ASHRAE-REHVA Guidebook
Towards Zero Energy Hospital Buildings

Wim Maassen
January 21st 2024

ASHRAE TC 9.6 meeting

Status

- All ASHRAE and REHVA reviewer comments were addressed beginning 2020.
- Permissions need to be completed for case studies and for pictures/tables.
- Lay-out needed to be adjusted to format ASHRAE

Updates

1. Include reference to Covid works such as the ASHRAE Covid material. Include references that offer energy efficiency such as UVC air cleaning which allows recirculation in places where it is currently not allowed – such as Europe.

2. Refer to ASHRAE Decarbonisation task force and published material. Note Decarbonisation guide for hospitals (which Walt Vernon's group is doing for ASHRAE).

3. Refer to proposed ASHRAE Decarbonised hospital guidance work. Including possible NZC guide for hospitals

4. Check case studies are still relevant and update or amend if necessary

Updates

5. Refer to recently published and publicly available material such as the UK NHS Net Zero Carbon Standard and related material.

6. Note that HTM 07 is about to be updated – this is known as Encode and covers energy usage/efficiency.

7. Note that the NHS are about to start a programme of training for Decarbonisation across all hospitals in England/UK.

8. Include new legislation e.g.: EU – Energy Performance Directive IV, EU – Taxonomy

9. Include Roadmap studies NL for Hospital Buildings achieving Net Zero in 2050

Planning

- Jan 2024 => TC 9.6 to review and approve new scope at Chicago meeting in Jan 2024.
- Jan => draft updates, list of required permissions and list of case studies
- Feb-March => finalize content
- Apr-May => finalize lay-out and permissions
- Jun => submit GB to reviewers or for vote
- Jun => formal vote TC 9.6
- Sept 2024 => address comments finalize GB
- Oct 2024 => submit GB to ASHRAE Publication
- Jan 2025 => Publication of Guidebook => ASHRAE Winter Conference

Background and content of Guidebook

Next step (ASHRAE-)REHVA(-TVVL) Guidebook

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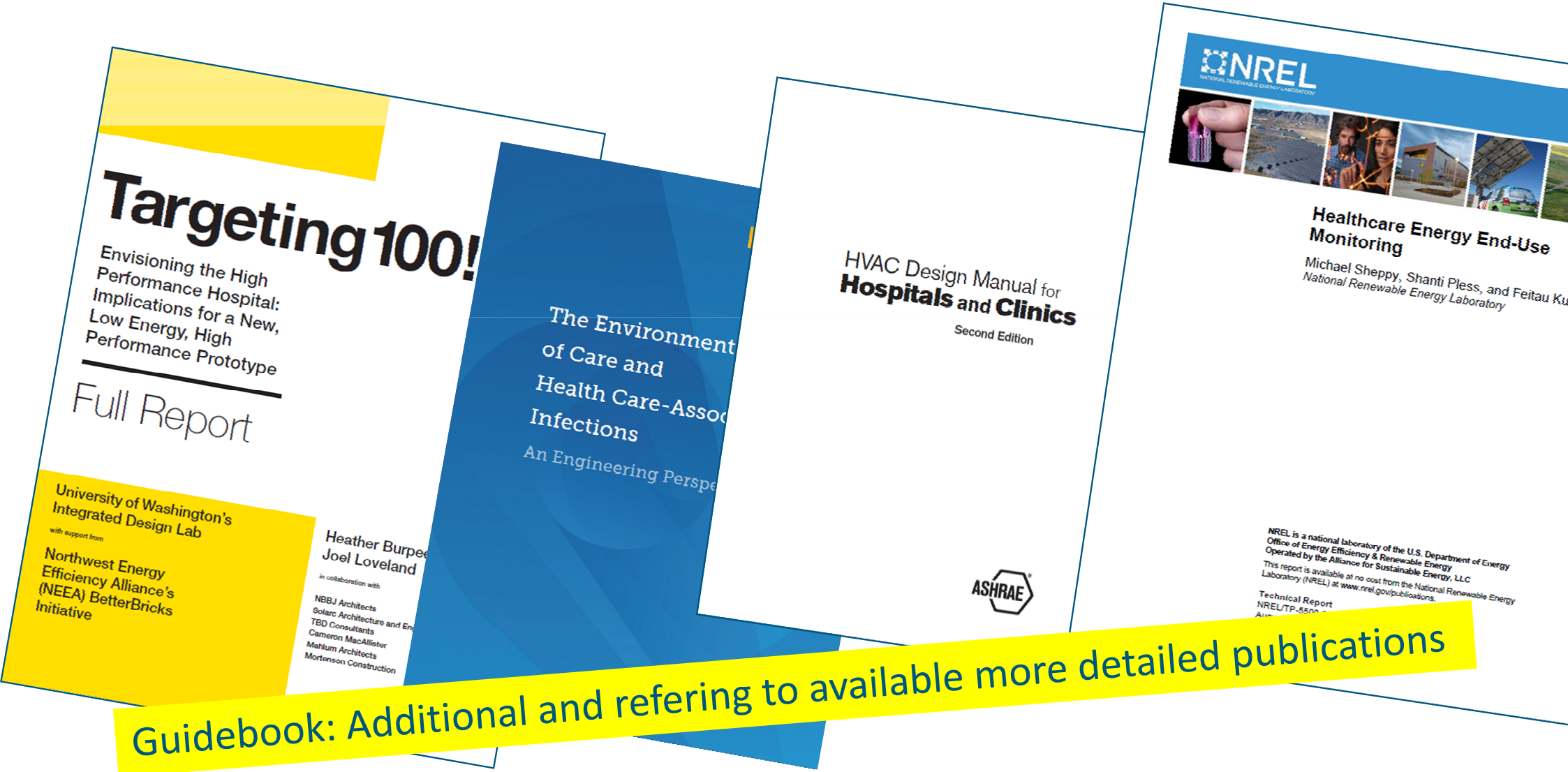

Guidebook: Additional and refering to available more detailed publications

MISSION :

Net Zero

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WHAT?

- ashrae rehva guidebook nzeb hospital buildings
- 50 pages
- 50% practice / evidence
- reference is made to other guidebooks on detailed engineering
- focus on approach, method, risk management and quantification benefits (not only cost reduction but improvement of primary process)

Realizing a positive attitude to CO2 emissions reduction in hospitals and creating "can do" mind set using a pragmatic approach, method, measures and evidence to realize CO2 emission reduction in new Hospital Buildings.

Considering future hospital operation and challenging the standards and design requirements.

Providing academic evidence and real examples.

positive attitude

"can do" mind set

pragmatic approach

future hospital operation

challenging the standards

academic evidence

real examples.

Questions to be answered

- where do we stand with NZE hospital building design ?
- what approach and methods can be used to realize NZE hospital ?
- what requirements and standards are in place and need to be challenged ?
- what are major opportunities ?
- what are key research/development topics ?
- what examples indicate the relevance of this (effective hospital building design)
- Don’ts! No gas?

Taskforce and reviewers

REHVA TRC Taskforce

- Wim Maassen – TVVL
- Frank Mills - CIBSE
- Jarek Kurnitski – EKVU
- Hans Besselink – TVVL

REHVA TRC Reviewers

- Livio Mazzarella – AiCARR
- Hywel Davies – CIBSE
- Jaap Hogeling – TVVL

ASHRAE TC 9.6 Taskforce

- David Eldridge
- Travis English
- Maya Salabasheva
- Heather Burpee
- Frank Mills
- Wim Maassen

ASHRAE TC 9.6 Reviewers

- David Schurk
- Paul Ninomura
- Amit Bhansali

Authors

- Travis English - Kaiser Permanente (US) - Author
- Maya Salabasheva - Kaiser Permanente (US) - Author
- Heather Burpee - University of Washington (US) - Author
- Kishor Khankari - AnSight LLC (US) - Author
- Frank Mills - Low Carbon Design Consultants (UK) – Chief Editor 2/Author
- Wim Zeiler – TU/e (NL) – Author
- Walt Vernon – Mazzetti + GBA (US) - Author
- Birol Kilkis, Baskent University (TR) - Author
- Wim Maassen – Royal HaskoningDHV, TU/e (NL) – Chief Editor 1/Author

Seminar 'Ziekenhuizen op weg naar energieneutraal!'

vrijdag 30 november 2018 van 14:00 uur tot 19:00 uur | OWC Erasmus MC | Bijeenkomst, Landelijk, Derden

Programma

14.00 uur	Ontvangst met koffie en thee
14.30 uur	Welkom door Marije Hulshof en Erasmus Medisch Centrum
14.35 uur	'Duurzaamheid en energieconcepten in het Erasmus MC/Nieuwbouw' door Arjan Windhorst
15.05 uur	'Ziekenhuizen: Wakker worden! De BENG-eisen komen eraan' door Wim Maassen
15.35 uur	Pauze
15.50 uur	'Towards net-zero hospitals in the UK' by Frank Mills
16.20 uur	'The hope and possibility of net-zero hospitals in the US regulatory context' by Travis English
16.50 uur	Forum discussion (Arjan, Frank, Travis, Wim)
17.10 uur	Netwerkborrel
17.45 uur	*(onder voorbehoud) Rondleiding nieuwbouw Erasmus MC*

Do No Harm

TVVL Platform voor mens en techniek

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TU/e Technische Universiteit Eindhoven University of Technology

Seminar: Towards Energy Neutral Hospital Buildings! 120 paticipants, 10 different Hospitals

https://www.linkedin.com/feed/update/urn:li:activity:6476363043440717824

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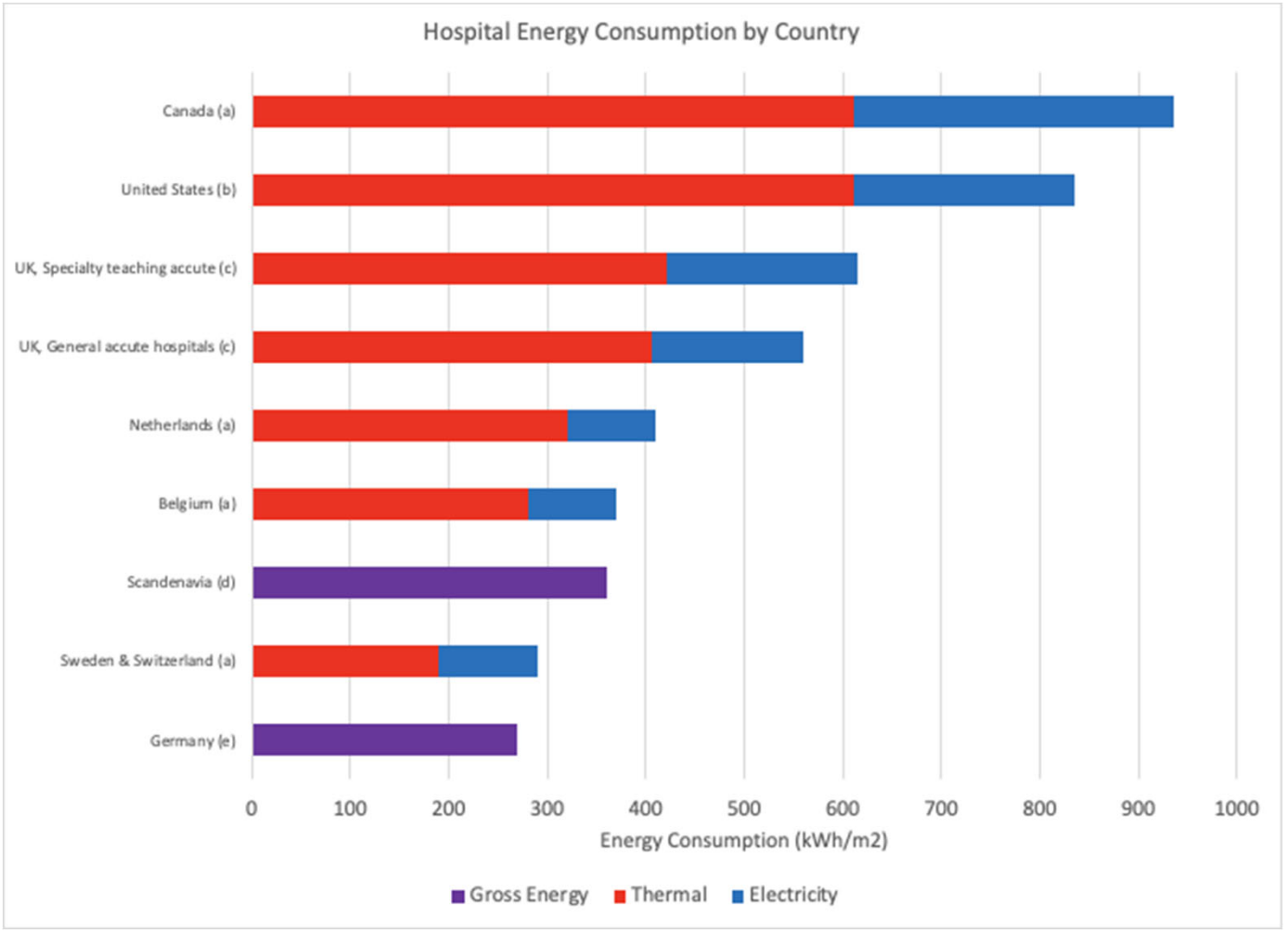
Content Guidebook

- Preface – Why Hospitals? Why Now?
- Introduction
- Approach
- Design solutions
- Commissioning
- Hospitals Moving Towards 2050
- Conclusions and Recommendations\
- References

- Appendix I – Energy Measurements and Definitions
- Appendix II – Case Studies
- Appendix III – Theoretical case

Content Guidebook

- Introduction



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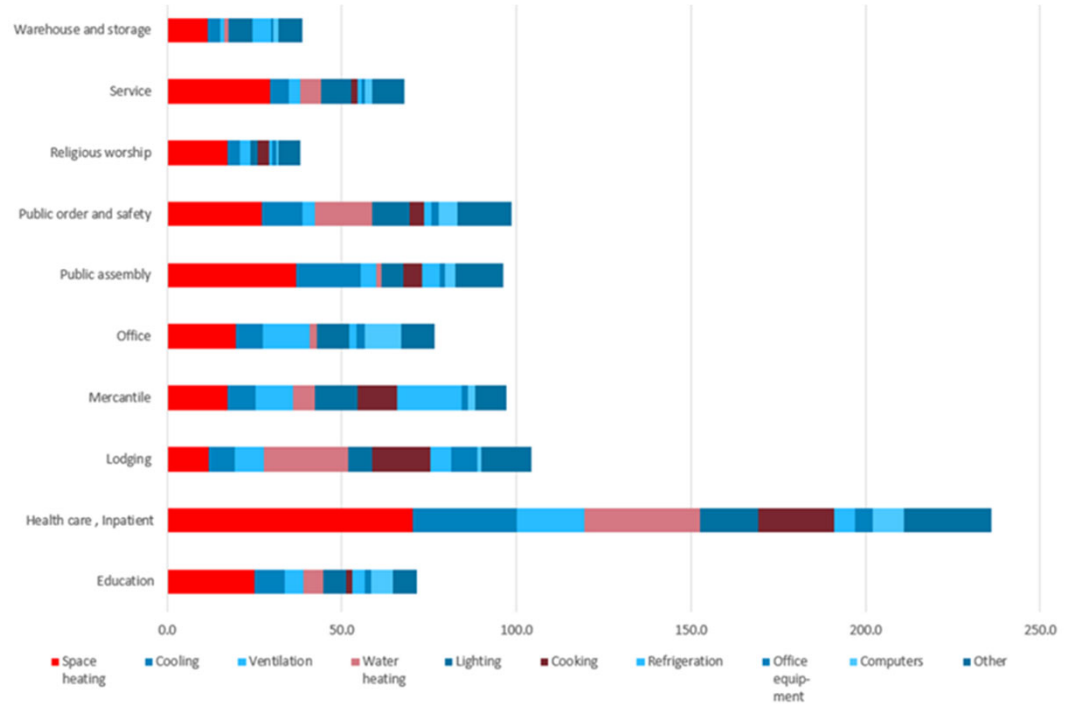

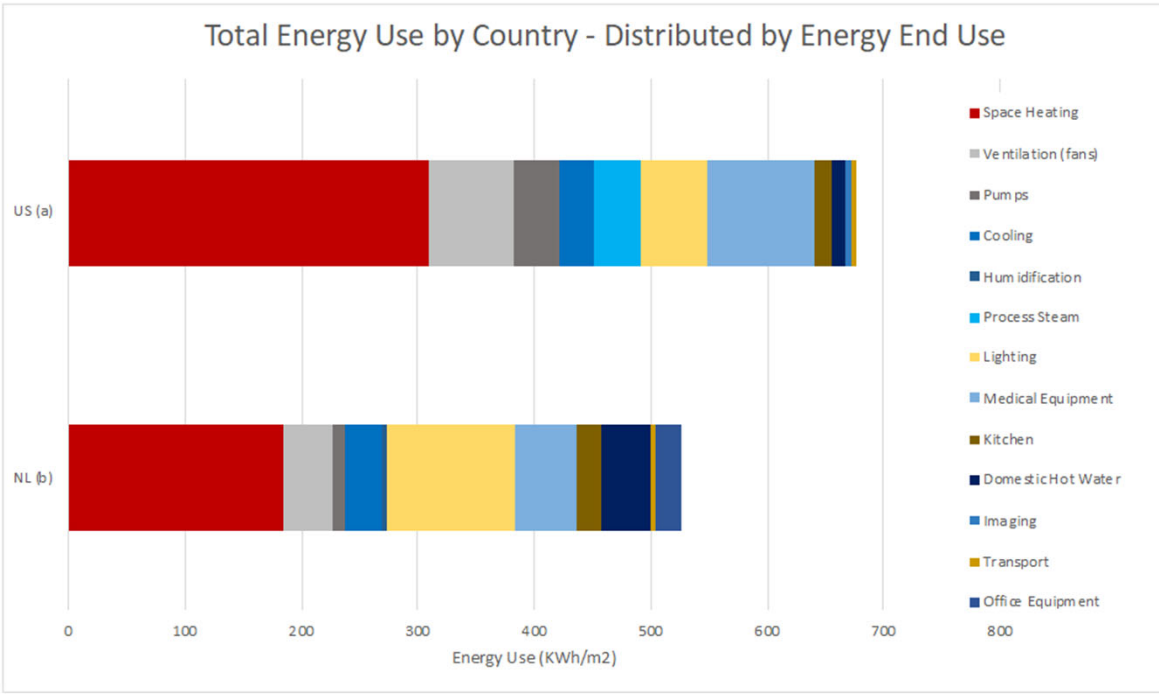

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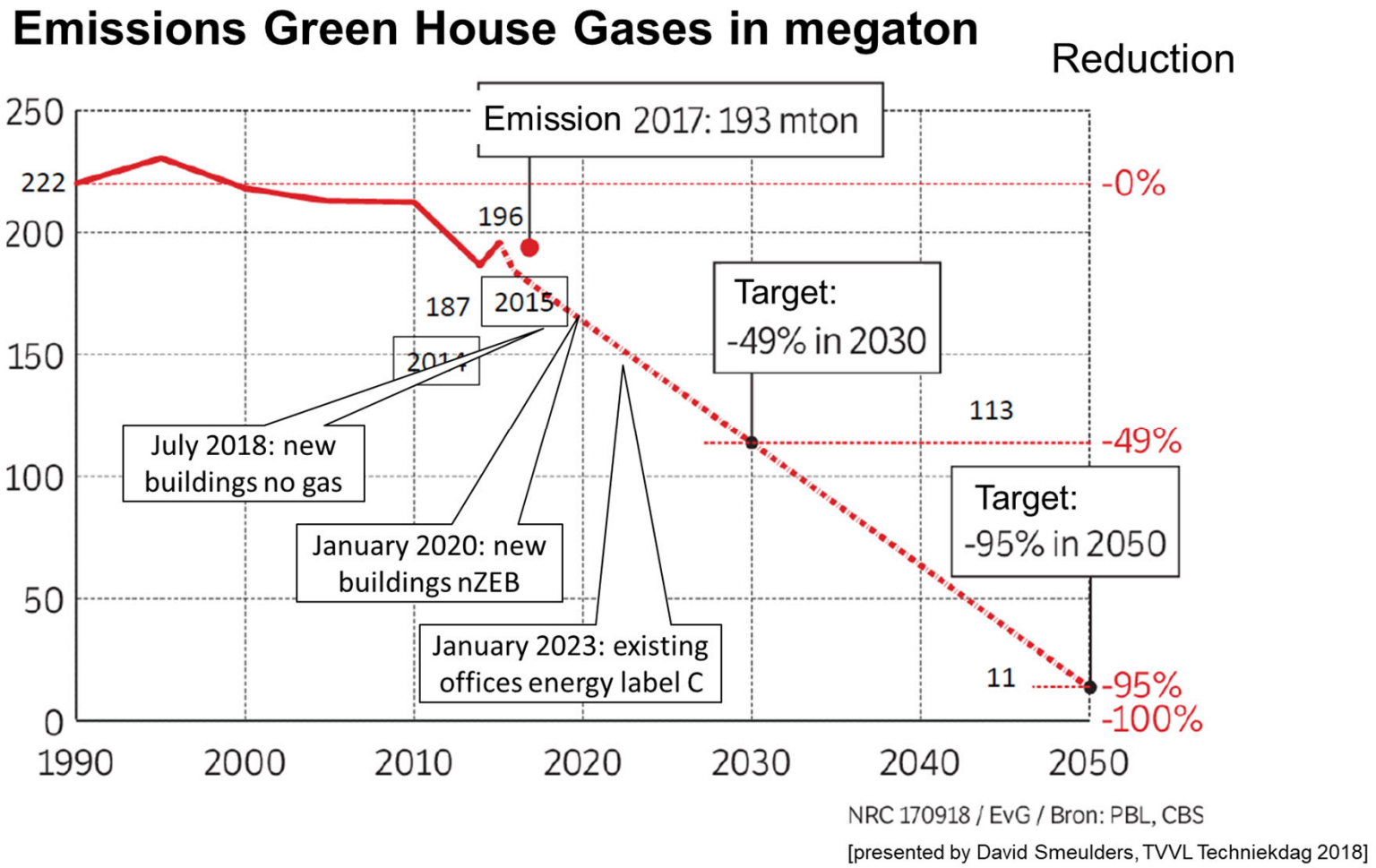

NRC 170918 / EvG / Bron: PBL, CBS

[presented by David Smeulders, TVVL Techniekdag 2018]

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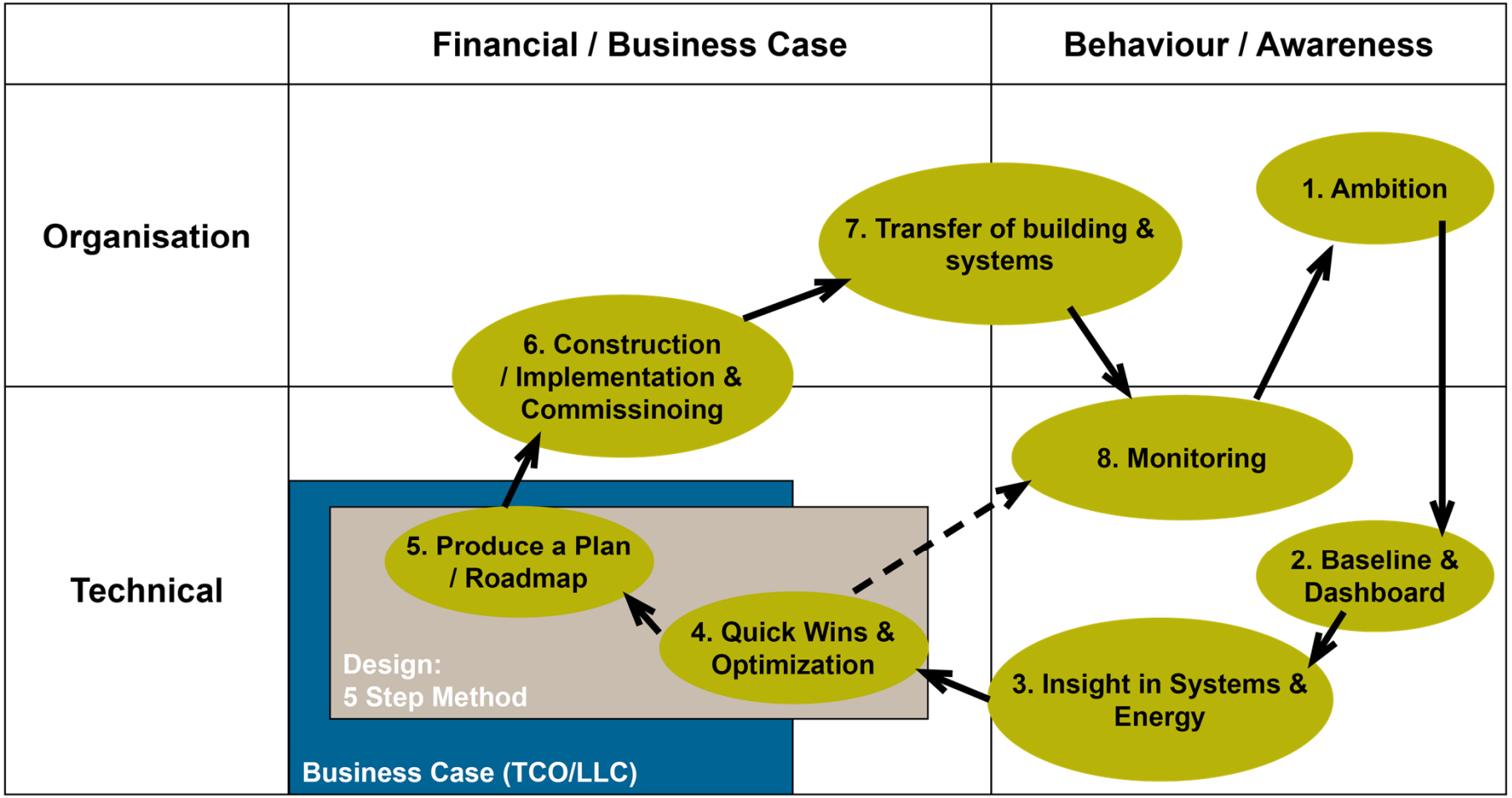
- Approach



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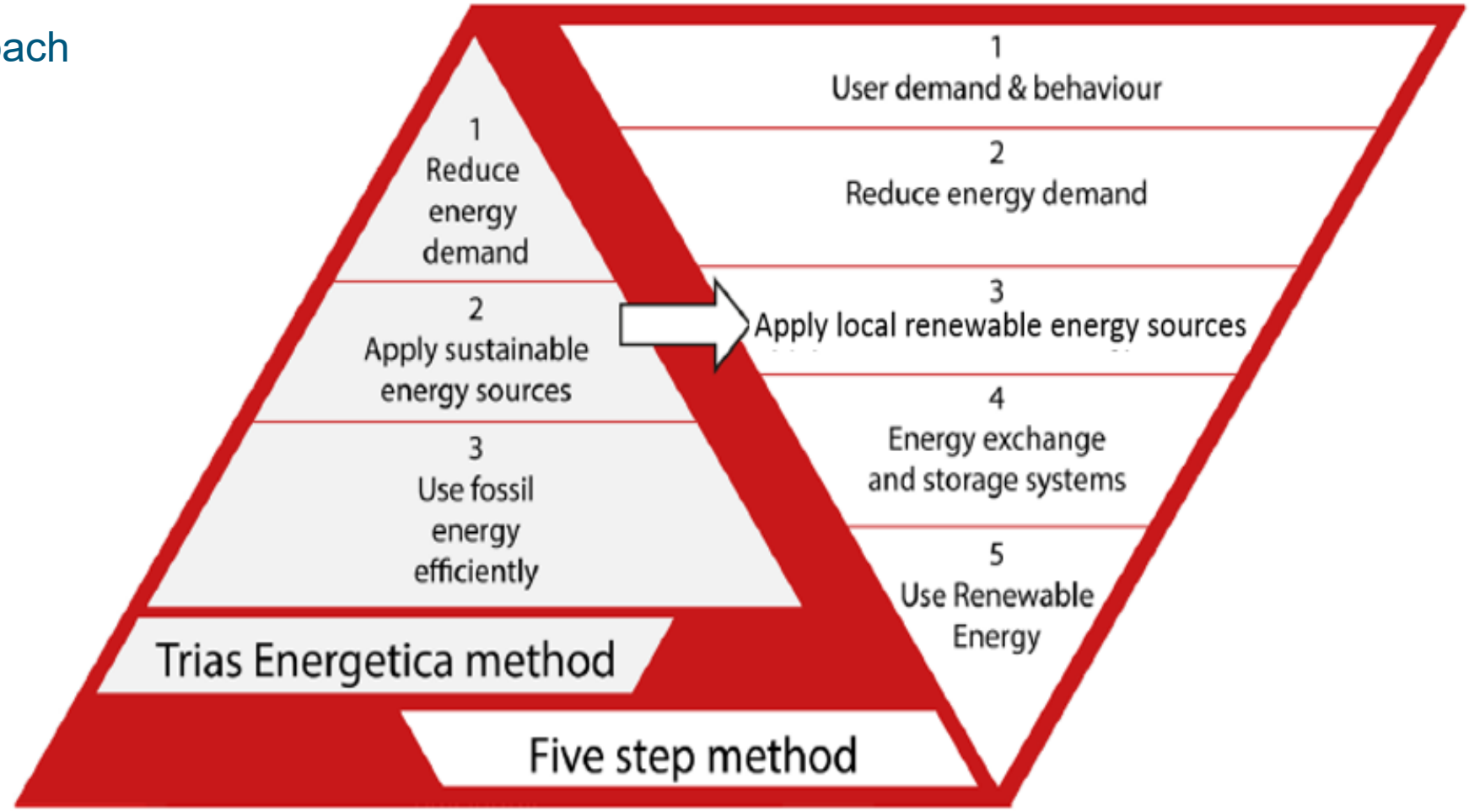

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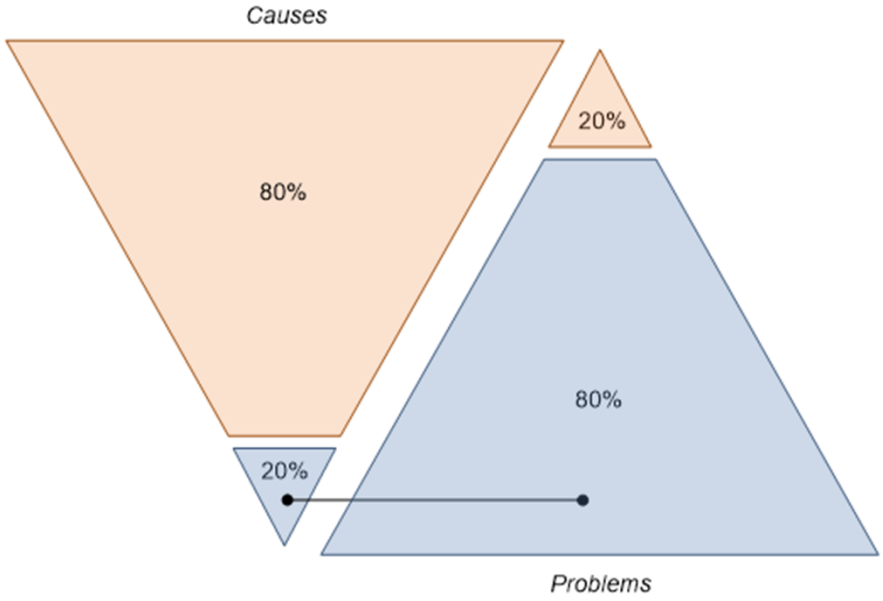

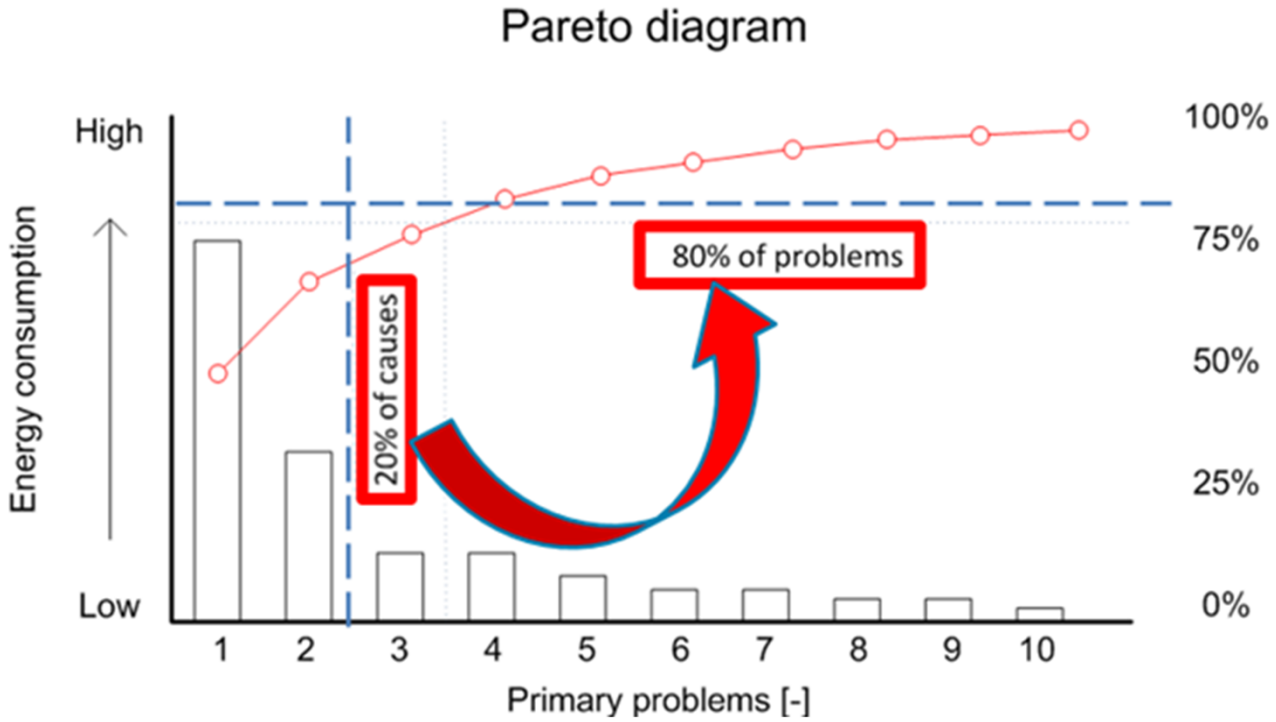

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- Design solutions

  ACR

FIGURE 5 Selected air change per hour (ach) rates over the years.[3]

	HISTORICAL AIR CHANGE RATES IN SELECTED NON-OPERATING OR ISOLATION SPACES (TOTAL ACH/OUTSIDE AIR ACH)																
	1959	1962	1964	1966	1968	1971	1974	1978	1982	1987	1991	1993	1997	2001	2006	2008	2013
RECOVERY		4	4	4	15/6	15/6	15/6	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2	6/2
NURSERY	8 to 12	12	12	12	15/5	15/5	15/5	12/5	12/5	12/5	12/5	6/2	6/2	6/2	6/2	6/2	6/2
ANESTHETIC STORAGE	2	2	–	8	8/8	8/8	8/8	8	8	8	–	8	8	8	8	8	8
PATIENT ROOM	1.5	1.5	2	4/2	4/2	4/2	2/2	2/2	2/2	4/2	–	2/1	2/2	6/2	6/2	6/2	4/2
INTENSIVE CARE	–	–	–	–	6/6	6/6	6/2	6/2	6/2	6/2	–	6/2	6/2	6/2	6/2	6/2	6/2
LDRP	–	–	–	–	–	–	–	–	–	–	4/2	2	2/2	6/2	6/2	6/2	6/2
PATIENT CORRIDOR	–	–	–	–	–	4/4	4/4	4/4	4/2	4/2	4/2	2	2	2	2	2	2
X-RAY D&T	–	6	6	10	6/6	6/6	6/6	6/2	6/2	6/2	6/2	6	6	6	6	6/2	6/2
EXAM	–	4	4	4	12/6	12/6	12/6	6/2	6/2	6/2	6/2	6	6	6	6	6/2	6/2
MED ROOM	–	–	–	–	–	–	–	4/2	4/2	4/2	4/2	4	4	4	4	4/2	4/2
TREATMENT	4	4	4	12/6	12/6	12/6	6/2	6/2	6/2	6/2		6	6	6	6	6/2	6/2
PHYSICAL THERAPY	–	–	–	–	4/4	4/4	4/4	6/2	6/2	6/2	6/2	6	6	6	6	6/2	6/2
SOILED HOLDING	–	3	3	4	12/4	12/4	12/4	10/2	10/2	10/2	10/2	10	10	10	10	6/2	6/2
CLEAN HOLDING	–	–	–	3	12/4	12/4	12/4	4/2	4/2	4/2	4/2	4	4	4	4	4/2	4/2

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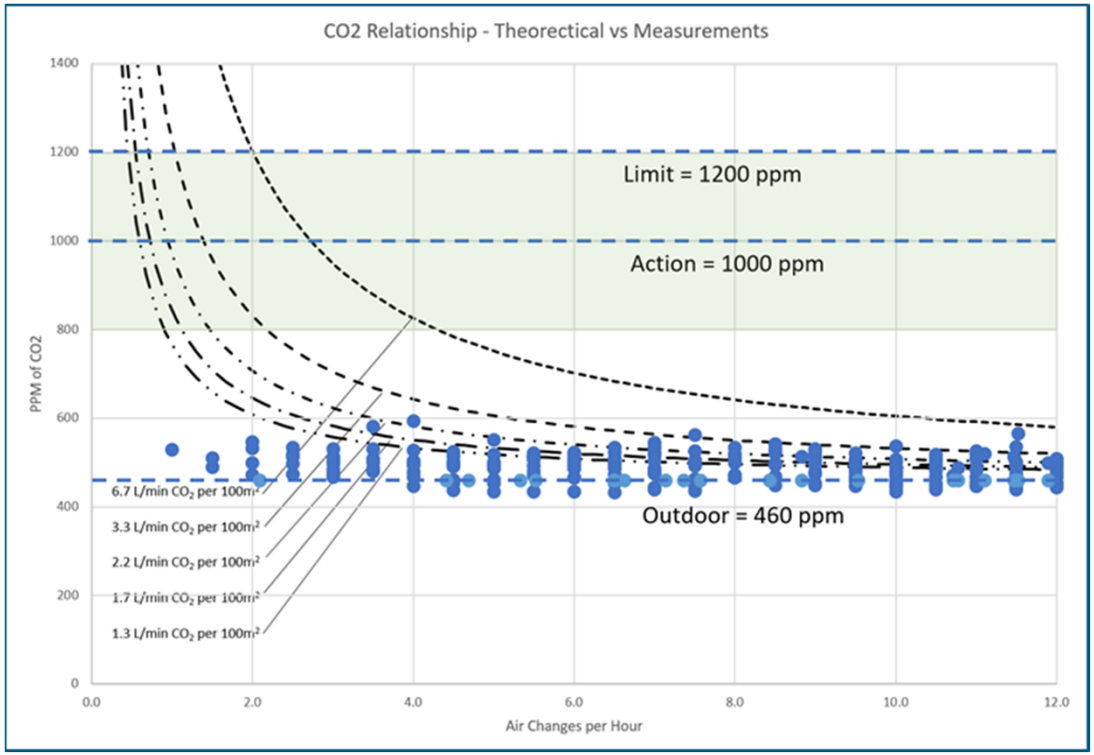
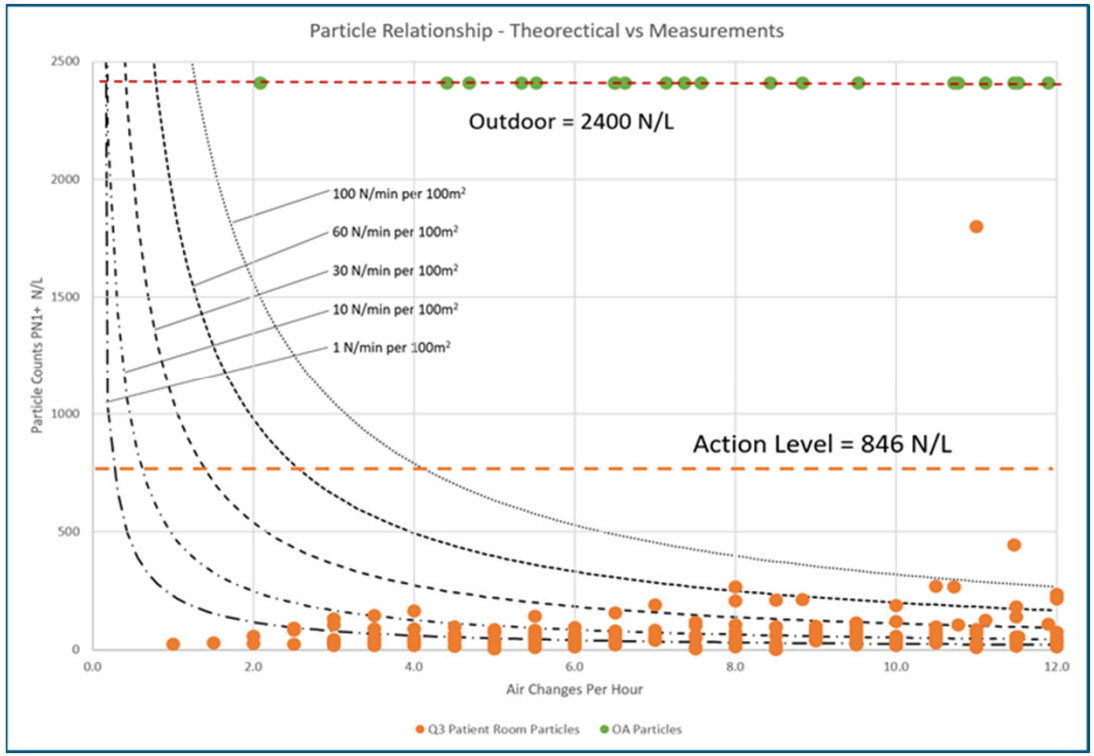
- Design solutions





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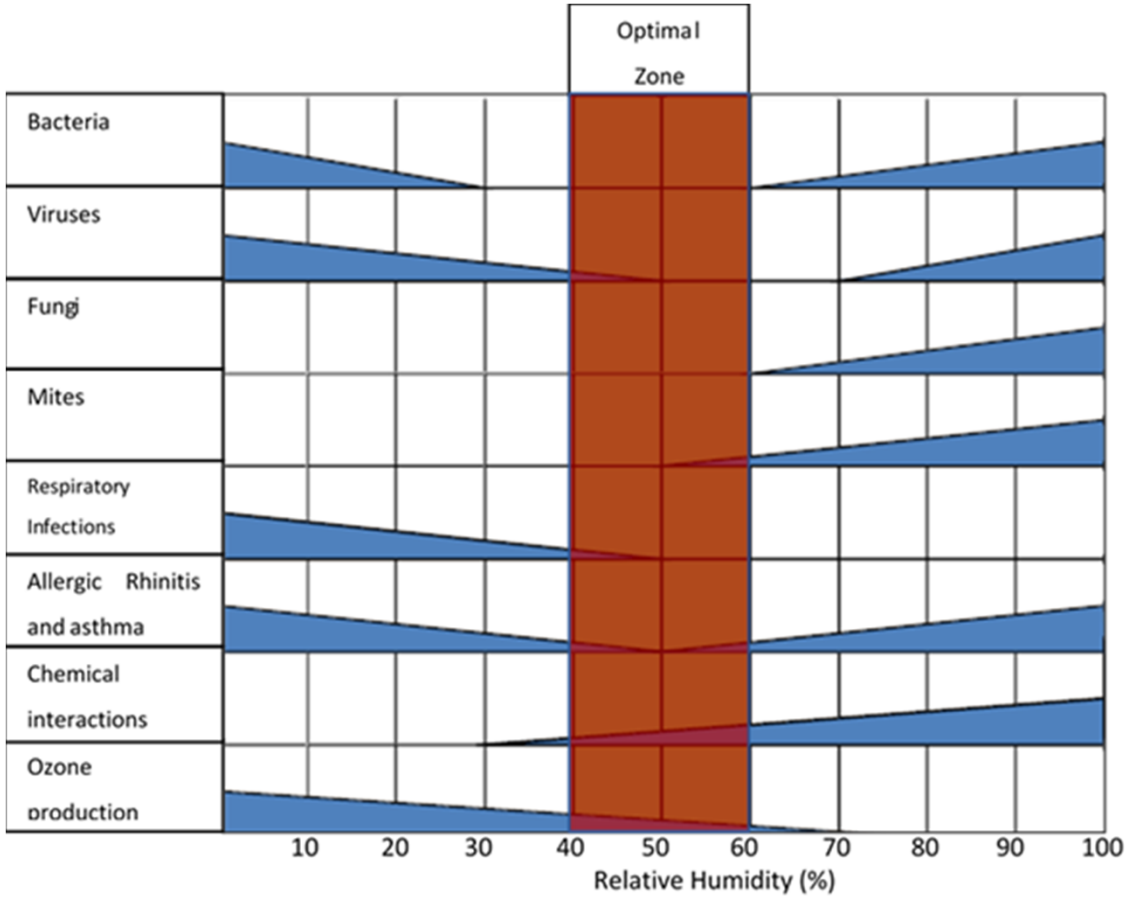
- Design solutions ➔ Relative Humidity



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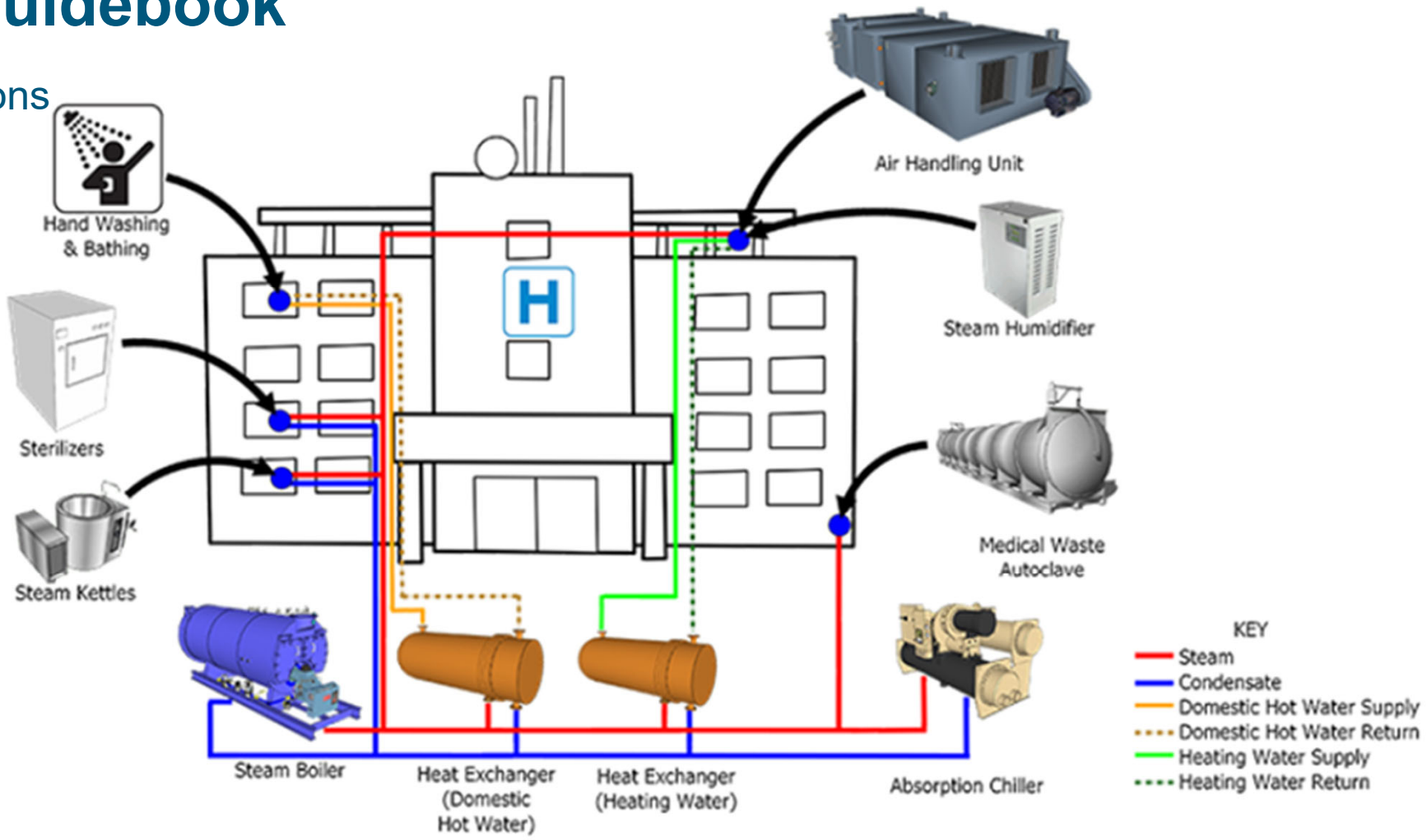
  Steam



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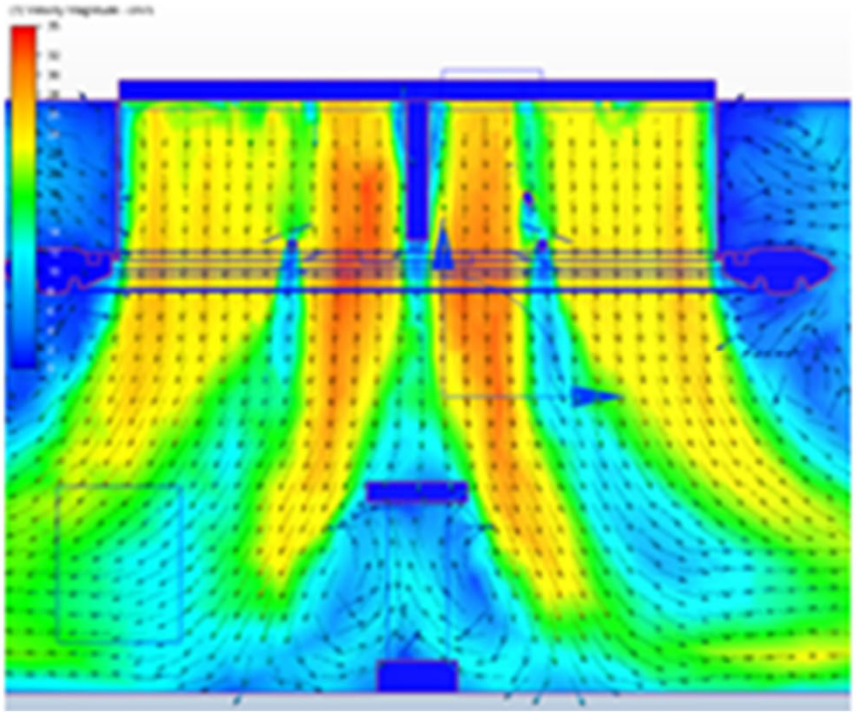
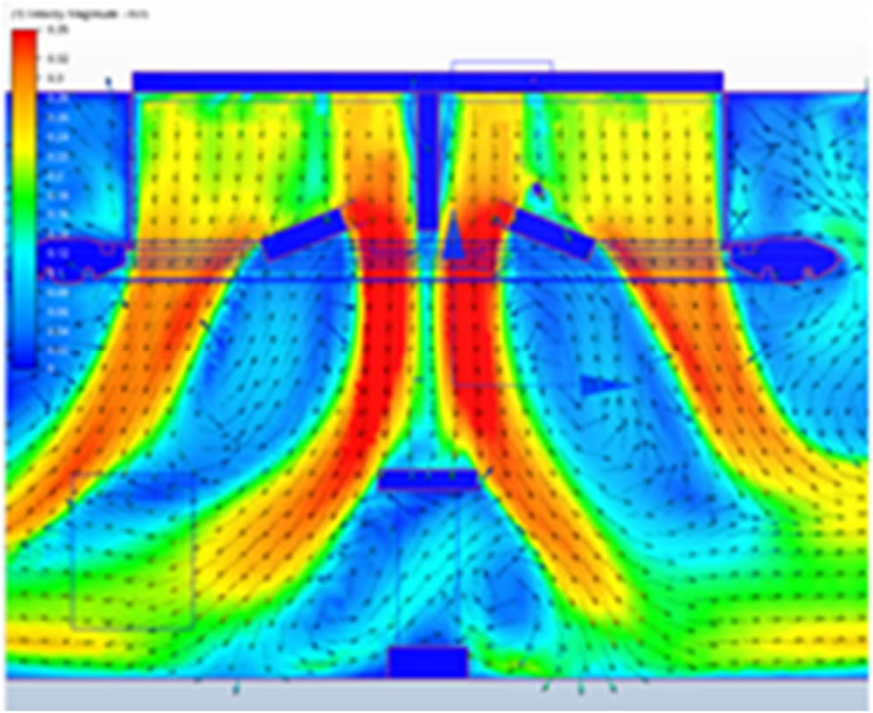
  Airflow strategies





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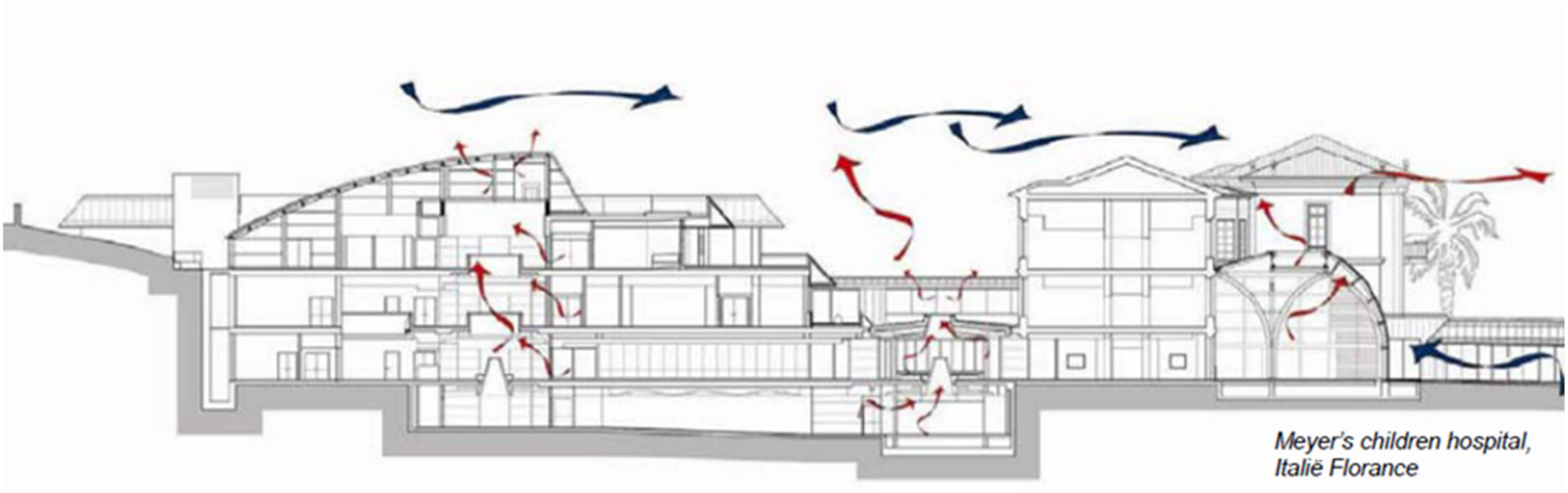
- Design solutions

  Natural ventilation



Meyer's children hospital, Italië Florance

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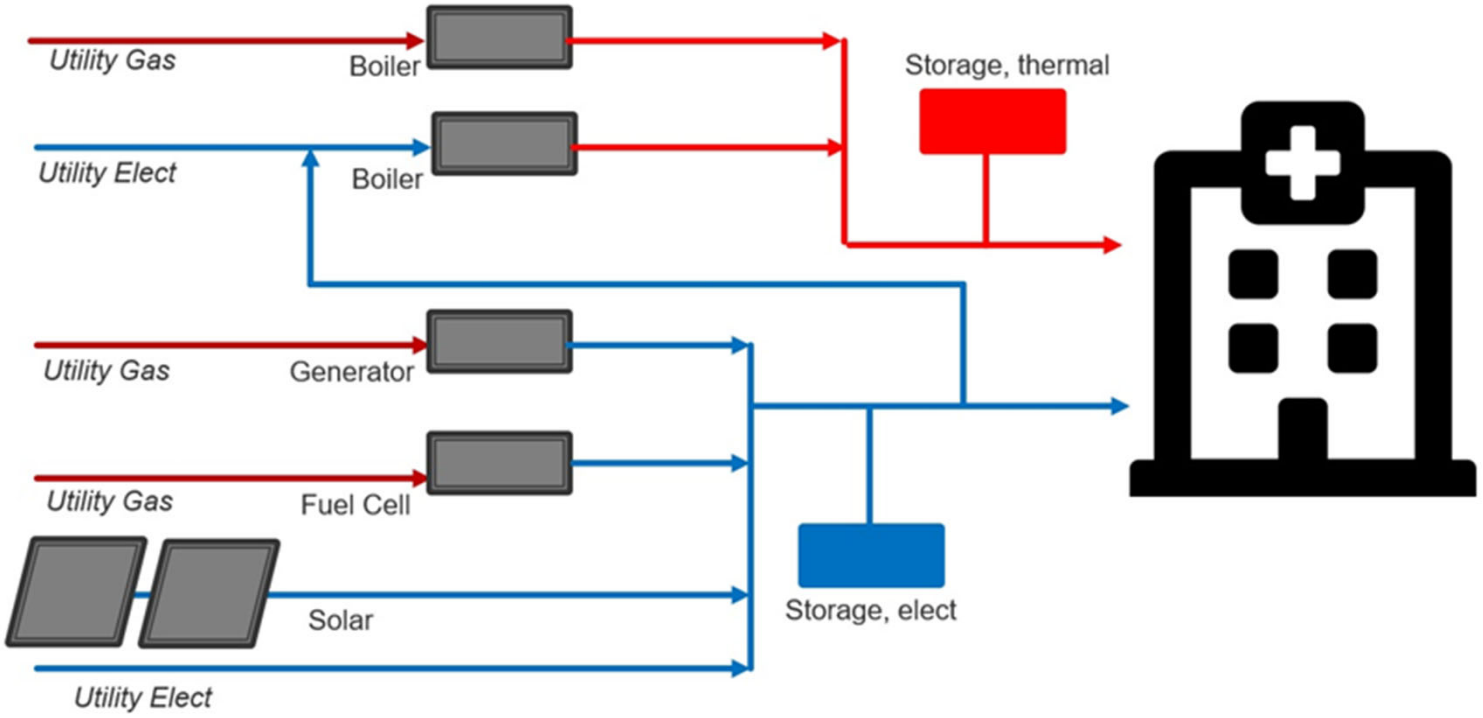
- Design solutions

  Flexibility – ”PROSUMAGERS”



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- Design solutions Summary

Step	Measures
1. User demand & Behaviour	Lower internal heat loads (more use of stand by mode), **smart zoning of the building**, smart positioning of building functions, **smart and individual control systems** (human in the loop, SR ventilation), low flow fume hoods, low energy consuming MRI, combining processes/equipment/test set ups, education of users
2. Reduce Energy Demand	Insulation, envelope airtightness, heat recovery ventilation/hot tapwater, use daylight, thermal mass, positioning of functions and integral design to make application of technologies possible e.g. natural/hybrid ventilation of wards, better Air Handling Units, larger ducts to reduce ventilation energy, variable air flow systems (**airflow management**), LED lighting, Less heating and cooling (change standards), energy efficient appliances, less or no humidification (clay products for dehumidification in ceilings), use **BMS and monitoring** to reduce energy consumption and to show and guarantee that systems perform as they should, less tap water stations with hot water supply.
3. Apply Sustainable & Energy Sources	Photovoltaic solar cells, biomass, wind energy, adiabatic cooling
4. Energy Exchange & Storage	Long term energy storage in the soil/acquifer (LTES), short term energy storage (buffers, Phase Change Materials), Concrete Core Activation (TABS), Exchange energy between internal/external functions
5. Efficient use of fossil energy	High efficient boilers, chillers, heat pumps, cogeneration of heat and power

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- Appendix II – Case Studies

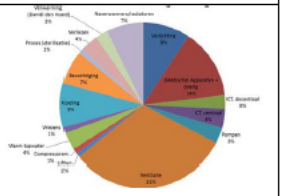
Example of Case Study

New Erasmus MC, Rotterdam, Netherlands	
Designers: Architect Structural design HVAC Energy consultant Electrical and automation	architect: EGM struc: Aronsohn building services (MEP): Royal HaskoningDHV building physics: Peutz in care programming of health organisations: pieterse terwel grevink Architect Landscape: Juurlink + Geluk
Construction year	2017
Photo or illustration	
Project description	University Medical Center Production facilities: 12 radiotherapy bunkers, 22 OR's of which 1 brachy and 2 hybrid, 4 intervention rooms, 15.000 sqm laboratories Treatment capacity: 522 Medium Care beds, 38 IC-boxes, 18 ICCU-boxes, 8 PACU-boxes, 10 Observatory units, 94 day care units, 18 Dialysis units, 5 Pheresis units Ordering principles: Patient first, Identity and human scale, Support of the professional, Efficient hospital management.

Project Phase	Initiative	Design	Construction	Realized	>3 years operation
				X	

Building address	

Building type	University Hospital	District/Community Hospital	Specialist Hospital		Existing	New	Renovated
	X					X	

	Hospital Building - with hospital functions: outpatient/inpatient-beds, surgery, etc.				
Building size:	207,000 m2 (?? SF)	Number of beds:	522 (medium care)		
Building functions	Healthcare with bed	Healthcare without bed	Offices	Teaching	General (hallways, ...)
	21 %	53 %	26 %		
Step 1: Match user Demand and Behaviour	Standby option for Operating Room, Pneumatic tube delivery system				
Step 2: Reduce energy demand Specific features of building envelope and architectural concept	High R-values for the façade (2.5 m².K/W), roof (3.5 m².K/W) and floors (4.0 m².K/W), Green roofs and roof gardens, Sun blinds				
Step 2: Building service systems	Heat Recovery in Air Handling Units, Concrete core activation, Low- and high-temperature distribution systems, Building Management Systems with smart energy meters, Pharmafilter				
Step 3: Apply local renewable energy sources					
Step 4: Energy exchange and storage systems	Aquifer Thermal Energy Storage system				
Step 5: Use fossil fuel efficiently	District heating 70/40				
Delivered energy use (simulated), including both regulated and not regulated energy uses, kWh/m²a	Heating (space heating and ventilation air)	61 kWh/m²a			
	Hot water	7 kWh/m²a			
	Fans and pumps	53 kWh/m²a			
	Cooling	7 kWh/m²a			
	Lighting	62 kWh/m²a			
	Appliances and medical equipment	kWh/m²a			
	Total delivered energy				
Delivered energy use (measured)	Total delivered energy (measured)	kWh/m²a			
Energy uses not included in the delivered energy		N/A			
Exported energy, kWh/m²a		N/A			
Primary energy, kWh/m²a	Natural Gas (PEF=1.0)	85 kWh/m²a	Natural gas 9.65 m3/m2 per year = 84.8 kWh/m2 per year		
	Electricity (PEF=2.56)	489 kWh/m²a	Electricity 191 kWh-e/m2 per year		
	Heat (PEF= 0.9)	77 kWh/m²a	Heating 0.31 GJth/m2 per year = 86.1 kWhth/m2 per year		
	Total	651 kWh/m²a	The energy consumption of the existing part of the Hospital Dijkzigt (1961) = 666 kWh/m²a (gas= 60; elec= 433; heat= 173)		
	Primary energy (del. - exported)	0 kWh/m²a	nZEB minimum requirement for office buildings 100 kWh/m² primary energy		

Renewable energy ratio	0 % of energy need		
Improvement compared to national requirements	5,4 %	Compared to	NL EPC 2006
Construction cost	??? M€ (??? €/m²)		
Additional cost of nZEB /Energy Measures	??? €/m² estimated		
Business case	Building qualities: Safety first, Healing is leading, Sustainable is cheaper in the end.		
www link	https://www6.erasmusmc.nl/nieuwbouw/?lang=en		
References	Presentation Arjen Windhorst (Erasmus MC), TVVL-Royal HaskoningDHV-TU/e Seminar Towards Zero Energy Hospital Buildings d.d. November 30th Rotterdam (Erasmus MC) see https://www.tvvl.nl/l/library/download/urn:uuid:6d424c36-99a4-4bbe-a022-5b21ce05eeca/arjan+windhorst+-+seminar+ziekenhuizen+op+weg+naar+energieneutraal+-+181130.pdf?format=save_to_disk&ext=.pdf		

Examples of measures according 5 step method:

Step	Measures
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Content Guidebook - Recommendations

- Great opportunities to reduce CO2 emissions => pick low hanging fruits using 5 step method and knowledge and experience other building types e.g. offices
- Design starting with considering the human/users and the processes
- Reduce and manage internal heat loads
- Challenge standards and regulations because sometime lacks scientific evidence
- Simultaneous improve primary process and energy efficiency

Thank you!

More information:
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