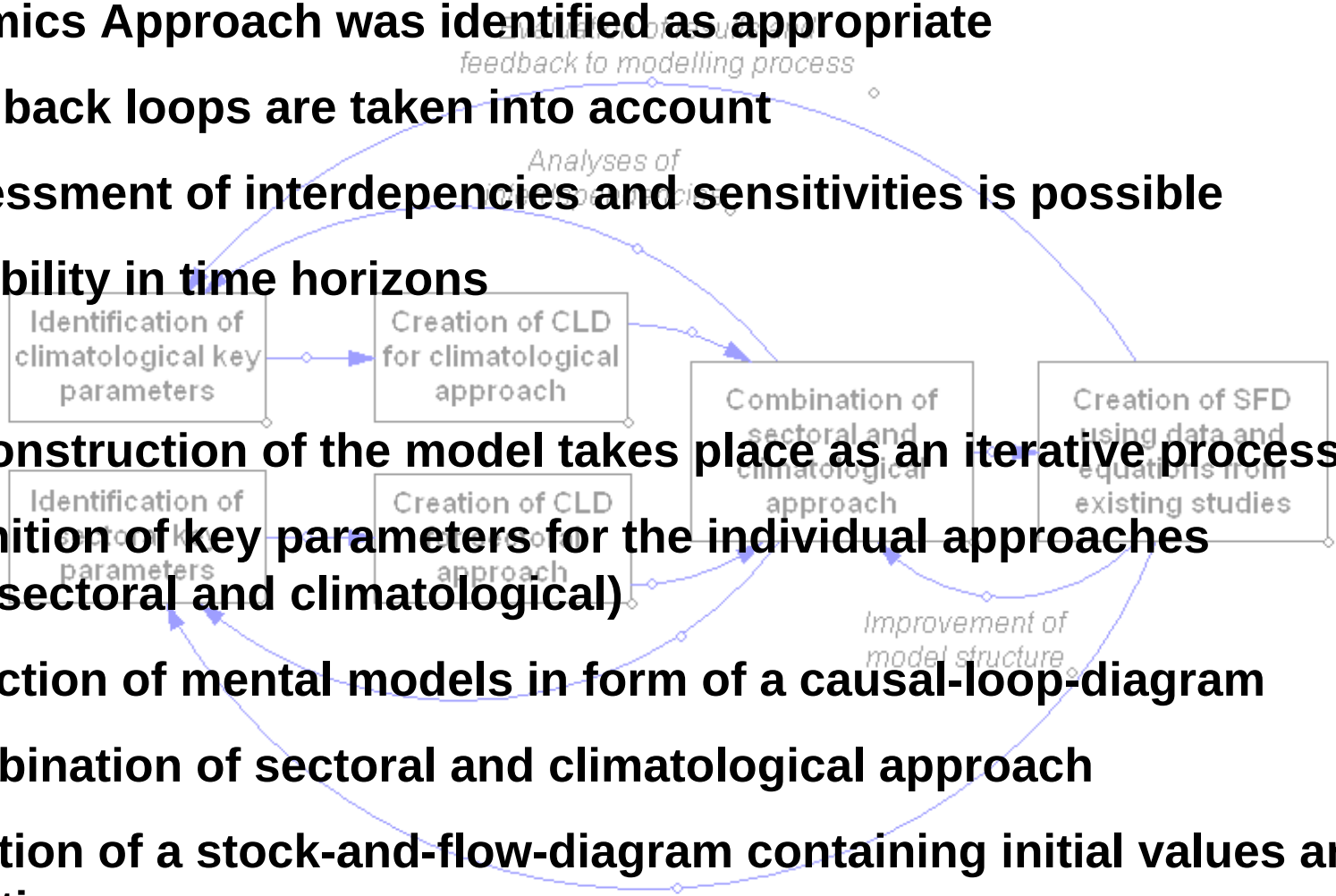
If other load-influencing factors such as the rate of air conditioners or heat pumps vary, then the stated changes could either be enforced or reduced.

OUTLOOK: The analysis is currently transferred to Germany

Synthesis

To integrate different approaches and disciplines, the System Dynamics Approach was identified as appropriate

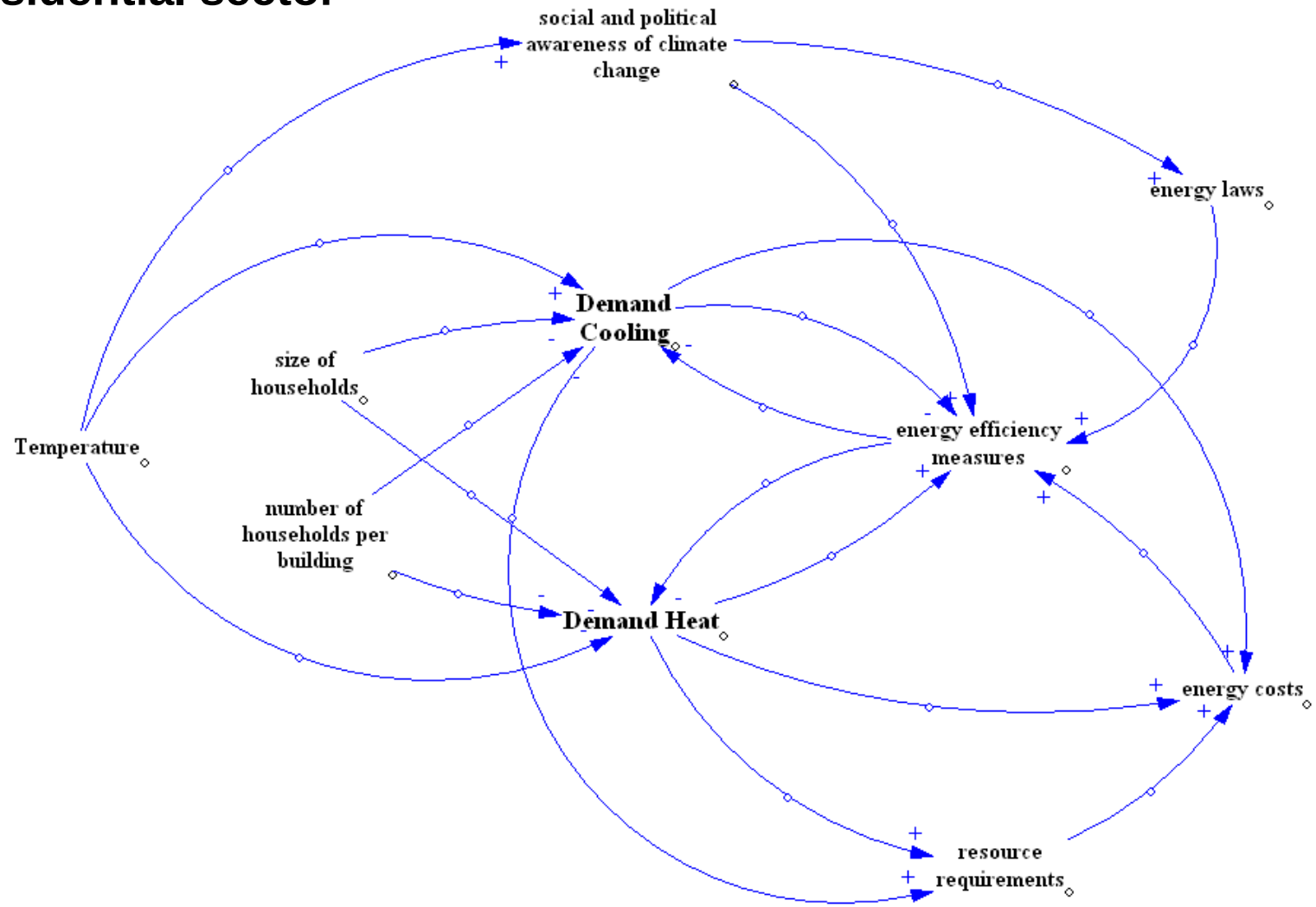
- **Feedback loops are taken into account**
- **Assessment of interdepencies and sensitivities is possible**
- **Flexibility in time horizons**



The construction of the model takes place as an iterative process:

- **Definition of key parameters for the individual approaches (i. e. sectoral and climatological)**
- **Depiction of mental models in form of a causal-loop-diagram**
- **Combination of sectoral and climatological approach**
- **Creation of a stock-and-flow-diagram containing initial values and equations**

A first model for the projection of energy demand within the residential sector



Questions ?

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