Performance standard for tropical outdoors: A proposal in a time of climate change

ICUC9 – ID2 | 23 Jul 2015 | R Emmanuel

Outline

- The coming airconditioning armagedon
  - Cities, climate change and the overheating problem in tropics
- Cooling load issues
  - Key issues in cooling load management
- Current impasse in climate-sensitive design
  - Technical
  - Governance
  - Cultural
- Where do we go from here?
  - Three strategies
  - Two approaches

"*it (air conditioning) changed the nature of civilization by making development possible in the tropics*" (Lee Kwan-Yew, 2009)

Airconditioning armageddon

History of misalignment

- Strategies developed for heating-only (or heating/cooling mode) climate don't work at all in the tropics
- Miasma theory and its continuing effects
- Current orthodoxy doesn't work:
  - Higher humidities in the tropics warrant design for higher wind movement to be the design priority;
  - Thermal comfort in the tropics depends more on air movement than on the reduction of solar radiation;
  - Night-time cooling occurs in the tropics

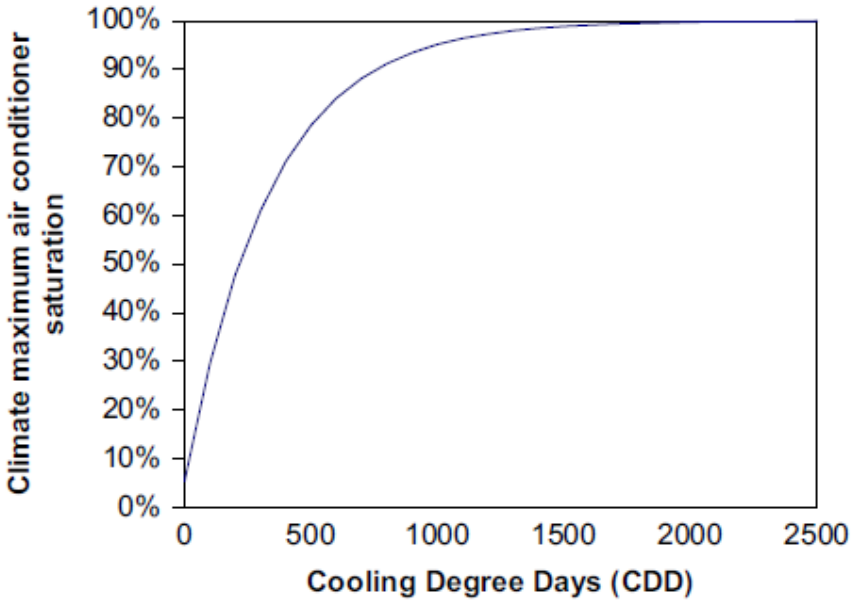
Global space heating/cooling trends

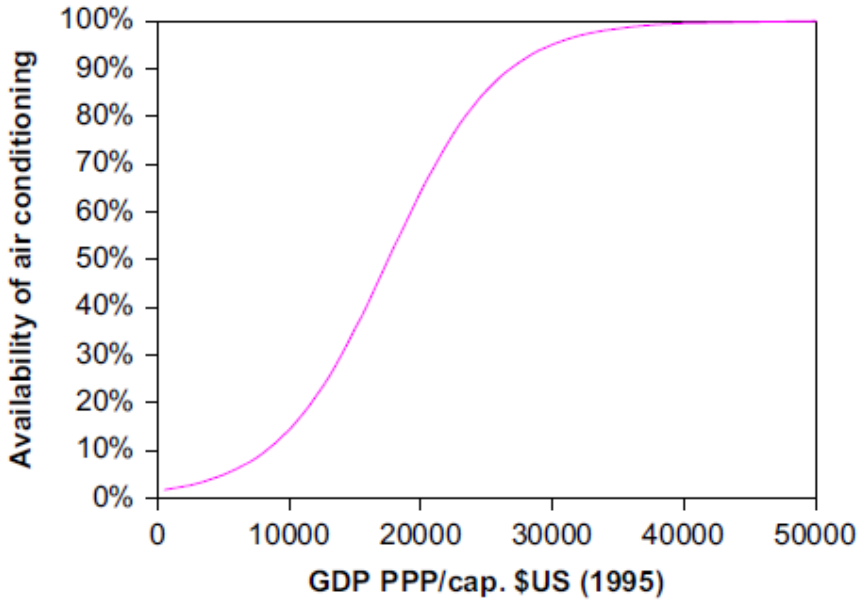
	2010	2020	2030	2040	2050
Pacific OECD[1]	126.1	122.4	119.1	116.0	113.4
N America	147.5	138.4	131.0	124.9	119.7
W Europe	128.3	123.1	118.4	114.2	110.4
Central & E Europe	152.6	148.1	144.8	141.8	139.1
Former Soviet Union	205.1	198.4	194.5	191.6	189.0
Latin America	63.3	60.2	59.5	59.3	59.6
Sub-Saharan Africa	56.2	53.4	52.9	53.0	53.4
Middle East and N Africa	55.6	55.1	56.0	57.4	58.0
Centrally Planned Asia[2]	37.4	41.2	43.8	46.8	47.5
South Asia	60.1	77.1	85.0	89.2	88.2
Other Pacific Asia[3]	46.4	45.5	45.6	45.9	46.5

[1]Australia, Japan, New Zealand
[2]Cambodia, China (incl. Hong Kong), Korea (DPR), Laos (PDR), Mongolia, Viet Nam
[3]Southeast Asia and the Pacific Island states

Source*: Based Ürge-Vorsatz et al., 2015*

Saturation of air conditioning

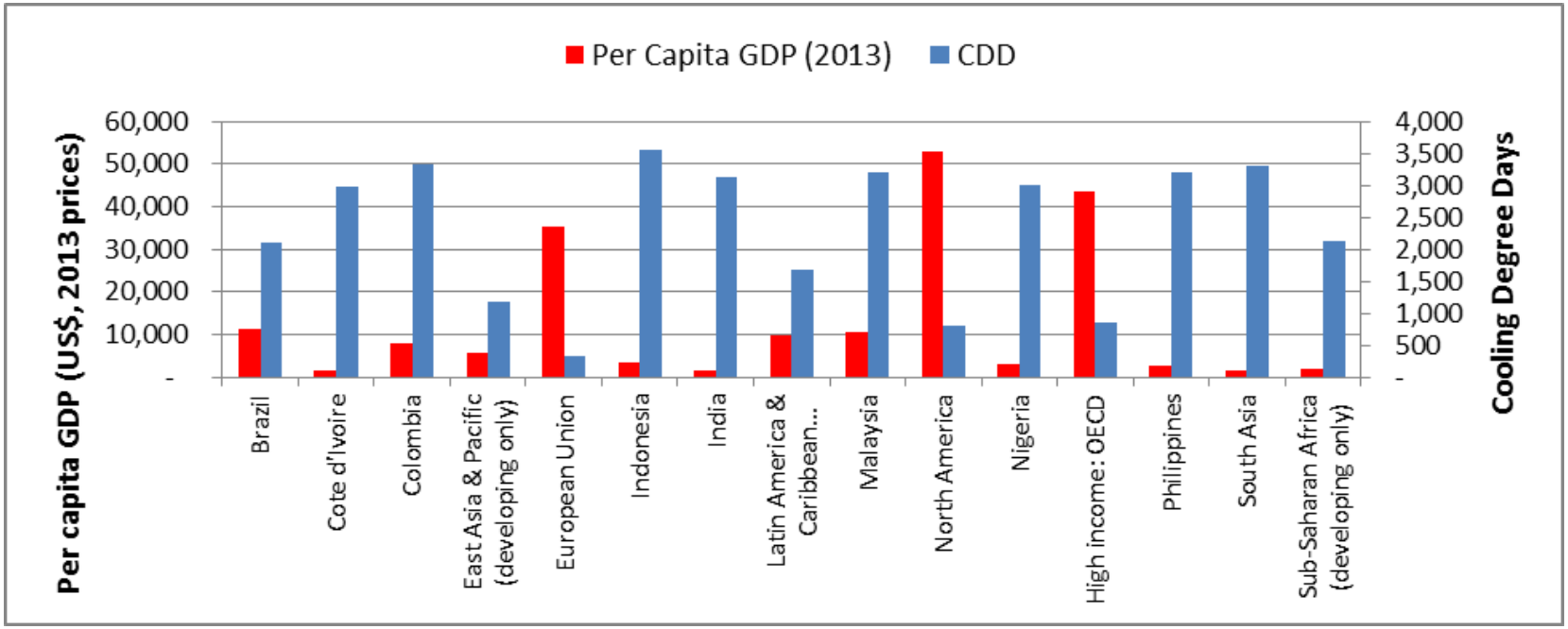




MAXIMUM AIR CONDITIONER SATURATION:
(left) as a function of climate and,
(right) as a function of income

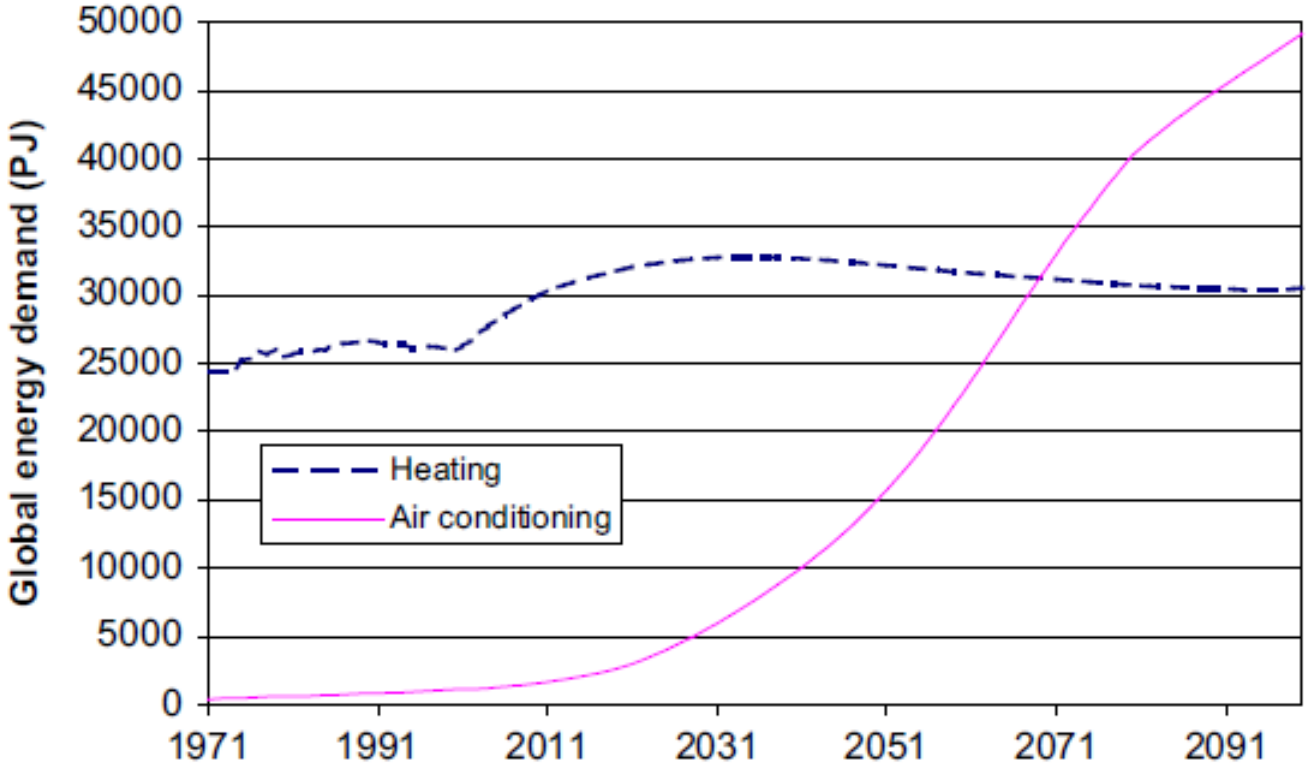
Source*: Isaac and Van Vuuren, 2009*

Income vs cooling load



Source: *Emmanuel, 2015*

Proliferation of air conditioning use



Source*: Isaac and Van Vuuren, 2009*

Coming A/c armageddon

- Much of the global heating demand is already manifest in energy demand whereas much of the global cooling demand is still latent;
- Greater improvement in heating efficiency has already occurred whereas technological development and efficiency improvements in cooling are yet to be achieved;
- Greater economic development leads to more appliance use, which leads to greater internal gain, necessitating a lowering of threshold temperature at which cooling is demanded

Cooling load issues

Why is cooling more problematic?

- Need to tackle increases in both the sensible and latent loads
- Use of A/c makes the urban situation worse
- Heating could be provided by a variety of lower carbon fuels while cooling is largely electricity-based
- Much of global heating demand is already manifest while cooling load is yet to be witnessed
- Global warming potential of refrigerants

Current impasse

Key issues

- Technical
  - Tropics (especially the urban tropics) have warmed to an extent that passive, building-level strategies to tackle it have been more or less exhausted
  - 'Traditional' solutions may no longer work
- Institutional / Governance issues
  - Climate-sensitive design is not a high priority in tropics
  - Institutional arrangements needed to embed it in planning
  - Whose priority?
- Cultural
  - Thermal indulgence
  - Issues with C-S D as an 'elite' project

Going forward: Lessons

Key strategies

- Reformulate ‘thermal pleasure’ (Hwang et al., 2009)
- Link in ‘in’ with ‘out’
- Adaptive opportunities formulated by activities

Reformulation of thermal pleasure

- Partially shaded pathways
- Strategically placed and adequate vegetation cover
- Water misting

	Average Range	Standard Deviation
Thermal sensation	+2.71 to -0.35	0.94
Comfort sensation	-1.41 to +1.82	1.03
Wettedness Sensation	+0.82 to 1.56	1.21 to 0.86

Source: Farnham et al., 2015

Linking the ‘in’ and the ‘out’

- Express performance standards in terms of percentage reduction over the contextual surroundings
- Reflect the purpose for which thermal comfort standards are being promulgated
  - Subject’s thermal sensitivity
  - Accuracy required for carrying out the task
  - Practicality of thermal control
  - Difference between indoor and outdoor conditions to be achieved

Adaptive opportunities by activity patterns

- Shopping streets
- Gathering places
- Provision for evening life
- Pedestrian paths and nodes (cf. Emmanuel, 2005)

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