Energy Sufficiency in (strongly intertwined) Building and City Design. Examples for temperate and mediterranean climates.

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- Director of Master RIDEF (Renewable, Efficiency, Energy Planning) www.ridef2.com
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www.eerg.it

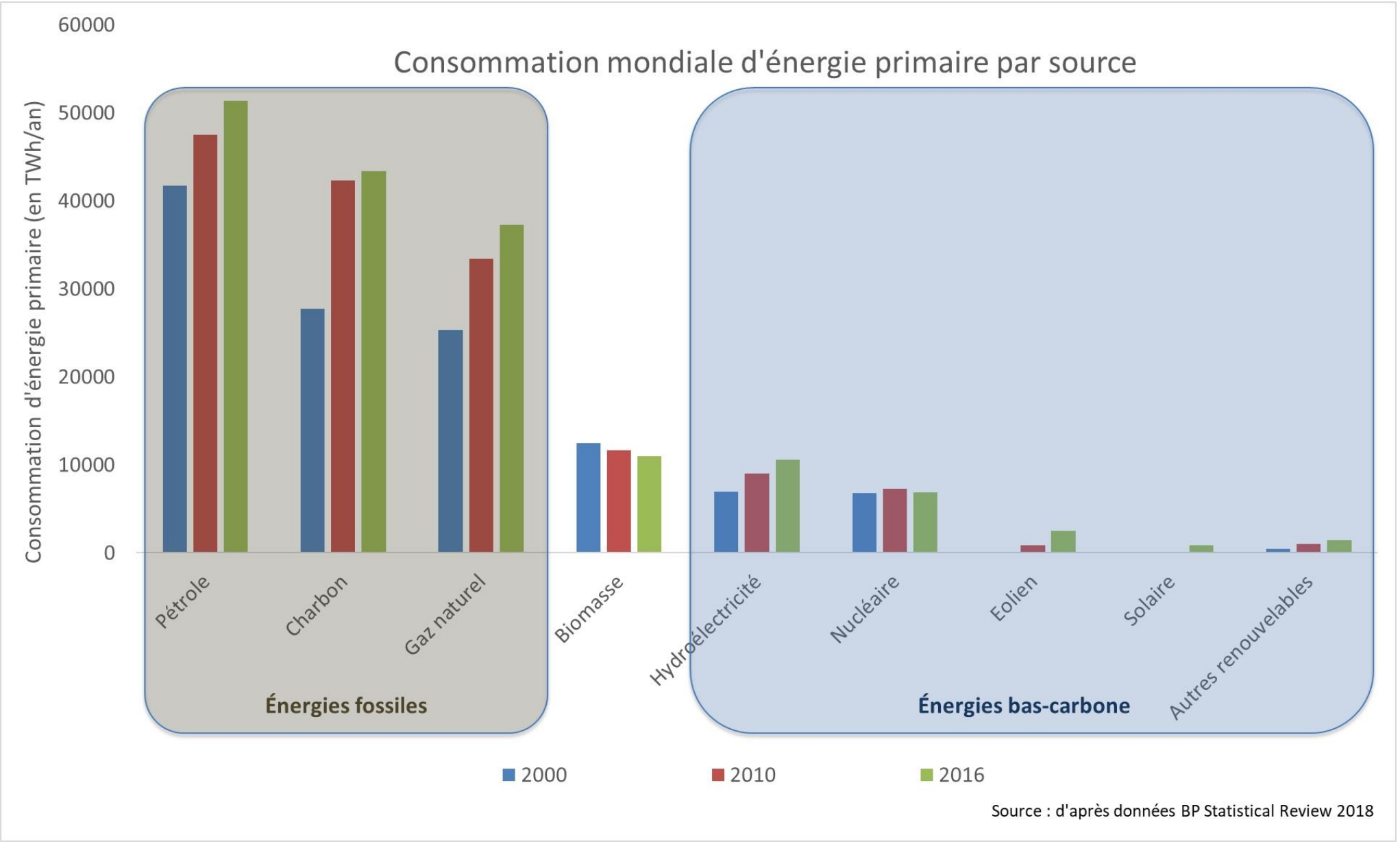
https://azeb.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 754174

2 Thesis and 1 question:

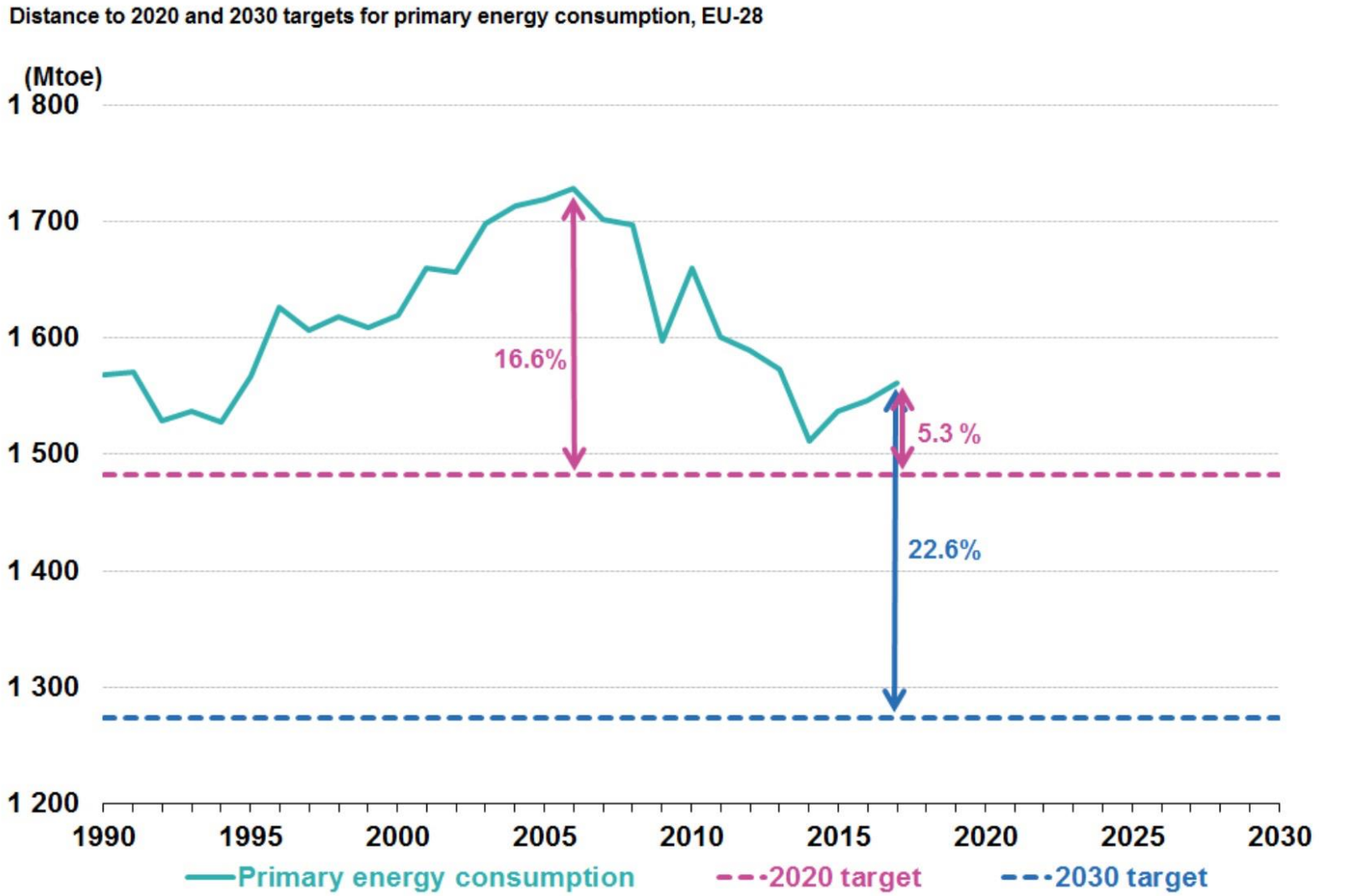
- Sufficiency (efficiency) actions by individuals are possible ONLY if options / infrastructures / legal frameworks for those actions are created by a collective choices
- Sufficiency (efficiency) actions in buildings are strongly connected with enabling/hindering conditions in cities
- Boundary condition tell us we must use energy sufficiency: would it turn out to be a pleasure?

Context 1: We are ADDING energy use, rather than substituting fossil



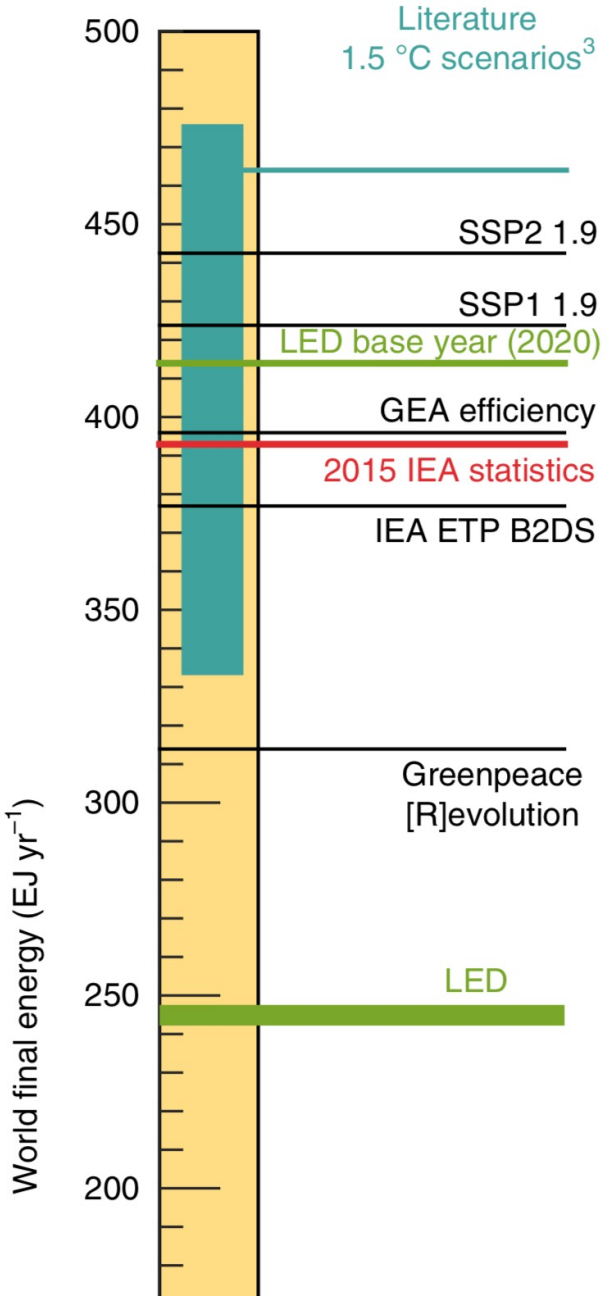
Jackson, R. B., Le Quéré, C., et Al(2018). Global energy growth is outpacing decarbonization. *Environmental Research Letters*, *13*(12), 120401. https://doi.org/10.1088/1748-9326/aaf303

IEA 2019: since 2000, the rate of electricity demand in buildings increased 5-times faster than improvements in the carbon intensity of the power sector.



Is this *TOTAL primary* or *NON-RENEWABLE primary*?

May EU Directives and documents use the precise and standadised concept and language of (EN ISO 5200)?



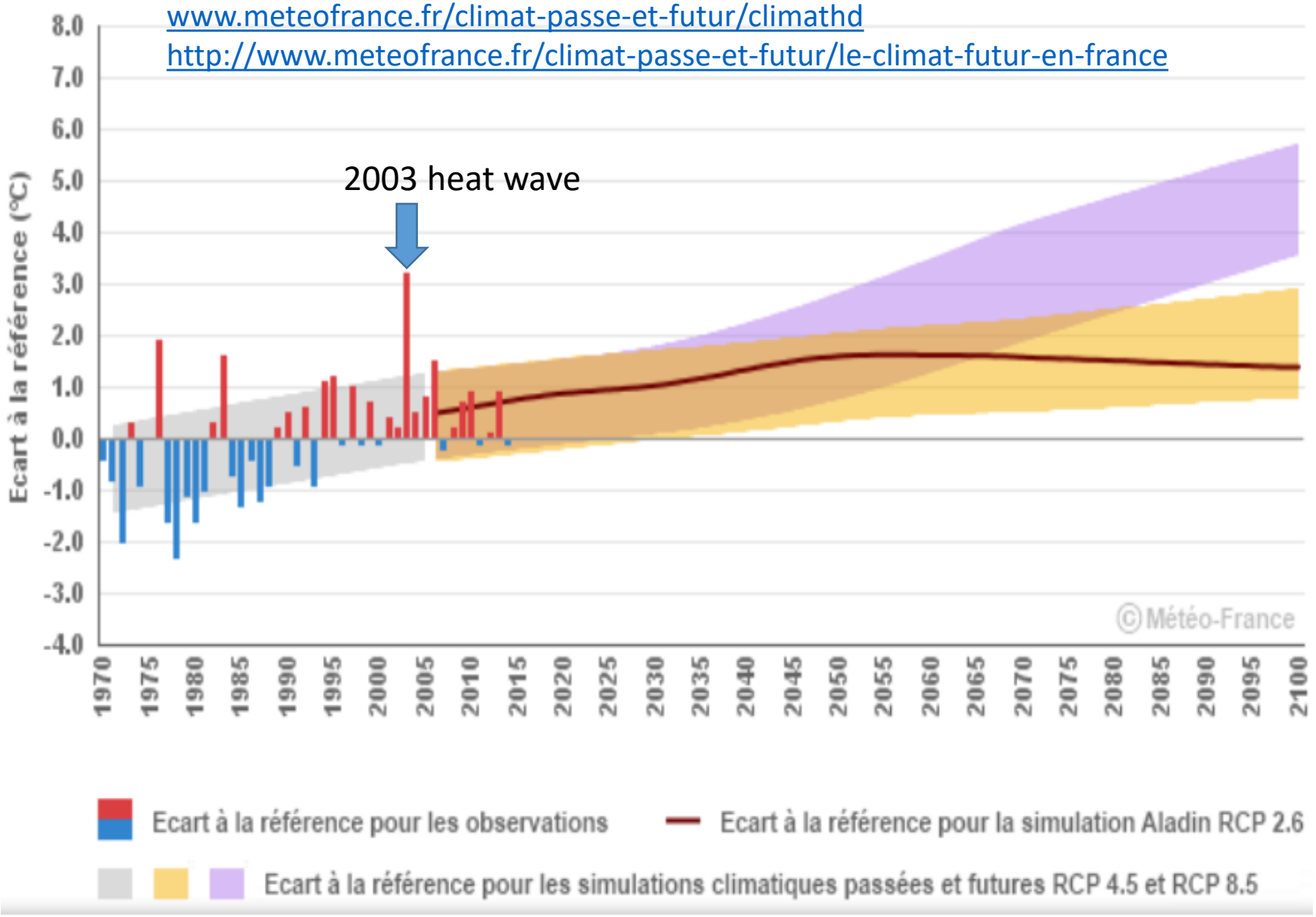
- A scenario for -40% final energy use by 2050 compared to today, at world level
- (EU has do -80%?)

- Grubler, A., Wilson, C., Bento, N., Boza-Kiss, B., Krey, V., McCollum, D. L., … Valin, H. (2018). A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies. *Nature Energy*, *3*(6), 515–527. https://doi.org/10.1038/s41560-018-0172-6

- Wilson, C., Grubler, A., Gallagher, K. S., & Nemet, G. F. (2012). Marginalization of end-use technologies in energy innovation for climate protection. *Nature Climate Change*, *2*(11), 780–788. https://doi.org/10.1038/nclimate1576

Context 2: Summer extreme temperatures are a serious reality (Paris, Isle de France case)

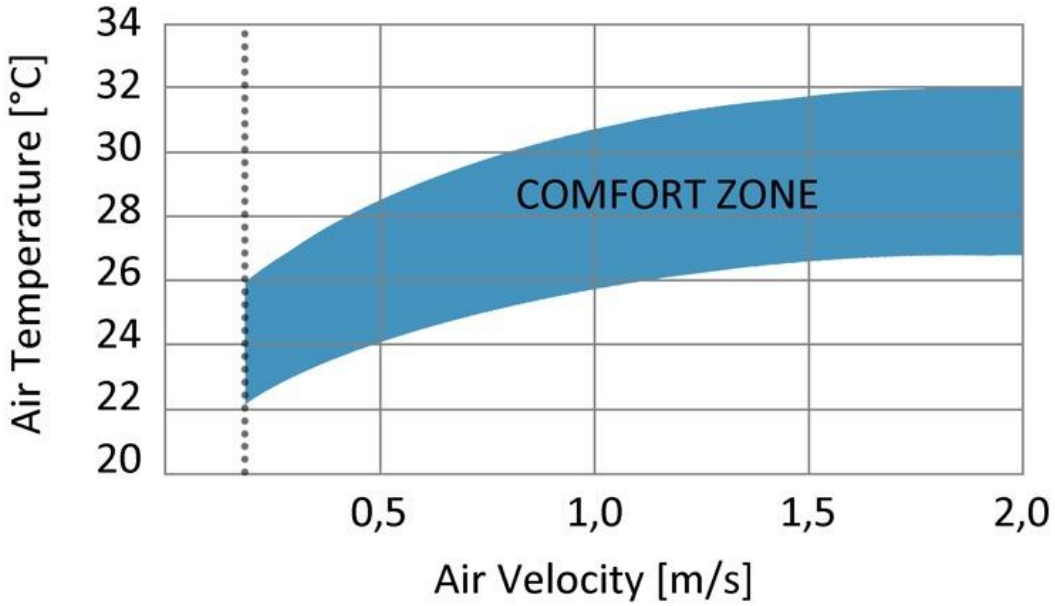
www.meteofrance.fr/climat-passe-et-futur/climathd
http://www.meteofrance.fr/climat-passe-et-futur/le-climat-futur-en-france

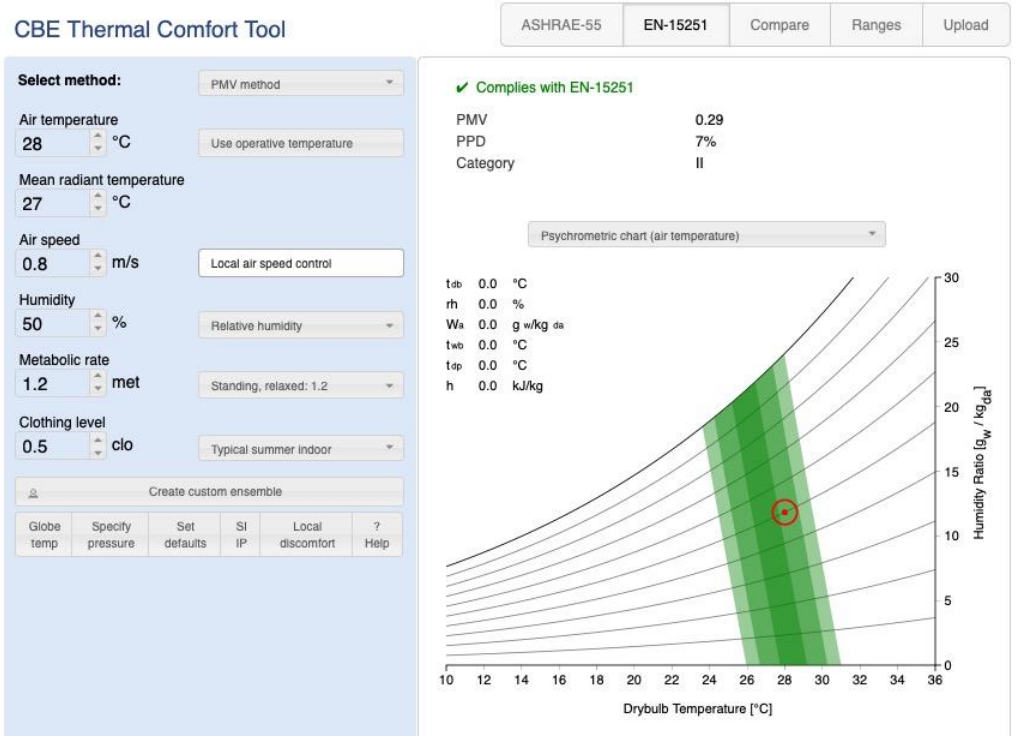


- J. Guiot, (CNRS Climate Laboratory, interview FanceInter 31 October 2016): "Heat waves like the one of 2003 (20 000 deaths in Italy)
- could occur every 5 years in the most favorable scenario and every year in the scenario more unfavorable "

Sufficiency actions in Building →	**Summer night ventilation + ceiling fans** (vs. Air Conditioning)	**Summer night ventilation (vs. Air Conditioning)**	**Adequate m2 per capita floor space**	**Adopt "sufficient" mobility modes: bicycle, walk, public transport**	**Line drying and water / hot water saving**
In order to perform sufficiency actions, **inhabitants would need:** →	**Silence at night, clean air**	**External air temperature < 20°C at night**	**Pleasant common indoor/outdoor spaces** to reduce need for individual volumes	Easy access to services, schools, work, Independence for children and elders	**Well designed spaces for line-drying, Water saving devices**
Presently Cities create **constraints**: →	noise, mainly from cars and motorcycles. PM10, PM2,5 pollution and other air contaminants	asphalt, city canyons	inhospitable districts, obligation for car parking spaces at buildings, free car parking on streets	distance between functions, unacceptable risks for cyclists, pedestrians, handicapped	Dust in air
Cities should offer **potentialities:** →	**Car-free residential districts**, zones at 20 or 30 km/h	white/cool surfaces. Geometries facilitating air movement. Water surfaces	**walkable, cyclabile districts, green spaces, spaces for playing, spaces in the building for common activities**	**equitable access to street space, equal access to various transportation modes**	Information campaigns on water saving devices, and on the high quality of drinking water from the tap
Legislation and Regulation should address: →	Objective and **adequate temperature and humidity set-points in regulation**	**Mandatory white/cool surfaces, mandatory external solar protections** (as e.g. in Switzerland)	Minimum requirements of green spaces, of common spaces for meetings	EPBD (and National build codes): **mandatory space for bicycles… in buildings**	**Mandatory spaces for line drying, mandatory labelling of low-flow water devices**

Air movement (e.g. by ceiling fan) allows for summer comfort at relatively high temperatures, according to international Standards ASHRAE 55 2017 and EN 15251.





H. Tyler, S. Stefano, P. Alberto, C. Toby, M. Dustin, and Kyle, 2017, CBE Thermal Comfort Tool. Center for the Built Environment, University of California Berkeley, http://comfort.cbe.berkeley.edu/

ENERGY STAR Most Efficient 2018 — Ceiling Fans

Haiku K3150-X2-PW-04-03-C

- Aerodynamic design (10 times less energy use than a conventional fan, already low)
- Accurate mechanical balancing of blades ensures silent operation
- Incorporates high efficiency – high colour quality LED lighting
- Passive Infrared presence sensor turns off the fan when room unoccupied
- Remote control via smartphone

Humidity has a low effect on Comfort

(ISO 7730)

Földváry Ličina, V., Pagliano, L. et Al. (2018).

Development of the ASHRAE Global Thermal Comfort Database II. Building and Environment, 142, 502–512. https://doi.org/10.1016/j.buildenv.2018.06.022

Fig. 3. Location of the field studies contained in the ASHRAE Global Thermal Comfort Database II.

Building and Environment

2018 Best Paper Award

CBE Thermal Comfort Tool

ASHRAE-55 | EN-15251 | Compare | Ranges | Upload

CBE Thermal Comfort Tool

ASHRAE-55 | EN-15251 | Compare | Ranges | Upload

Select method: PMV method

Air temperature: 27 °C — Use operative temperature

Mean radiant temperature: 27 °C

Air speed: 0.6 m/s — Local air speed control

Humidity: 80 % — Relative humidity

Metabolic rate: 1.2 met — Standing, relaxed: 1.2

Clothing level: 0.5 clo — Typical summer indoor

Create custom ensemble

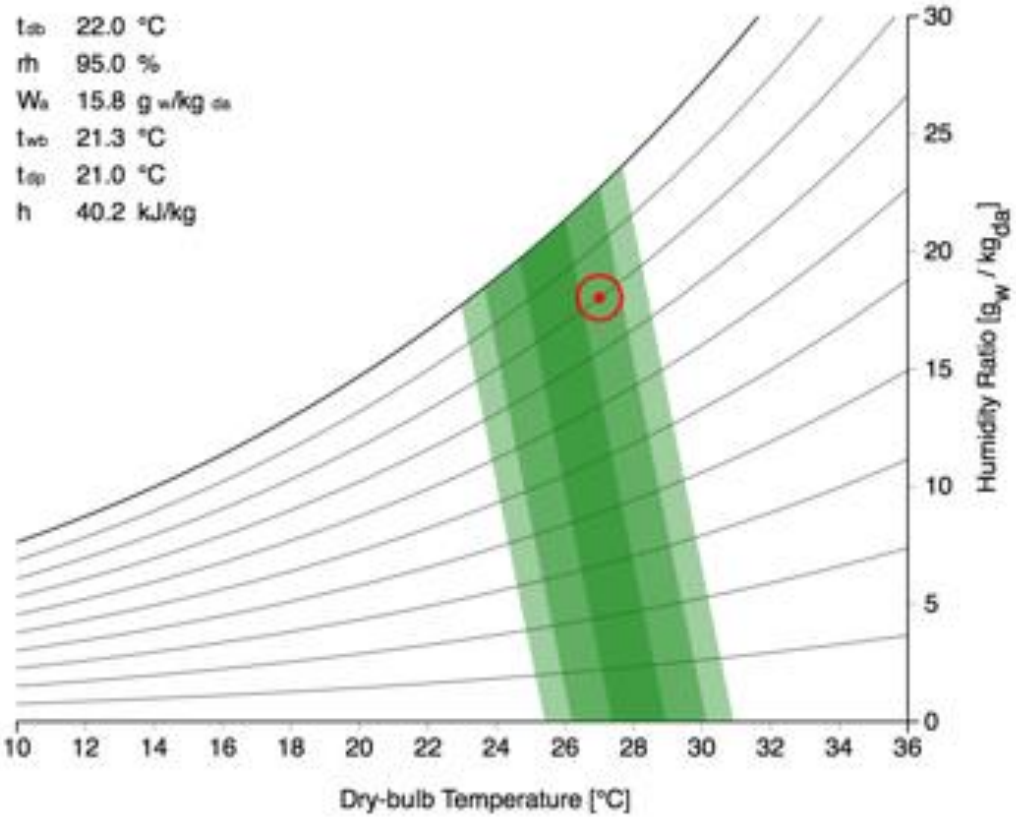
Globe temp | Specify pressure | Set defaults | SI IP | Local discomfort | ? Help

✔ Complies with EN-15251

PMV	0.34
PPD	7%
Category	II

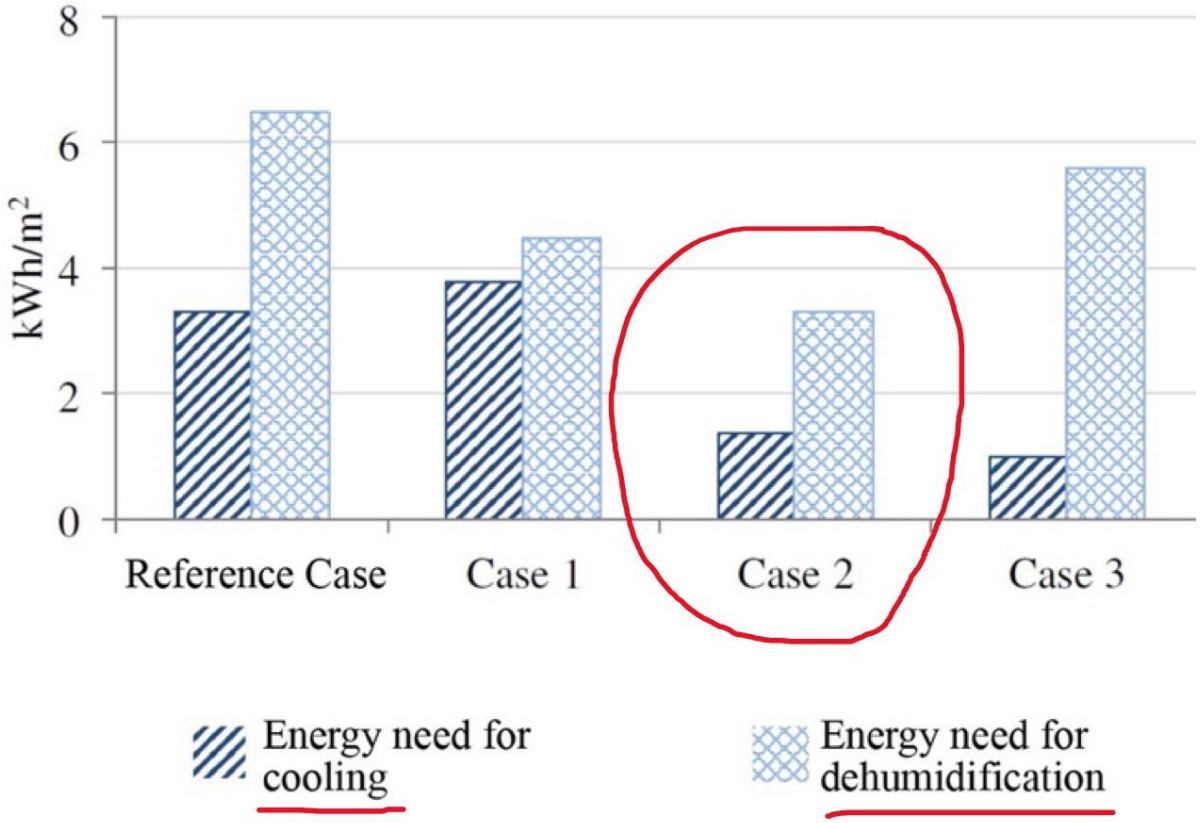
Psychrometric chart (air temperature)

t_{db} 22.0 °C
rh 95.0 %
W_a 15.8 g_w/kg_{da}
t_{wb} 21.3 °C
t_{dp} 21.0 °C
h 40.2 kJ/kg



SIMULATION	Top	R.U.	v	PMV	clo	met
	°C	%	m/s	-	-	-
Reference case	26	60	0.01	0.5	0.5	1.2
Case 1	25.7	70	0.01	0.5	0.5	1.2
Case 2	27.3	70	0.5	0.5	0.5	1.2
Case 3	27.6	60	0.5	0.5	0.5	1.2

While humidity control in summer has important effects on *energy needs* in high efficiency buildings



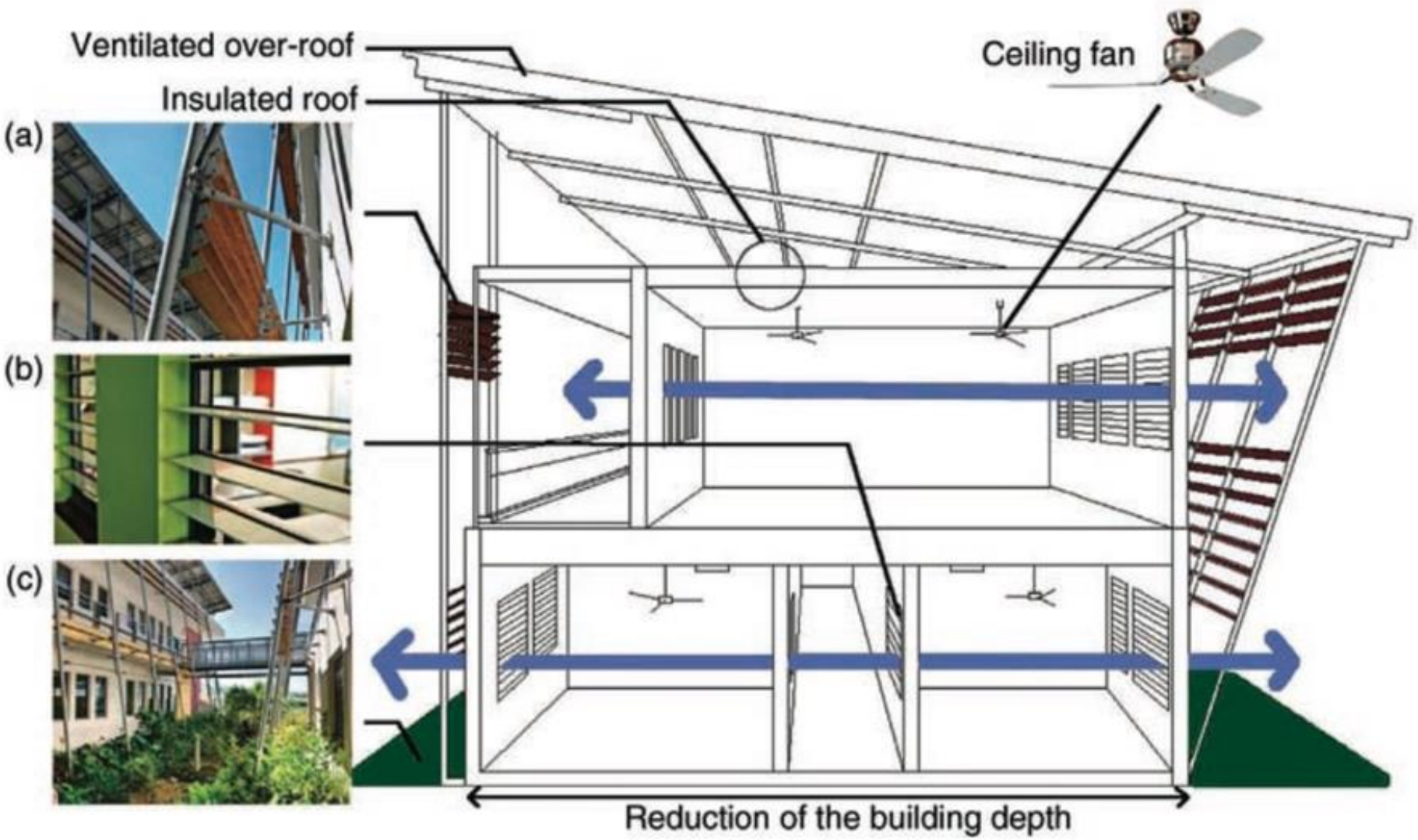
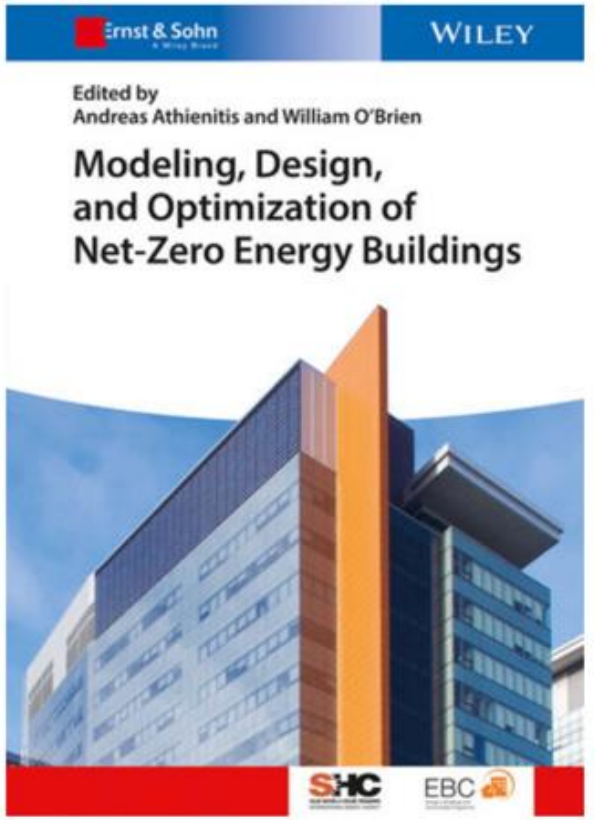


Fig. 7.73 Main features of the Net ZEB design of the ENERPOS building: (a) Exterior fixed sol

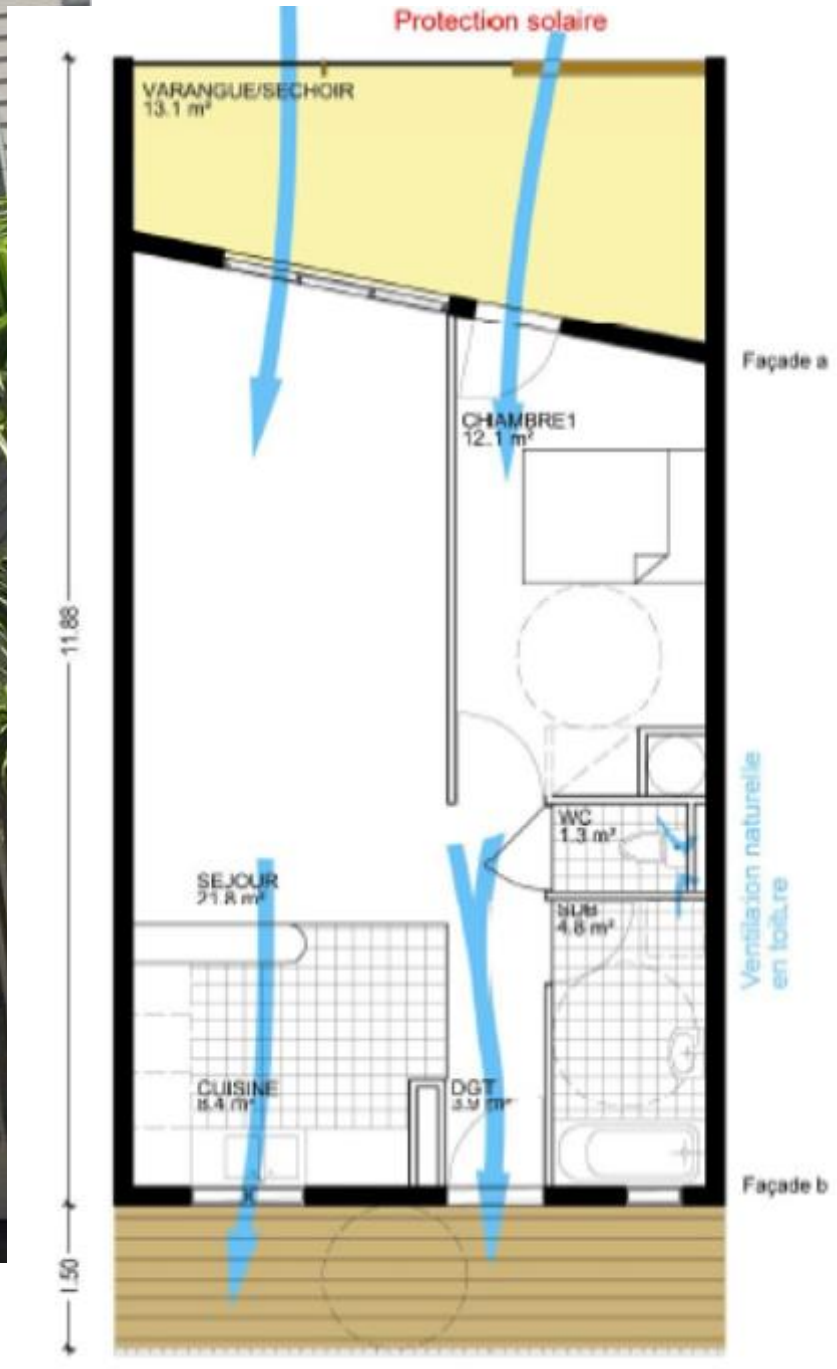
5 min



- 85% reduction in energy use for cooling vs other buildings on campus,
- high majority of comfort votes by students

Opération Florès Malaca, Le Port, La Réunion

Architectes : Perrau et Reynaud



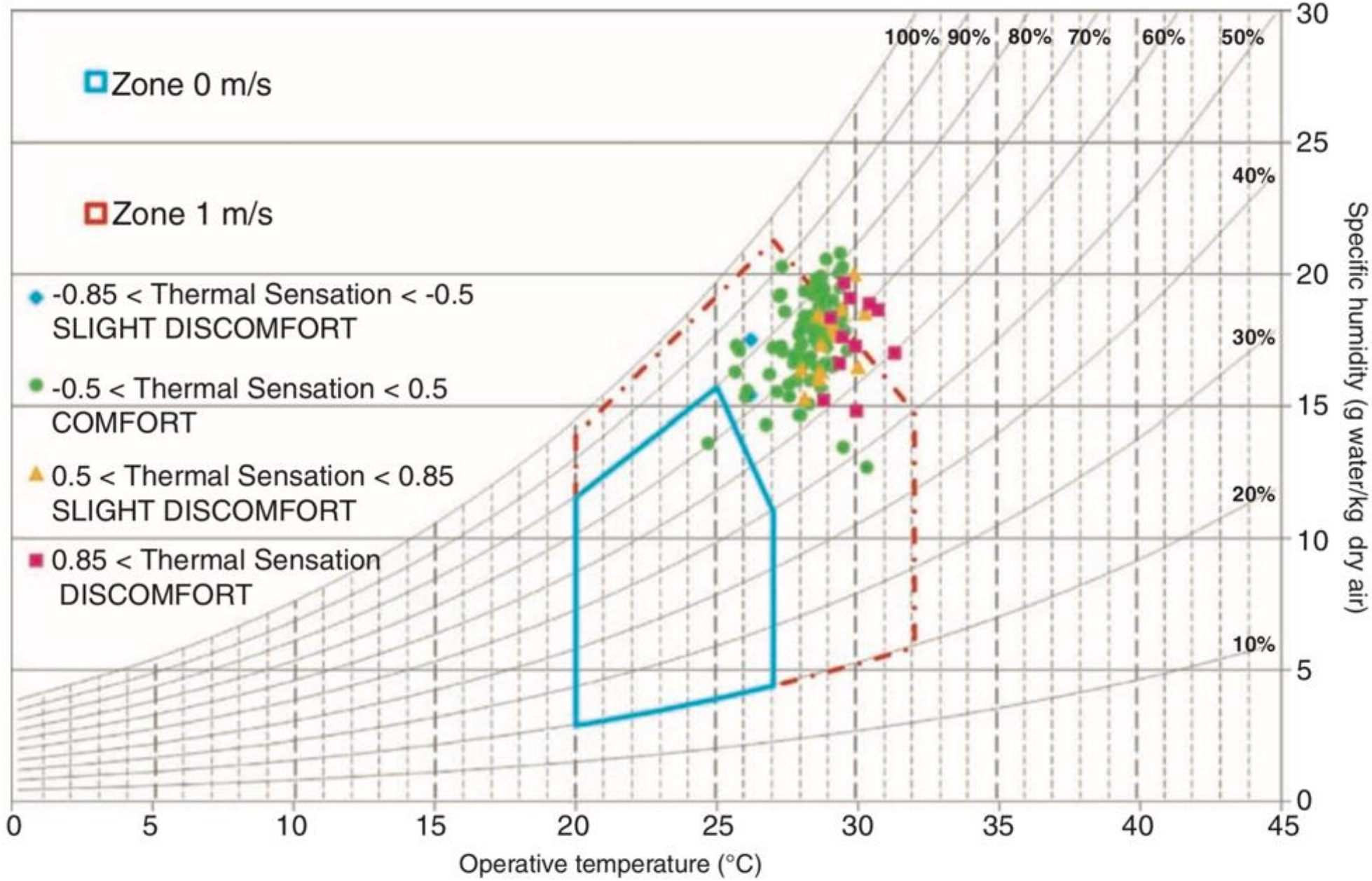
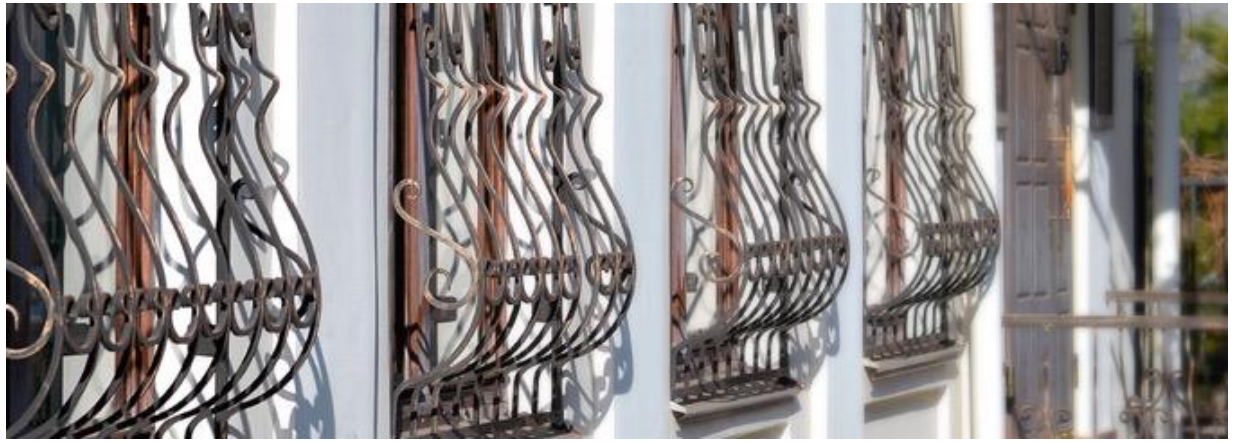


Fig. 7.82 Experimental data from the thermal comfort survey plotted with the Givoni comfort zones

Movable External solar protections devices and well designed ant-intrusion structures to enable night ventilation have long been part of architectural design



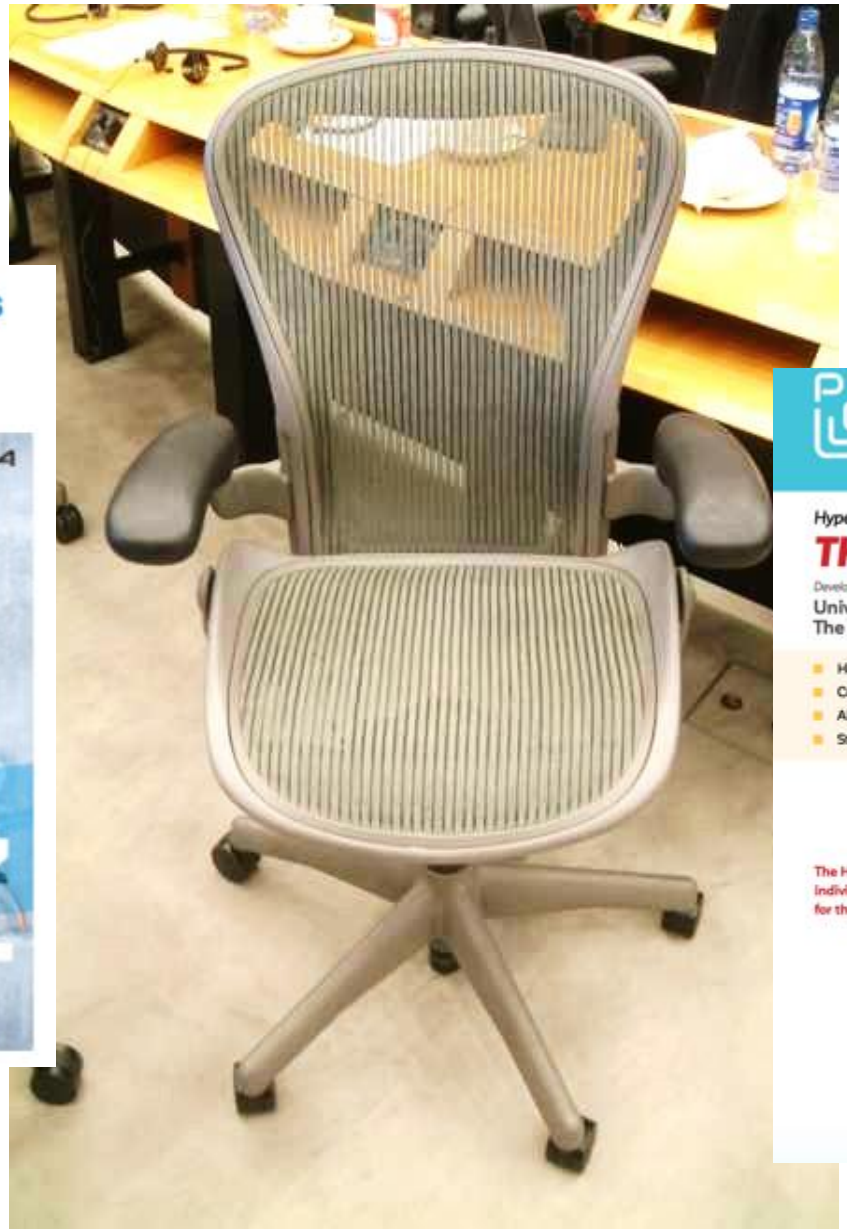
- Swiss regulation (SIA):
- Winter: high termal insulation levels, high performance windows…
- Summer: active air conditioning systems are authorized only after verification that building fabric has been done right (thermal insulation, thermal mass, solar protections, night ventilation)
- external solar protections (with specified total solar transmittance value) are mandatory by law.
- City of **Zurich** verifies (via the public energy utility) the peak summer demand and compares with authorization to install Air Conditioning (private communication at IEA annex meeting)

Solar protection of public spaces can reduce outdoor temperature -->

- outdoor comfort
- enabling ventilative cooling in buildings

Reduction of insulation around the body, as evaluated by ISO7730 & EN15251

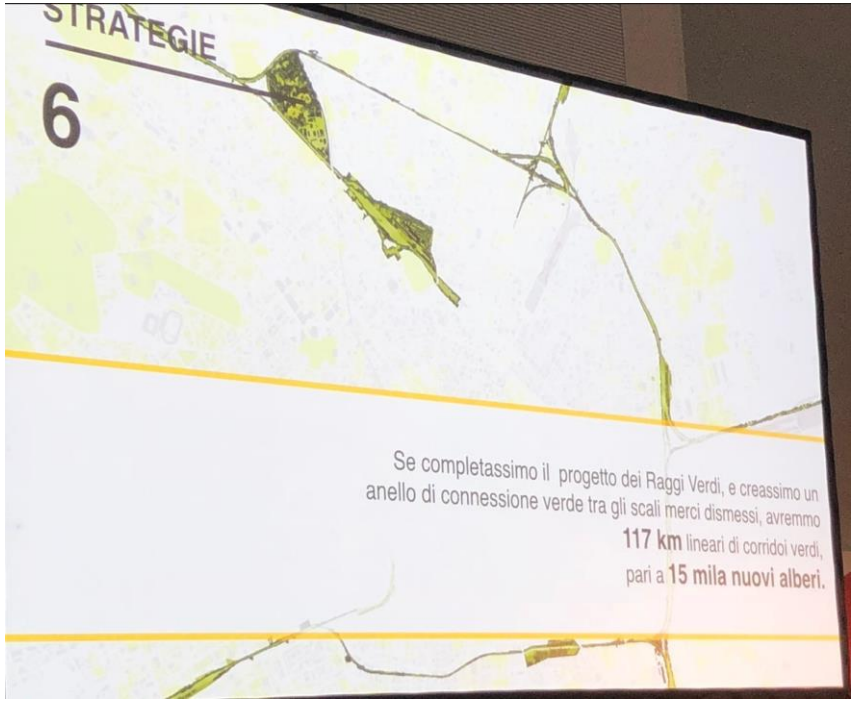
- Flexible clothing code (i.e. Japan, United Nations,…)



- Chair with low thermal resistance (ISO 7730)

City of Milano to add 3 million new trees by 2030 ?

- green canopy in Milano is just 7% of the urban area.
- Frankfurt is at 21.5% , Amsterdam at 21 % Paris at 9 % (World Economic Forum's Green View Index).
- In Milano the night-time temperature can be 6 °C higher than in the surrounding area.
- Milan endures 35 tropical nights (> 20 °C) a year.
- Are the planned new green areas sufficient ?



For individuals to practice night ventilation, external air should be at < 20-22°C --> need for cool surfaces, free of cars

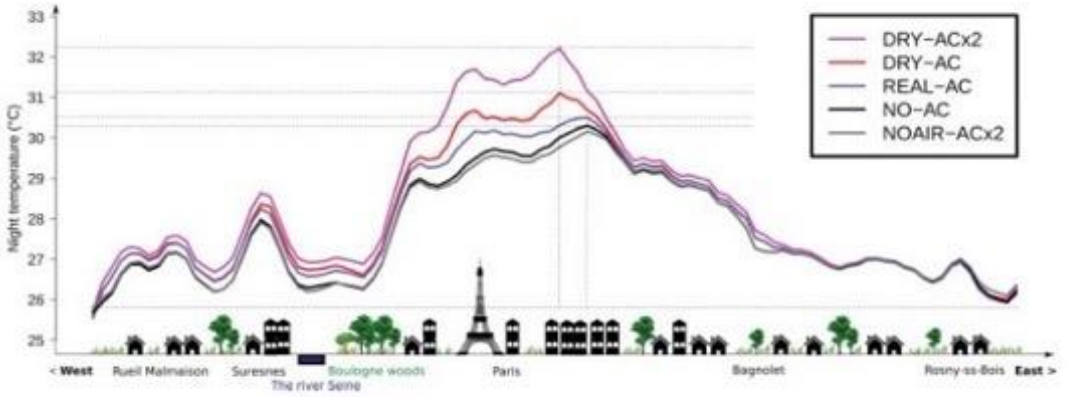
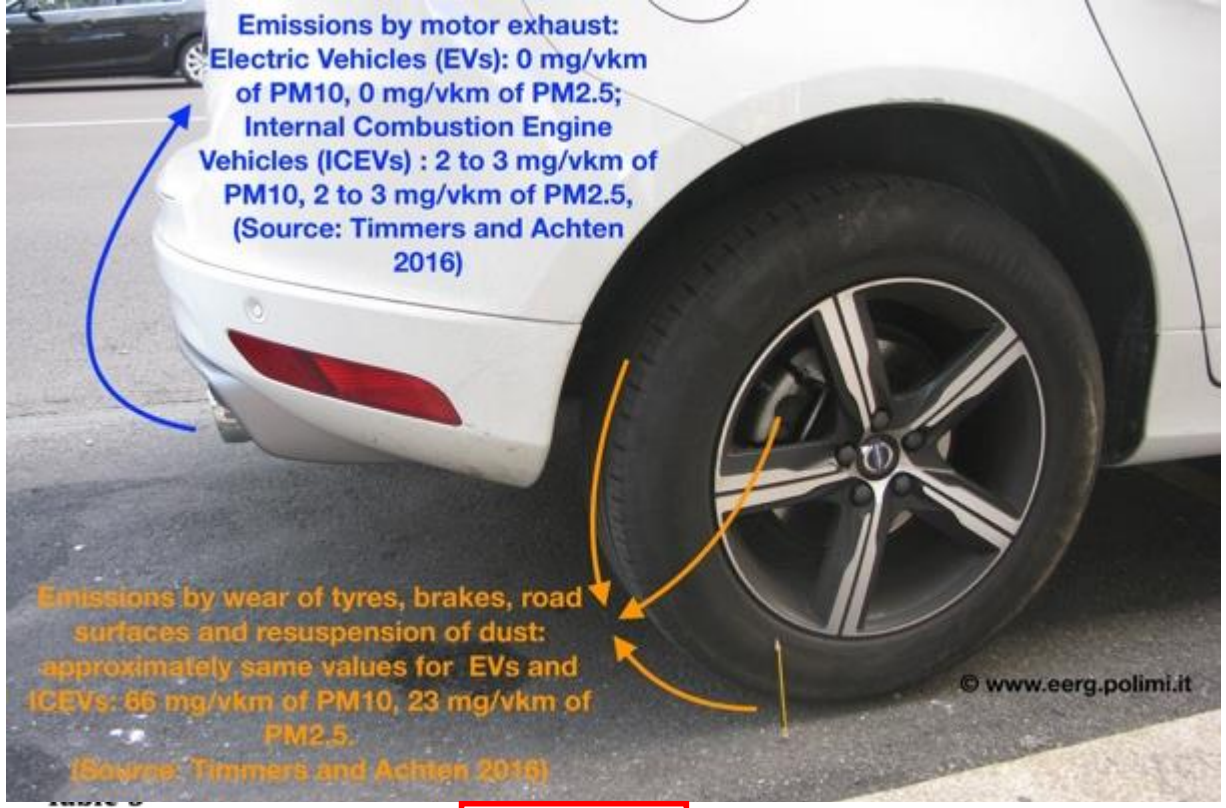


Figure 11. Temperature profiles showing Paris UHI for a west-to-east section passing through the warmest districts of inner Paris (8, 9 and 10, as shown by the black line in Figure 7 for the NO-AC scenario).

10 min

The Praça do Toural, Portugal.



Night ventilation (5-10 Ach) requires clean air and this requires less and lighter cars, independently of the motor

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Review article

Non-exhaust PM emissions from electric vehicles

Victor R.J.H. Timmers [a,*], Peter A.J. Achten [b]

Comparison between expected PM_{10} emissions of EVs, gasoline and diesel ICEVs.

Vehicle technology	Exhaust	Tyre wear	Brake wear	Road wear	Resuspension	Total
EV	0 mg/vkm	7.2 mg/vkm	0 mg/vkm	8.9 mg/vkm	49.6 mg/vkm	**65.7 mg/vkm**
Gasoline ICEV	3.1 mg/vkm	6.1 mg/vkm	9.3 mg/vkm	7.5 mg/vkm	40 mg/vkm	**66.0 mg/vkm**
Diesel ICEV	2.4 mg/vkm	6.1 mg/vkm	9.3 mg/vkm	7.5 mg/vkm	40 mg/vkm	**65.3 mg/vkm**

Table 6

Comparison between expected $PM_{2.5}$ emissions of EVs, gasoline and diesel ICEVs.

Vehicle technology	Exhaust	Tyre wear	Brake wear	Road wear	Resuspension	Total
EV	0 mg/vkm	3.7 mg/vkm	0 mg/vkm	3.8 mg/vkm	14.9 mg/vkm	**22.4 mg/vkm**
Gasoline ICEV	3.0 mg/vkm	2.9 mg/vkm	2.2 mg/vkm	3.1 mg/vkm	12.0 mg/km	**23.2 mg/vkm**
Diesel ICEV	2.4 mg/vkm	2.9 mg/vkm	2.2 mg/vkm	3.1 mg/vkm	12.0 mg/vkm	**22.6 mg/vkm**

La stratégie d'Oslo pour réduire, voire éliminer, les voitures personnelles

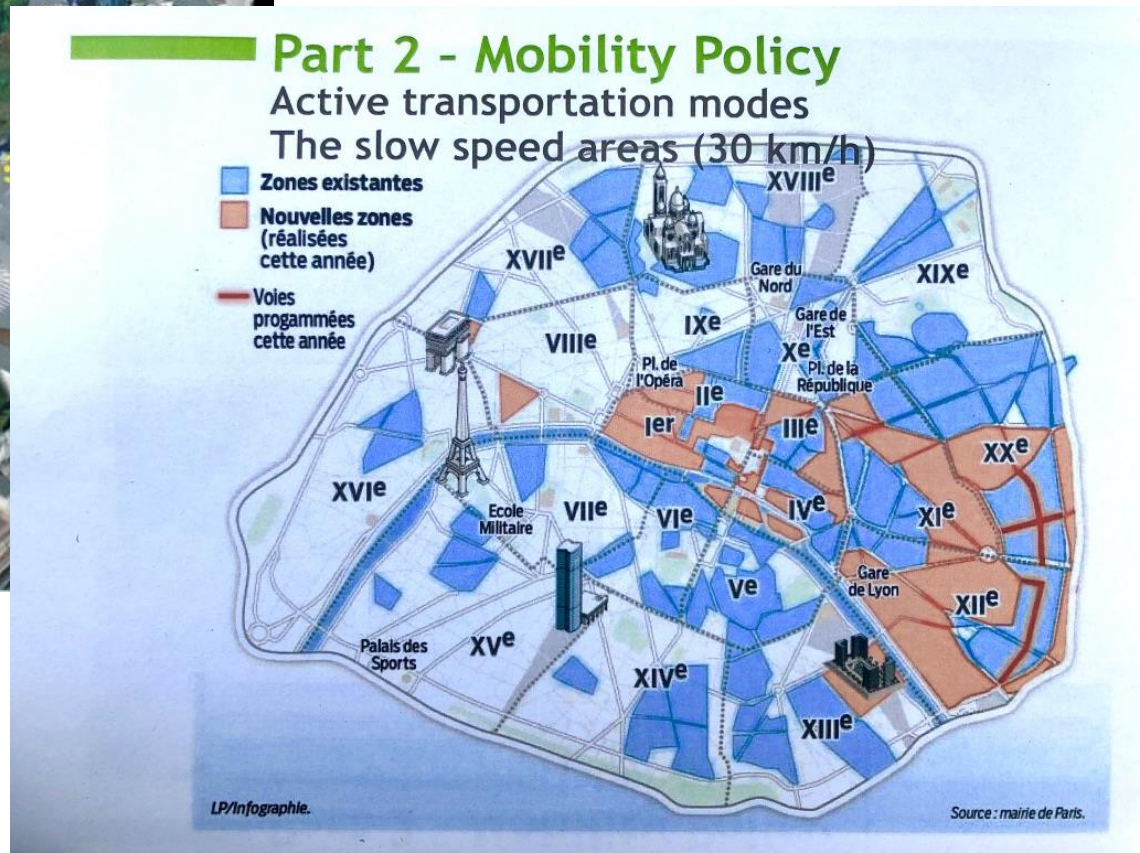
La capitale norvégienne abandonne la notion de transport public pour se lancer dans la « mobilité comme service ». Objectif : supprimer la voiture.

LE MONDE | 03.11.2017 à 17h54 • Mis à jour le 03.11.2017 à 18h18 | Propos recueillis par Francis Pisani

Tramways et piétons dans une rue d'Oslo. Metrocentric - Wikimedia - CC BY 2.0

Paris Is Redesigning Its Major Intersections For Pedestrians, Not Cars

The new designs make sure pedestrians get at least 50% of the public space, lanes of traffic be damned.



https://www.fastcompany.com/3058685/paris-is-redesigning-its-major-intersections-for-pedestrians-not-cars

https://www.paris.fr/velo

Why Paris will be the first post-car metropolis

'The city's parking spaces will become bike or scooter paths, café terraces or playgrounds'

Simon Kuper

SEPTEMBER 7, 2017 by Simon Kuper

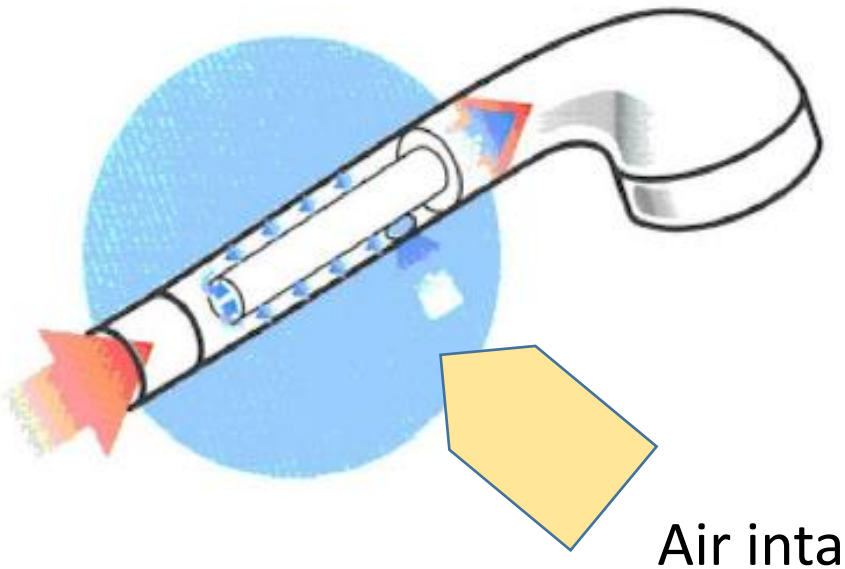
Source: Financial Times
https://www.ft.com/content/1b785f3e-9299-11e7-a9e6-11d2f0ebb7f0

»Sufficient« mobility actions require infrastrucure

- *Proposed Amendement 405 to EPBD:*
  4a.Member States shall ensure that in all new buildings and in all buildings undergoing major renovation, at least a space for bicycles, cargo-bicycles, e-bikes, pedelec, walking frames, wheel-chairs and push-chairs is created; the space shall be common, covered, theft-protected, free of architectural barriers and proportional to the number of users of the building;
- Rejected at the ITRE meeting on October 11, 2017,
- included in milder form in EPBD recitals

In Switzerland, faucets and shower-heads with low water flow are certified by laboratory measures with labeling.

Low flow is e.g. mandatory in Portugal.

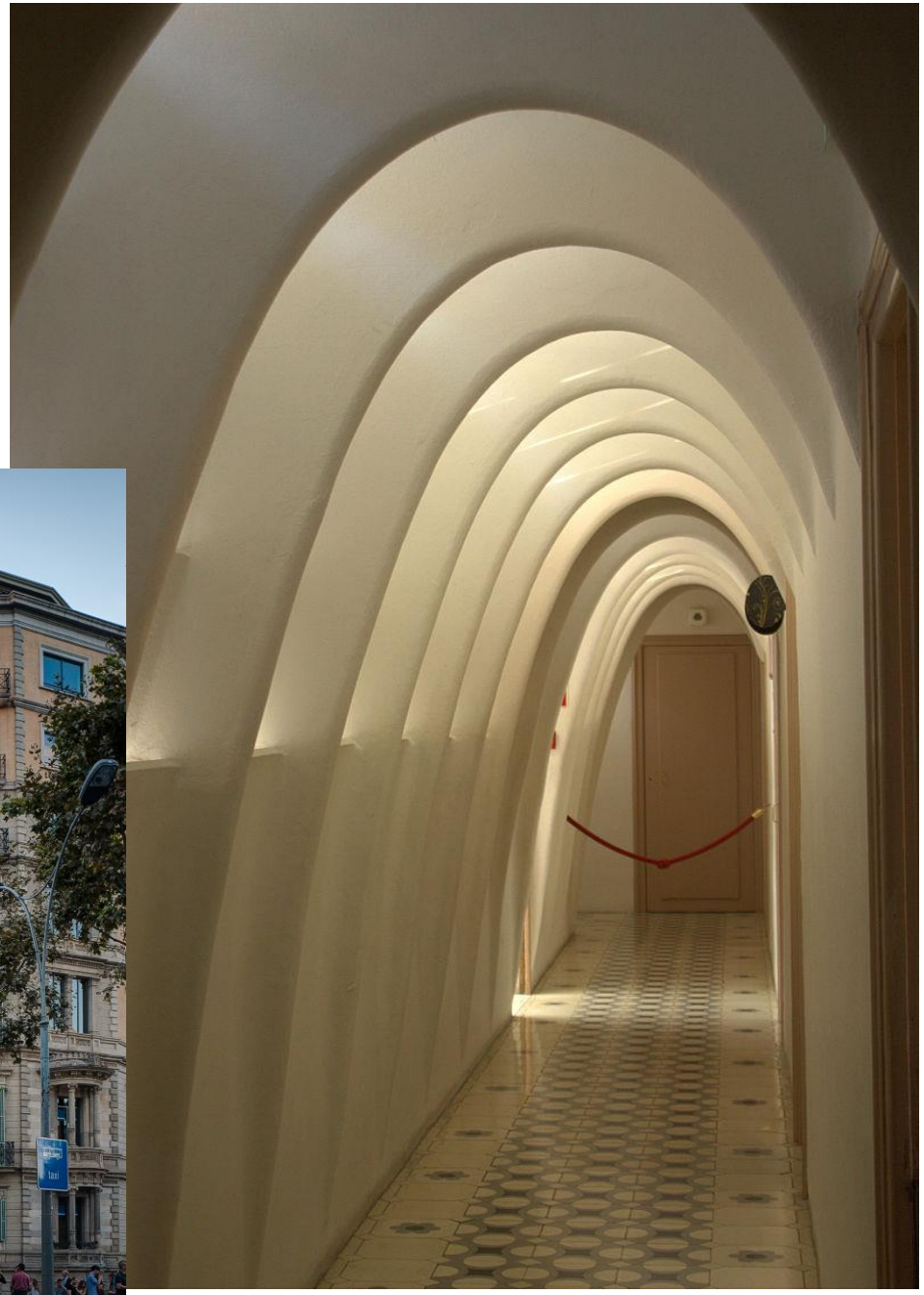


Air intake due to Venturi effect

	Standard water volume
Class A =	≥ 4 to < 6 litres/minute
Class B =	≥ 6 to < 9 litres/minute
Class C =	≥ 9 to < 12 litres/minute
Class D =	≥ 12 to < 15 litres/minute
Class E =	≥ 15 to < 18 litres/minute
Class F =	≥ 18 to < 21 litres/minute
Class G =	≥ 21 litres/minute

Line drying requires
- infrastructure
- clean air

- E.g. Venice traditional line drying
- E.g. the loft of Casa Batlló building from Gaudi was a service area with laundry rooms and storage areas. It contains a series of sixty catenary arches
- https://en.wikipedia.org/wiki/Casa_Batlló#/media/File:Casa_Batlló_Parabolic_Arches.jpg



- Brent Toderian (Former Vancouver chief planner, Council for Canadian Urbanism)
- Jan Ghel (Denmark & world): «human scale cities»
- Janette Sadik Kahn (2007-13, New York City's Department of Transportation, 500 km bike lanes)

New New Urbanism in USA

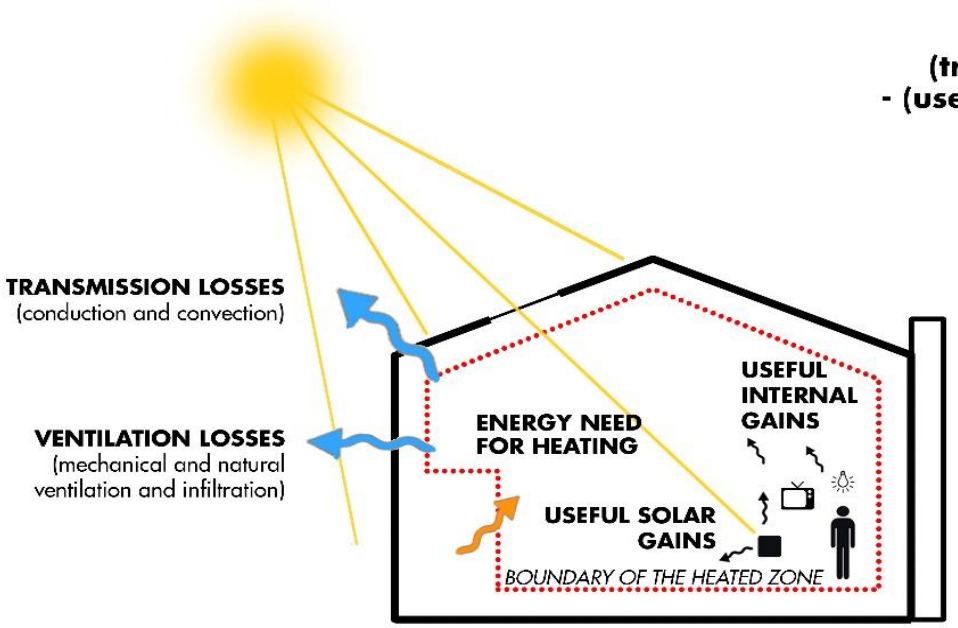
"The goal: resilient, equitable, carbon-neutral cities that *people want to live in*

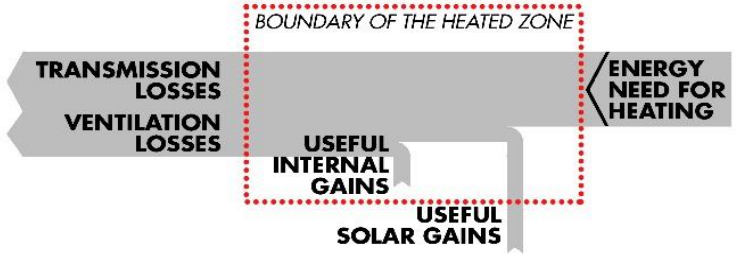
That's the *new* New Urbanism."

https://medium.com/age-of-awareness/new-urbanism-isnt-dead-but-thanks-to-climate-change-it-is-evolving-de2080b8986b
https://www.cnu.org/resources/what-new-urbanism

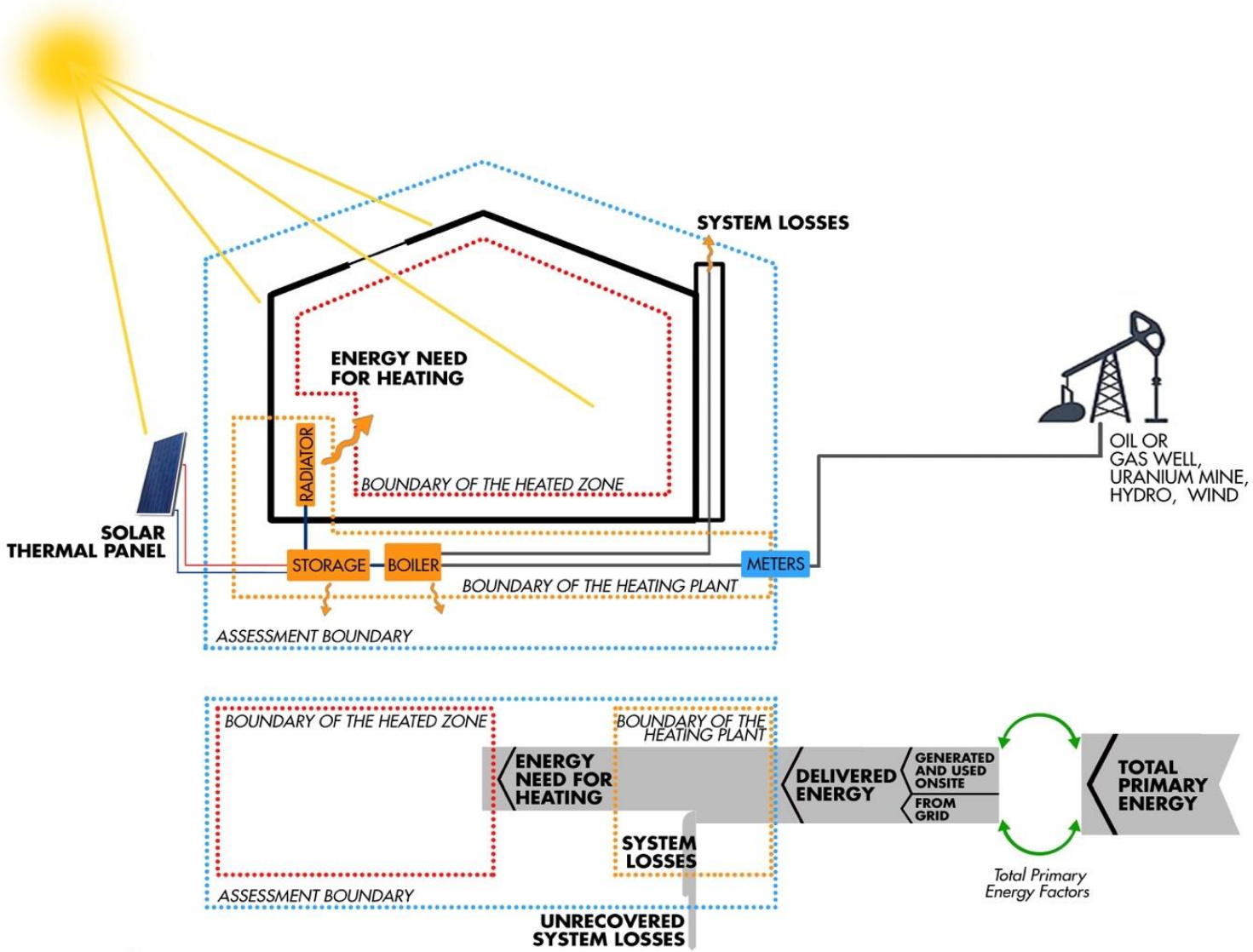
https://www.theguardian.com/cities/2018/feb/28/child-friendly-city-indoors-playing-healthy-sociable-outdoors

Energy need for heating =
(transmission losses + ventilation losses)
- (useful solar gains + useful internal gains)





Pagliano, L., & Roscetti, A. (2019). *Calculating Energy Performance Chapt 5 of «Implementing the EPBD, a BPIE report»* http://bpie.eu/wp-content/uploads/2019/04/Implementing-the-EPBD_BPIE_2019.pdf


SYSTEM LOSSES
ENERGY NEED FOR HEATING
RADIATOR
BOUNDARY OF THE HEATED ZONE
SOLAR THERMAL PANEL
STORAGE
BOILER
METERS
BOUNDARY OF THE HEATING PLANT
ASSESSMENT BOUNDARY
OIL OR GAS WELL, URANIUM MINE, HYDRO, WIND
BOUNDARY OF THE HEATED ZONE
BOUNDARY OF THE HEATING PLANT
ENERGY NEED FOR HEATING
DELIVERED ENERGY
GENERATED AND USED ONSITE
FROM GRID
TOTAL PRIMARY ENERGY
SYSTEM LOSSES
ASSESSMENT BOUNDARY
Total Primary Energy Factors
UNRECOVERED SYSTEM LOSSES

Tiered Base Plan

PG&E's Standard Rate Plan

PG&E's standard Tiered Base Plan has four pricing tiers. **As you use allotted electricity for each tier during your bill period you move to the next, higher priced tier**.

To save on your bill, you'll need to conserve energy to stay on lower price tiers as long as possible, as well as once you've reached higher price tiers. To learn how, visit Understand Your Energy Use.

Energy Alerts

PG&E can alert you by text, email or phone when you've moved to higher priced tiers with Energy Alerts.

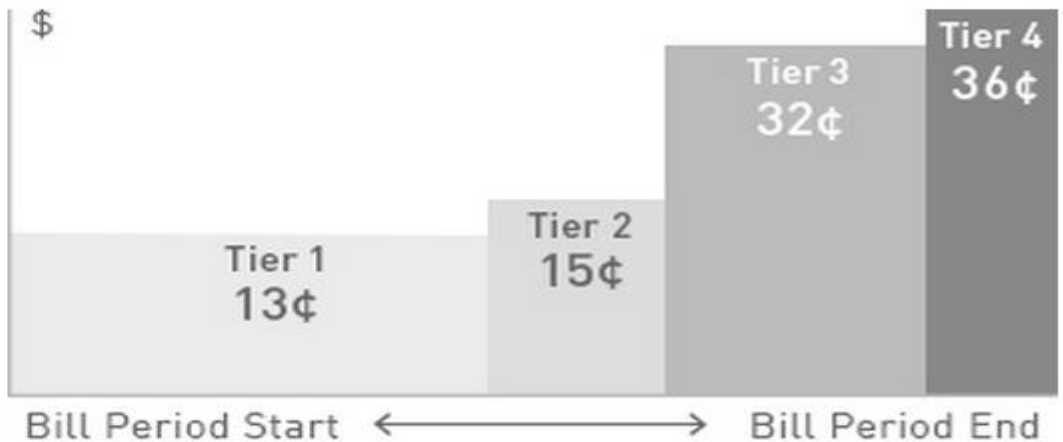
How Tiers Work

Tier 1: Each monthly billing period begins at the lowest rate. While you want to stretch as far as possible, average customers use all of Tier 1 in about 15-20 days.

Tier 2: With about one third the allotment of Tier 1, Tier 2 costs slightly more (+2¢). If your Tier 1 lasts 15-20 days, Tier 2 could last another 5-6 days.

Tier 3: The rate increases dramatically (+17¢) in this tier. Customers who enter Tier 3 are consuming significant amounts of electricity.

Tier 4: Finally; if you enter tier 4, you are using more than twice your Tier 1 total, and the rate increases by an additional 4¢.



NOTE: This chart represents an above average usage customer. The length of time in each tier depends on monthly energy usage.

eERG
end-use Efficiency Research Group
Gruppo di ricerca sull'efficienza negli usi finali dell'energia

POLITECNICO MILANO

www.eerg.it

Thank you for your attention

Some parts of the this presentation have been prepared in the context of the AZEB projects

AZEB
Affordable Zero Energy Buildings

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 754174

https://azeb.eu

- Finally costly access to basic info is a barrier to effective design. E.g. the EN-ISO standards and their national declinations are a large number, and are not available for free in spite of being an essential part of regulation.

- Overall instruments purely based on market/price seem, at least withtin this area of application, to be weak in terms of:
- being able to achieve effects in isolation from public investments in effective controls and in capacity building
- being able to fine tune the evolution of the market towards the (stated) goals

- A second critical aspect concerns the choice of the **indicators of the building performance** in regulations. There are signals that national regulation in some countries and at EU level (EPBD recast, annex I) is moving towards using as unique indicator of building performance, the *non-renewable primary energy use*, thus implying that a very large use (in fact even an infinite) use of energy would be ok, as long as it is from renewable sources. This negates the limitations due to space, landscape preservation, raw materials use and the impact of corresponding mining and transport.
- Interim report of the project Affordable Zero Energy Buildings, deliverable 2.1., to be published in May 2019
- Finally costly access to basic info is a barrier to effective design. E.g. the EN-ISO standards and their national declinations are a large number, and are not available for free in spite of being an essential part of regulation.

Indicators of building performance

- The energy performance of a building shall be expressed in a transparent manner and shall include an energy performance indicator **and** [bold by the authors] a numeric indicator of primary energy use, based on primary energy factors per energy carrier…")
- and reduces it only to one, namely "primary energy" (not better specified in the texts). This is in contradiction with the Standard ISO EN 52000 produced under Mandate 480 by the EU Commission. In fact, the Standard states: *"the use of only one requirement, e.g. the numeric indicator of primary energy use, is misleading".*
- The Standard ISO EN 52000 explains which indicators are needed and why. Summarising:
- *energy needs for heating and cooling* (for quantifying and promoting the reduction of energy losses through the envelope and ventilation)
- *total primary energy* use (for quantifying and promoting the