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Barriers to electricity load shift in companies: a survey-based exploration of the end-user perspective

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Introduction: objective

- Load shift
  - voluntary reduction or increase of momentary electricity demand in response to incentives.
- Need for load shift:
  - Growing demand and increasing diffusion of solar and wind challenge grid stability
  - Alternatives are expensive and/or slow
- Problem: slow uptake/diffusion
- Why?
  - Which **barriers** to uptake do end-users perceive?

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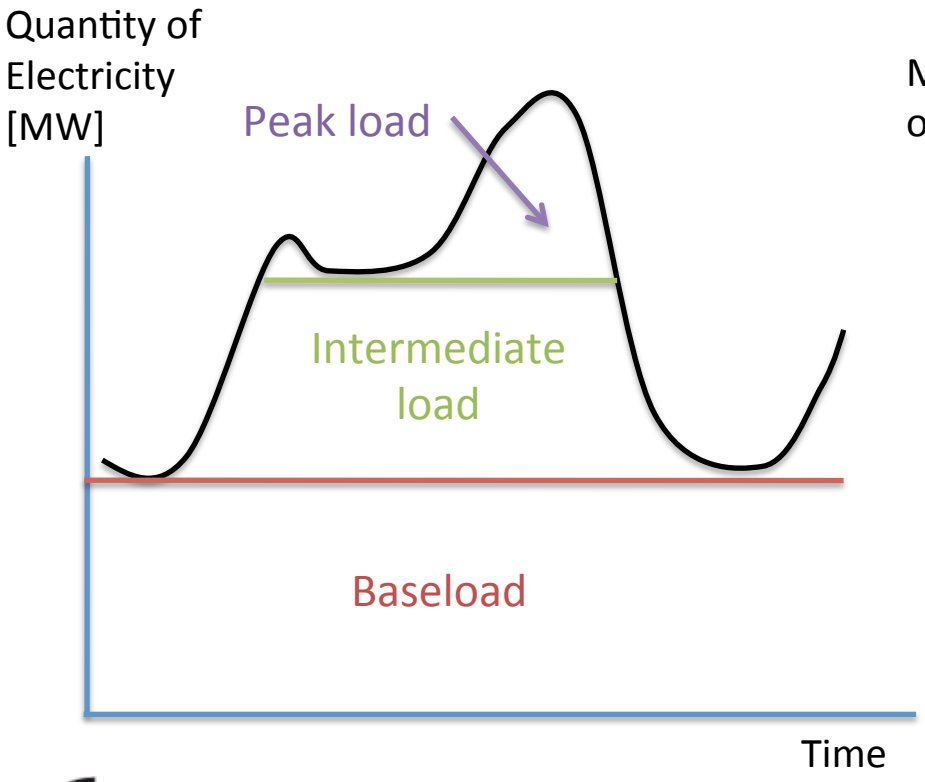
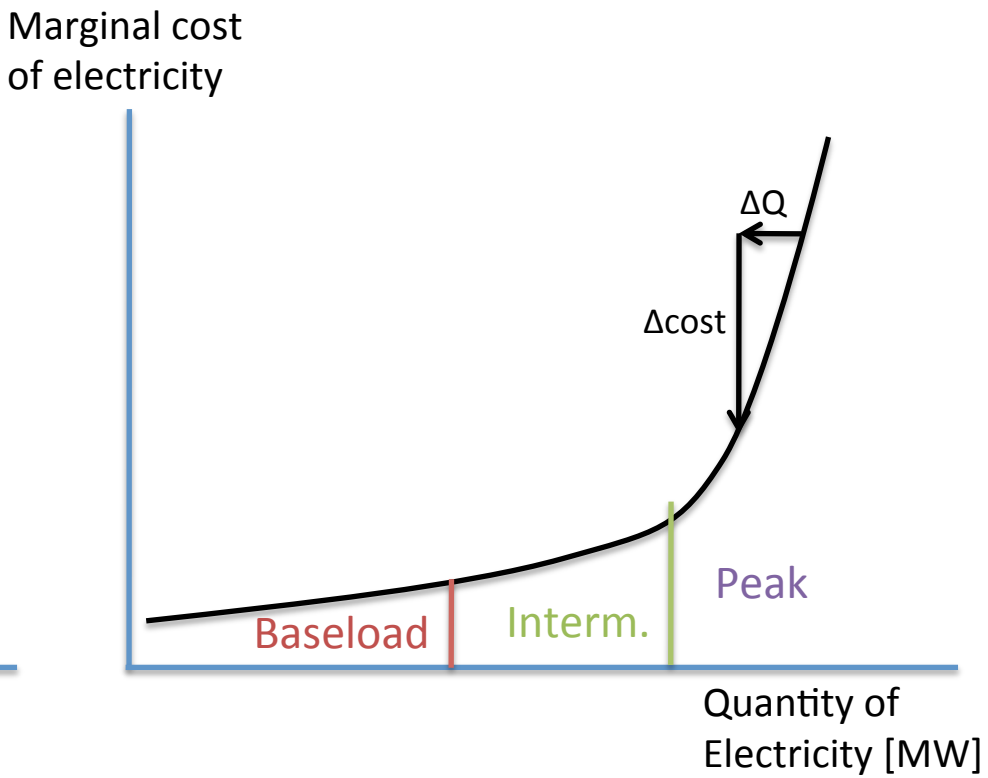
Introduction: Old World





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Introduction: research questions

1. Under current public policies, which barriers keep manufacturing businesses from practicing load shift more?
2. Which barriers to load shift can be grouped together?
3. Do company characteristics matter for the perception of barrier relevance?

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Data & method: design

- Empirical, quantitative exploration (not done before for load shift)
- One-time online survey: cross-sectional data
- Multi-sectoral: Manufacturing industries
  - Significant unused potential
  - Low-hanging fruit
- Level of analysis:
  - Electricity users, production sites
- Region: Southern Germany
  - Ahead of the curve: pilot for other countries

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Data & method: building on energy efficiency literature

- Extensive literature on Energy Efficiency Barriers
- Is this knowledge transferrable to Load Shift?
- Load Shift ≠ Energy Efficiency
- Expected:
  - Transferrable approach
  - Different barriers and ranking
- Frameworks:
  - Sorrel et al. 2004: theoretical barrier taxonomy
  - Cagno et al. 2013: actor-based barrier taxonomy

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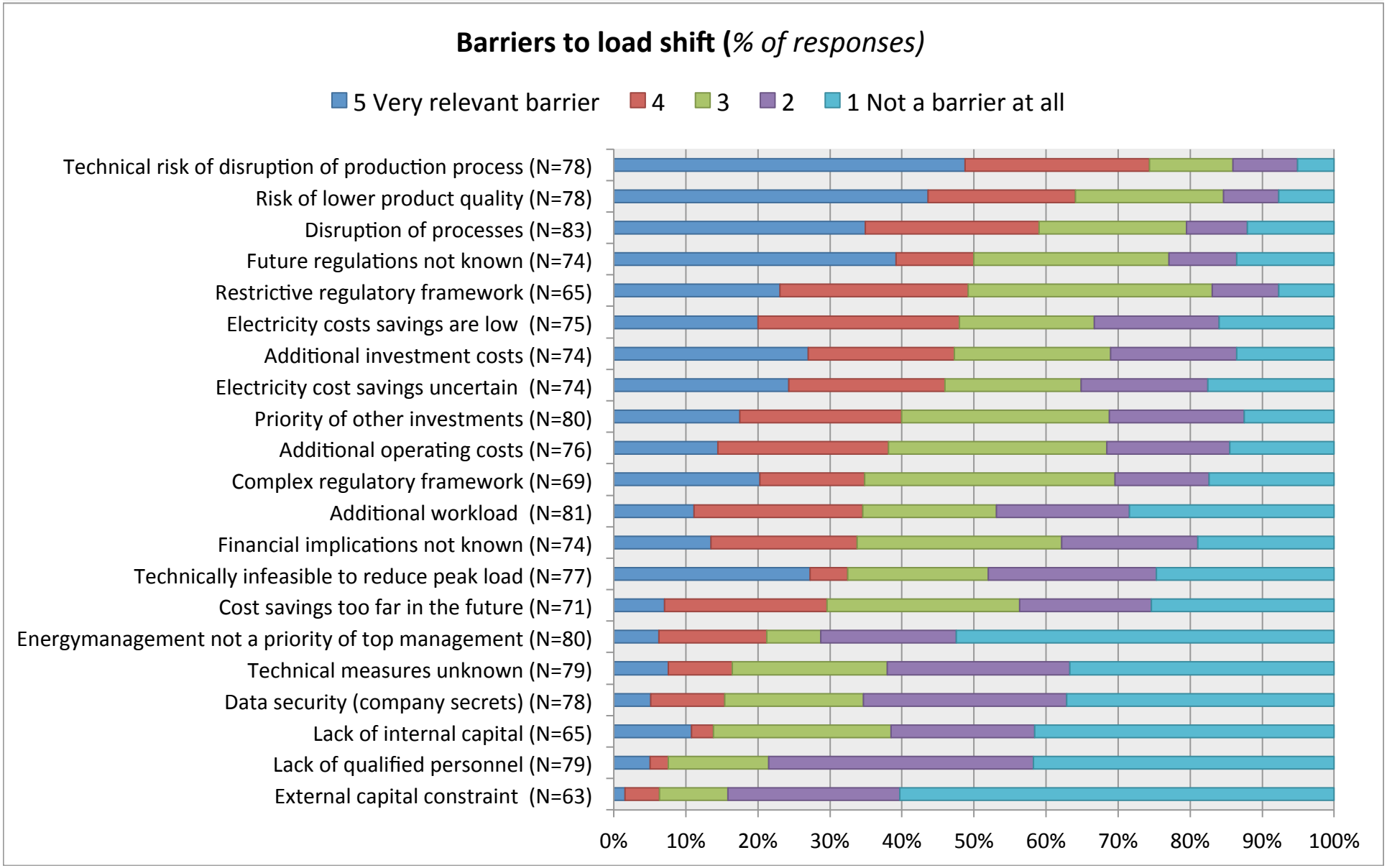
Data collection: self-administered online survey

Barrier category (Cagno et al. 2013)	**Barrier items in the questionnaire**
Technological	1. Technological measures unknown 2. Technically infeasible to reduce peak load 3. Technical risk of disruption of the production process 4. Risk of lower product quality 5. Data security
Information	6. Electricity cost savings uncertain 7. Financial implications not known
Regulatory	8. Future regulations not known 9. Restrictive regulatory framework 10. Complex regulatory framework

Method: 21 survey questions (cont'd)

Barrier category (Cagno et al. 2013)	**Barrier items in the questionnaire**
Economic	11. Electricity cost savings are low 12. Cost savings too far in the future 13. Additional operating costs 14. Additional investment costs 15. Access to external capital 16. Access to internal capital 17. Disruption of operations
Behavioral	18. Energy management not a priority of top management 19. Priority of other investments
Organizational	20. Additional workload
Competences	21. Employees lack the right skills

Results: barrier ranking



Results: principal com[illegible]t

1. Financial uncertainty
2. Interference/Tech risk
3. Availability of options
4. Low priority
5. Competencies

Rotated Component Matrix[a] (N=48)

Barrier	1	2	3	4	5	Commu-nalities
Energy cost savings too far in the future	**.695**	.102	.304	.152	-.124	.624
Financial consequences unknown	**.619**	.048	.264	.267	.128	.542
Additional operating costs	**.626**	.230	.076	.180	-.098	.492
Electricity cost savings are uncertain	**.800**	-.080	-.010	.235	-.104	.712
Required investments too high	**.546**	.078	.466	.340	-.436	.828
Low electricity cost savings	**.740**	.022	.107	.136	.198	.618
Regulations too complex	**.663**	.260	.207	.014	.273	.625
Regulations are too restrictive	**.596**	.302	-.364	.005	.164	.606
Future regulations uncertain	**.735**	.058	-.009	-.203	.296	.673
Technologically impossible to reduce peak load	-.184	**.877**	.042	.059	-.096	.818
Interference with personnel planning	.232	**.772**	.226	-.016	.198	.741
Potential negative impact on product quality	.156	**.851**	-.203	.207	.020	.834
Technical risk of production process disruption	.253	**.846**	-.053	.125	.122	.813
Lack of access to external capital	-.004	-.165	**.756**	.209	-.021	.643
Lack of (access to) internal capital	.233	.061	**.801**	-.201	.117	.754
Technological options unknown	.091	.064	**.741**	.228	.115	.627
Energy management not a priority for top management	.140	.094	.143	**.707**	.367	.684
Other investments have priority	.277	.273	.137	**.790**	.022	.794
Employees lack skills	.078	.057	.264	.318	**.774**	.780
Data security	.378	.384	-.083	.136	.471	.537
Additional workload	.384	.103	.447	.389	.307	.604

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

Results:
Effect of company characteristics

Barriers	**Electricity expenditures**			**Normal electric load**			**Electricity intensity**		
	samples	*N*	*Δ(means)*	*samples*	*N*	*Δ(means)*	*samples*	*N*	*Δ(means)*
Lack of access to internal capital	High Low	26 32	0.183	High Low	26 35	-0.122	High Low	23 27	**-0.723***
Technological options unknown		38 34	-0.395		36 37	-0.403		28 30	**-0.695***
Additional operating costs		35 34	**0.605***		34 38	0.570		29 28	-0.107
Electricity cost savings uncertain		32 35	0.500		31 39	**0.715***		27 28	0.561
Regulations too restrictive		28 31	**0.599***		26 35	0.331		22 28	**0.909****
Future regulations uncertain		32 35	**0.891****		31 39	0.396		30 27	0.148
** p < 0.05, ** p < 0.01*									

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Results:
Effect of company characteristics

Barriers	**Batch production**			**Just-in-Time production**			**Continuous production**		
	samples	*N*	*Δ(means)*	*samples*	*N*	*Δ(means)*	*samples*	*N*	*Δ(means)*
Energy management not a priority of top management	Batch	13	0.038	JiT	14	**1.017****	Cont.	32	**-0.769***
	Other	52		Other	50		Other	27	
Additional workload		13	0.743		15	0.427		32	**-0.808***
		53			50			28	
Interference with personnel planning		13	**1.155****		15	-0.020		33	**-0.688***
		54			51			28	
Potential negative impact on product quality		14	0.643		15	0.264		28	**-0.633***
		49			47			29	
Technical risk of production process disruption		14	0.541		15	0.317		29	**-0.655***
		49			48			29	
Avg of all barriers for full cases		9	0.322		6	0.435		18	**-0.557***
		29			31			15	

** p < 0.05, ** p < 0.01*

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Conclusions

- First quantitative study of barriers to load shift within a conceptual framework borrowed from energy efficiency
- Results show differences between energy efficiency and load shift
  - Technical risk is the most important concern
  - Financial risk is second
  - Access to capital not (yet) important

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Issues for further investigation

- How is load shift different from energy efficiency?
  - Transferability of knowledge
  - Synergies and antagonisms
  - Implications for adoption?

- More than financial: shift of risk to end-user?

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