Rethinking energy efficiency in the built environment as dynamic relation between moving targets

Thomas Berker @ ntnu no
Centre for Technology and Society and
The Norwegian Research Centre on Zero Emission Buildings
Norwegian University of Science and Technology

Where we come in:

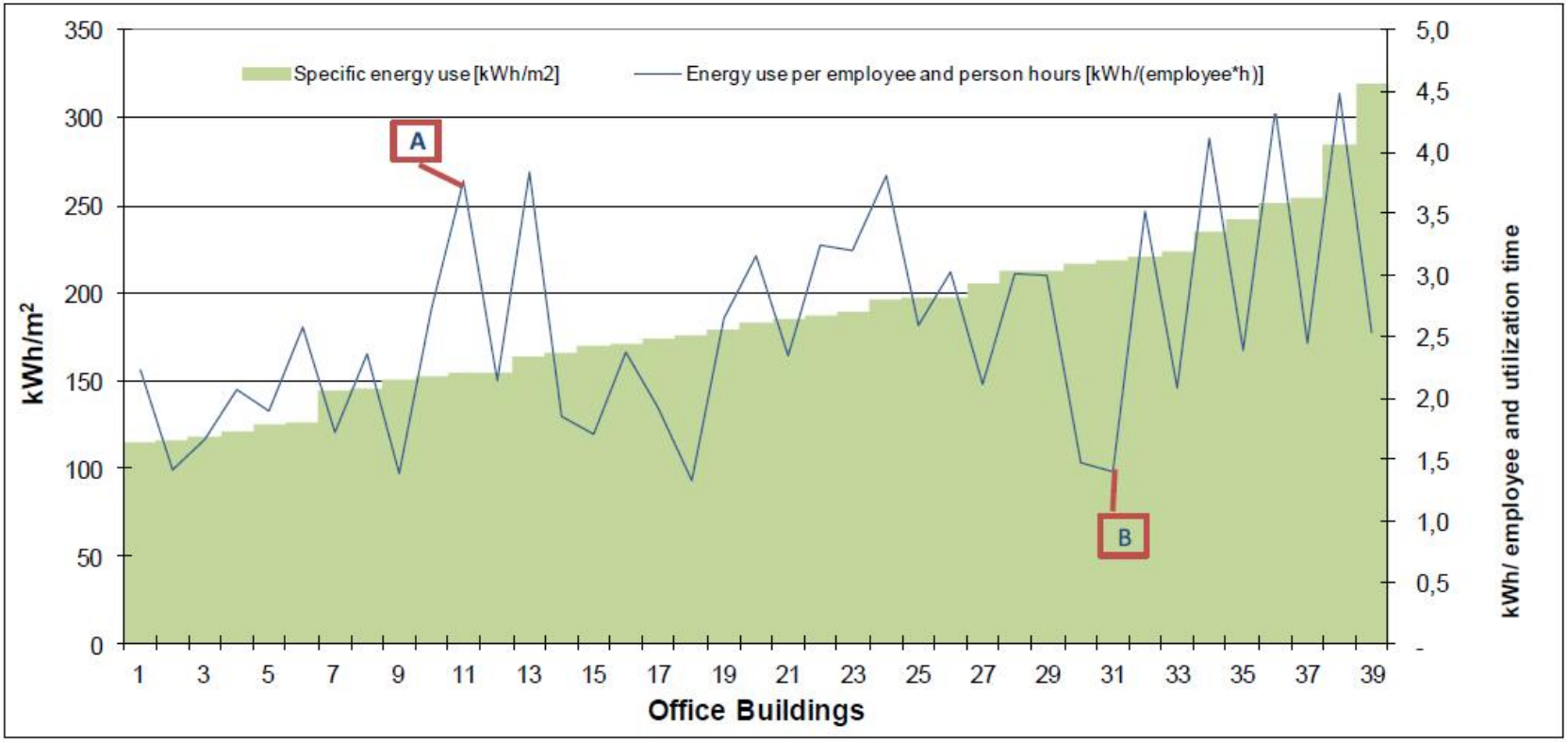
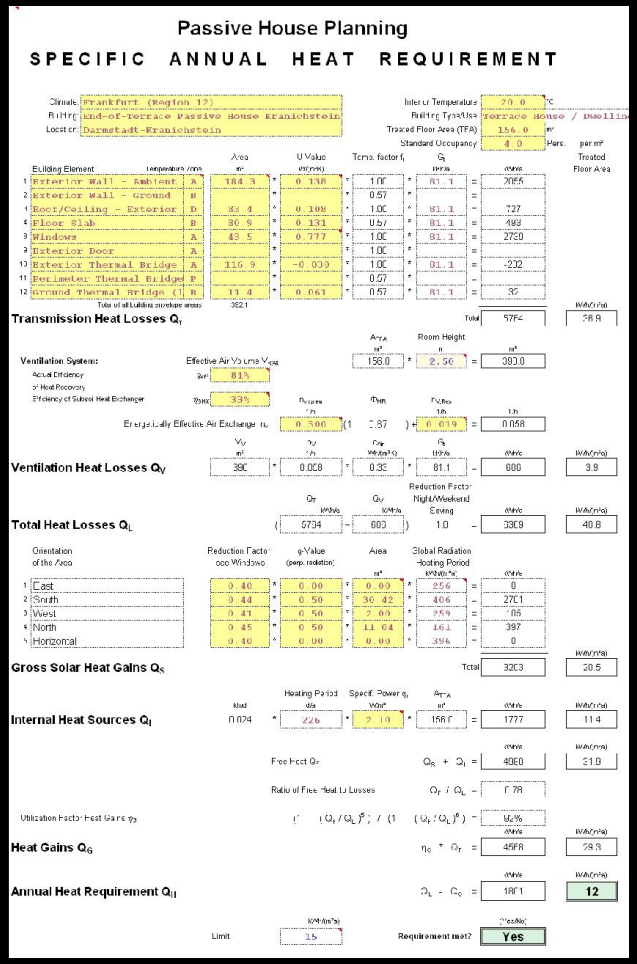


Figure 4-1: **Ranking of energy efficiency (kWh/m^2.) versus energy effectiveness (specific energy consumption /persons * time utilization) for office buildings from Enova's building network (Rønning, 2012).**

Rønning et al. (2012): Managing Smart in Smart Grid:
http://ostfoldforskning.no/uploads/dokumenter/publikasjoner/708.pdf

Saving energy - zooming in



Passive House Planning

SPECIFIC ANNUAL HEAT REQUIREMENT

Climate: Frankfurt (Region 12)
Building: End-of-Terrace Passive House Kranichstein
Location: Darmstadt-Kranichstein

Interior Temperature: 20.0 °C
Building Type/Use: Terrace House / Dwelling
Treated Floor Area (TFA): 156.0 m²
Standard Occupancy: 4.0 Pers. per m² Treated Floor Area

	Building Element	Temperature Zone	Area m²		U-Value W/(m²K)		Temp. factor f_t		G_t kKh/a			kWh/a	kWh/(m²a)
1	Exterior Wall - Ambient	A	184.3	*	0.138	*	1.00	*	81.1	=		2065	
2	Exterior Wall - Ground	B		*		*	0.57	*		=			
4	Roof/Ceiling - Exterior	D	83.4	*	0.108	*	1.00	*	81.1	=		727	
6	Floor Slab	B	80.9	*	0.131	*	0.57	*	81.1	=		469	
8	Windows	A	43.5	*	0.777	*	1.00	*	81.1	=		2750	
9	Exterior Door	A		*		*	1.00	*		=			
10	Exterior Thermal Bridge	A	116.9	*	-0.030	*	1.00	*	81.1	=		-232	
11	Perimeter Thermal Bridge	P		*		*	0.57	*		=			
12	Ground Thermal Bridge (1)	B	11.4	*	0.061	*	0.57	*	81.1	=		36	
	Total of all building envelope areas		382.1										

Transmission Heat Losses Q_T — Total: 5764 kWh/a; 38.8 kWh/(m²a)

Ventilation System: — A_{TFA} 156.0 m² × Room Height h 2.50 = 390.0 m³

Actual Efficiency η_{HR}: 81%
Heat Recovery
Efficiency of Subsoil Heat Exchanger η_{WTA}: 33%

Energetically Effective Air Exchange n_v: 0.300 (1 − 0.87) + 0.019 = 0.058 1/h

Ventilation Heat Losses Q_V: V_V 390 m³ × n_v 0.058 1/h × c_{ρ} 0.35 Wh/(m³K) × G_t 81.1 kKh/a = 600 kWh/a; 3.9 kWh/(m²a)

Total Heat Losses Q_L: (Q_T 5734 − Q_V 600 kWh/a) × Reduction Factor Night/Weekend Setback 1.0 = 3309 kWh/a; 40.8 kWh/(m²a)

	Orientation of the Area	Reduction Factor due Windows		ϕ-Value (perp. radiation)		Area m²		Global Radiation Heating Period kWh/m²a		kWh/a
1	East	0.40	*	0.00	*	0.00	*	256	=	0
2	South	0.44	*	0.50	*	30.42	*	406	=	2701
3	West	0.41	*	0.50	*	2.00	*	259	=	105
4	North	0.45	*	0.50	*	11.04	*	161	=	397
5	Horizontal	0.40	*	0.00	*	0.00	*	396	=	0

Gross Solar Heat Gains Q_S — Total: 3203 kWh/a; 20.5 kWh/(m²a)

Internal Heat Sources Q_I: kkd 0.024 * Heating Period d/a 226 * Specif. Power q_i W/m² 2.10 * A_{TFA} 156.0 m² = 1777 kWh/a; 11.4 kWh/(m²a)

Free Heat Q_F: $Q_S + Q_I$ = 4980 kWh/a; 31.9 kWh/(m²a)

Ratio of Free Heat to Losses: Q_F / Q_L = 0.78

Utilization Factor Heat Gains η_G: 1 − (1 − (Q_F / Q_L)^5) / (1 − (Q_F / Q_L)^6) = 62%

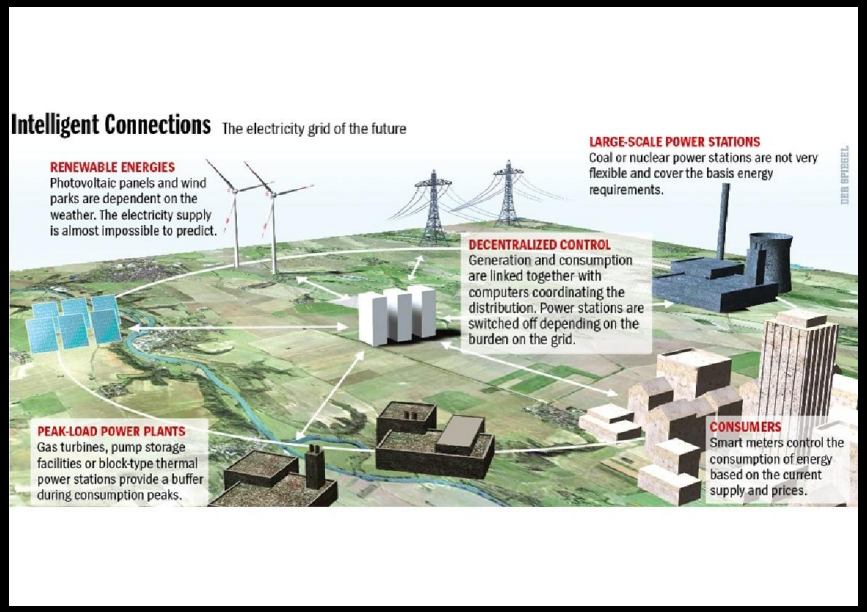
Heat Gains Q_G: η_G * Q_F = 4578 kWh/a; 29.3 kWh/(m²a)

Annual Heat Requirement Q_H: Q_L − Q_G = 1871 kWh/a; **12** kWh/(m²a)

Limit: 15 kWh/(m²a) — Requirement met? Yes

http://www.passivhaustagung.de/Passive_House_E/PHPP_sheet_annual_Balance.png

Saving energy - zooming out



http://www.spiegel.de/international/europe/bild-743616-87143.html

http://www.garvindirect.com/2010/06/european-supergrid-sets-high.html

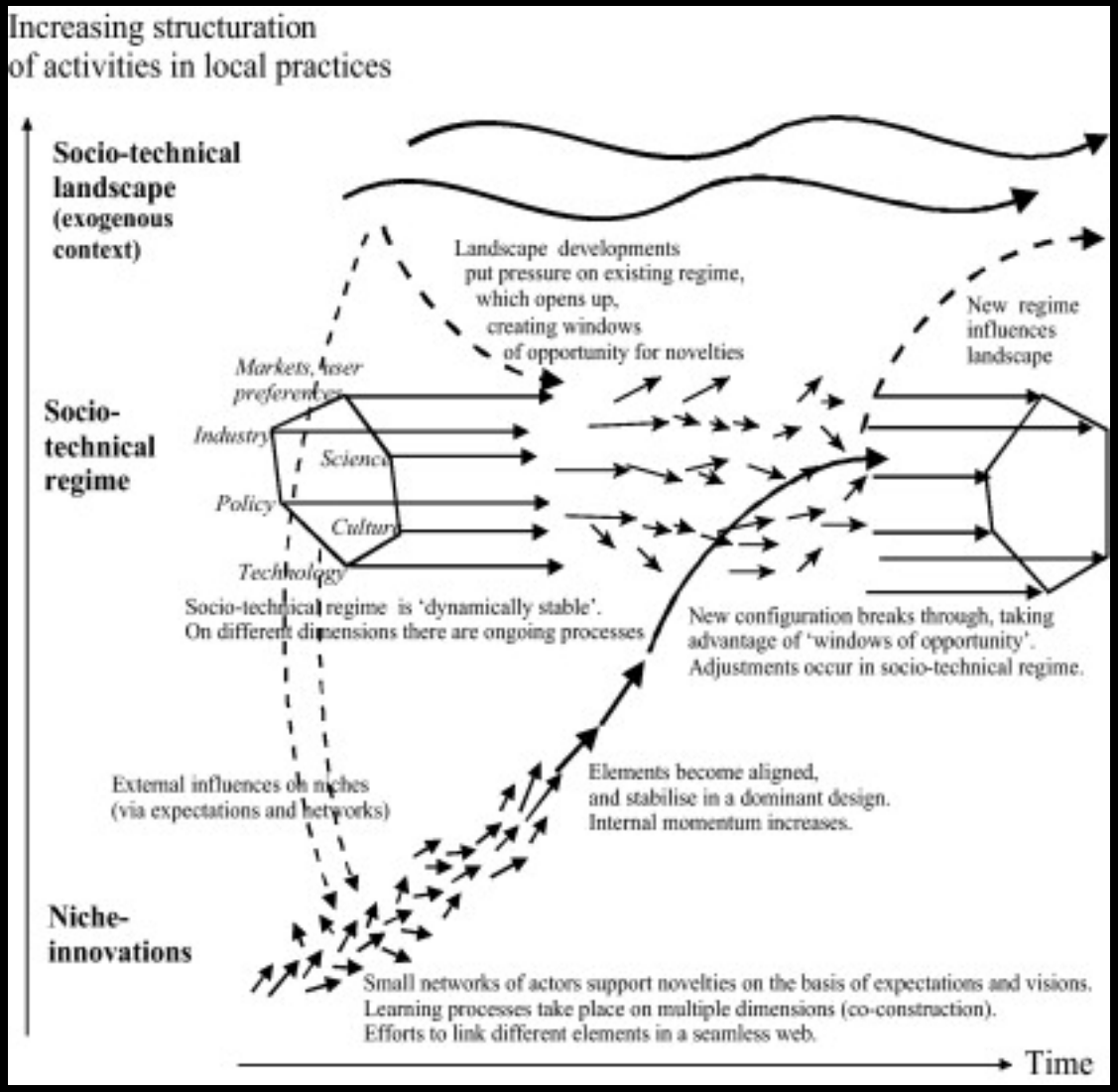
Saving energy - Social science approaches

- Zooming in: Qualitative studies of energy use, e.g. "Energy comes home" (Aune 2007)
- Zooming out: Research on aggregated actors and structures, eg.: socio-technical innovation

Practices

- **Zooming in:** Practice as performance (mostly studied through interviews/observations)
- **Zooming out:** Practice as entity (mostly through historical studies of everyday life)
- Connected in the **duality** of structure (Giddens)

Socio-technical transitions



Two additional proposals inspired (among others) by ANT

- meticulously and continuously (re)creating **productive connections** between the **dynamic and heterogeneous** elements that make up the built environment

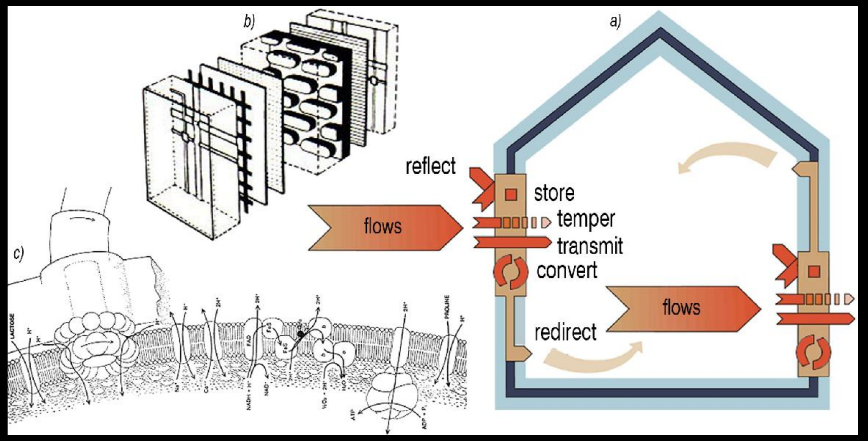
1) Maintenance instead of innovation

- Refurbishment as the new frontier
  - zooming in: exchanging components
  - zooming out: connecting in new ways
- From "Mr. Wolf" to continuous tuning and fine-tuning of existing buildings = Maintenance

http://www.ventsolutionsfbx.com/hrv_with_air_filtration_photo_gallery

2) Transforming intermediaries into mediators

- Rethinking the building envelope as flexible layer (Goia 2013)
- And then there was the janitor (Aune et al. 2009)



Finding dialogue partners within Science & Techology

- Zooming in-dialogues
- Zooming out-dialogues
- Mediator-dialogues
- Maintenance-dialogues
- More?

References

- Aune, Margrethe. 2007. “Energy Comes Home.” Energy Policy 35 (11): 5457–65. doi:10.1016/j.enpol.2007.05.007.
- Aune, Margrethe, Thomas Berker, and Robert Bye. 2009. “The Missing Link Which Was Already There: Building Operators and Energy Management in Non-Residential Buildings.” Facilities 27 (1/2): 44 – 55. doi:10.1108/02632770910923081.
- Goia, Francesco. 2013. "Dynamic Building Envelope Components and nearly Zero Energy Buildings: Theoretical and experimental analysis of concepts, systems and technologies for an adaptive building skin". PhD thesis. NTNU. http://urn.kb.se/resolve?urn=urn:nbn:no:ntnu:diva-23867