Natural materials: System performance and applications to traditional buildings

Toby Cambray 26/06/2024

What are systems?

Components, boundaries

“A system is a set of things—people, cells, molecules, or whatever—interconnected in such a way that they produce their own pattern of behaviour over time.”

Donella H. Meadows, Thinking in Systems: A Primer

Interactions

Performance

Systems

- At the core of all types of engineering
- We can make models of systems
  - Try to predict behaviours
  - Understand the system *through the act of making* the model
- Limits to Growth (Meadows et al)
- Escape from Model Land (Erica Thompson)

Buildings as systems

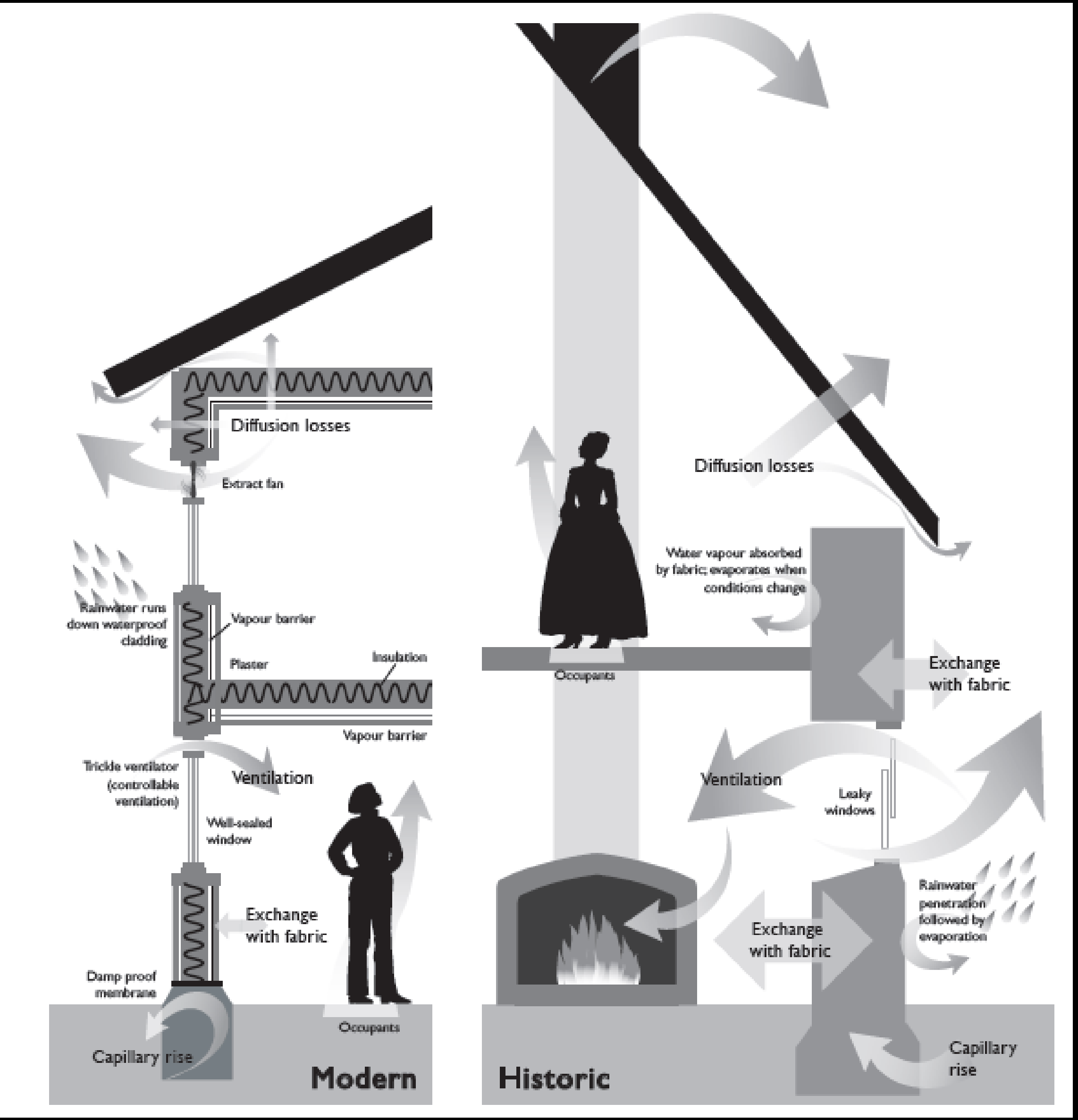
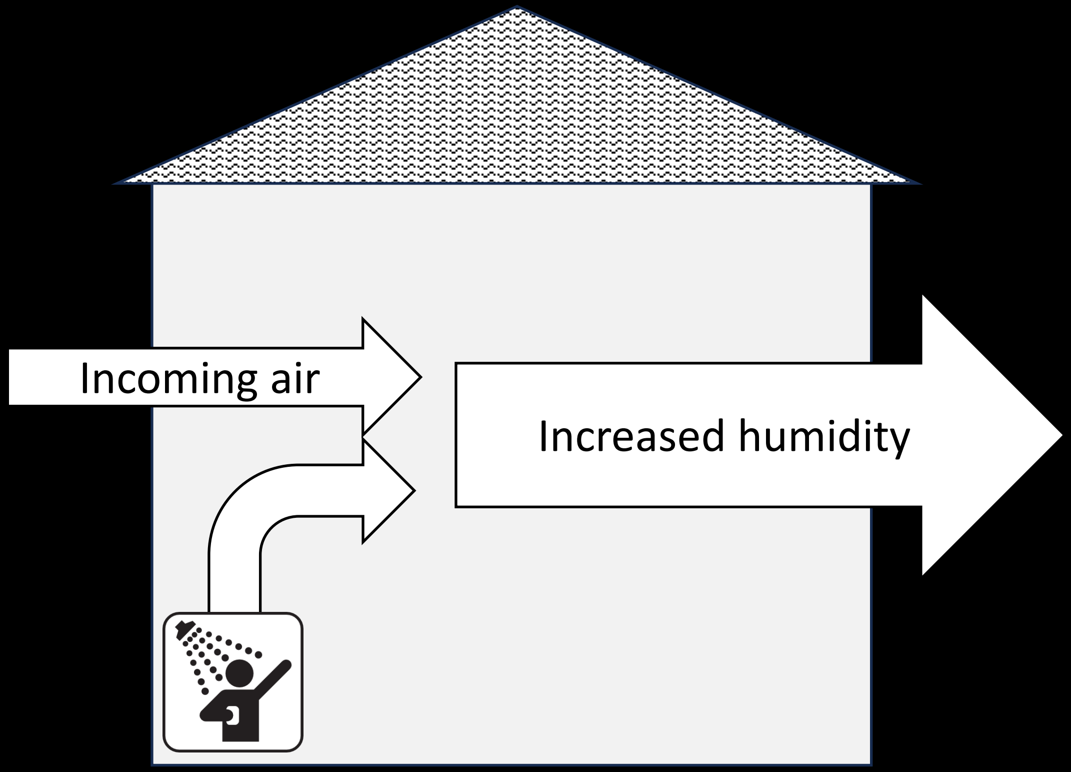


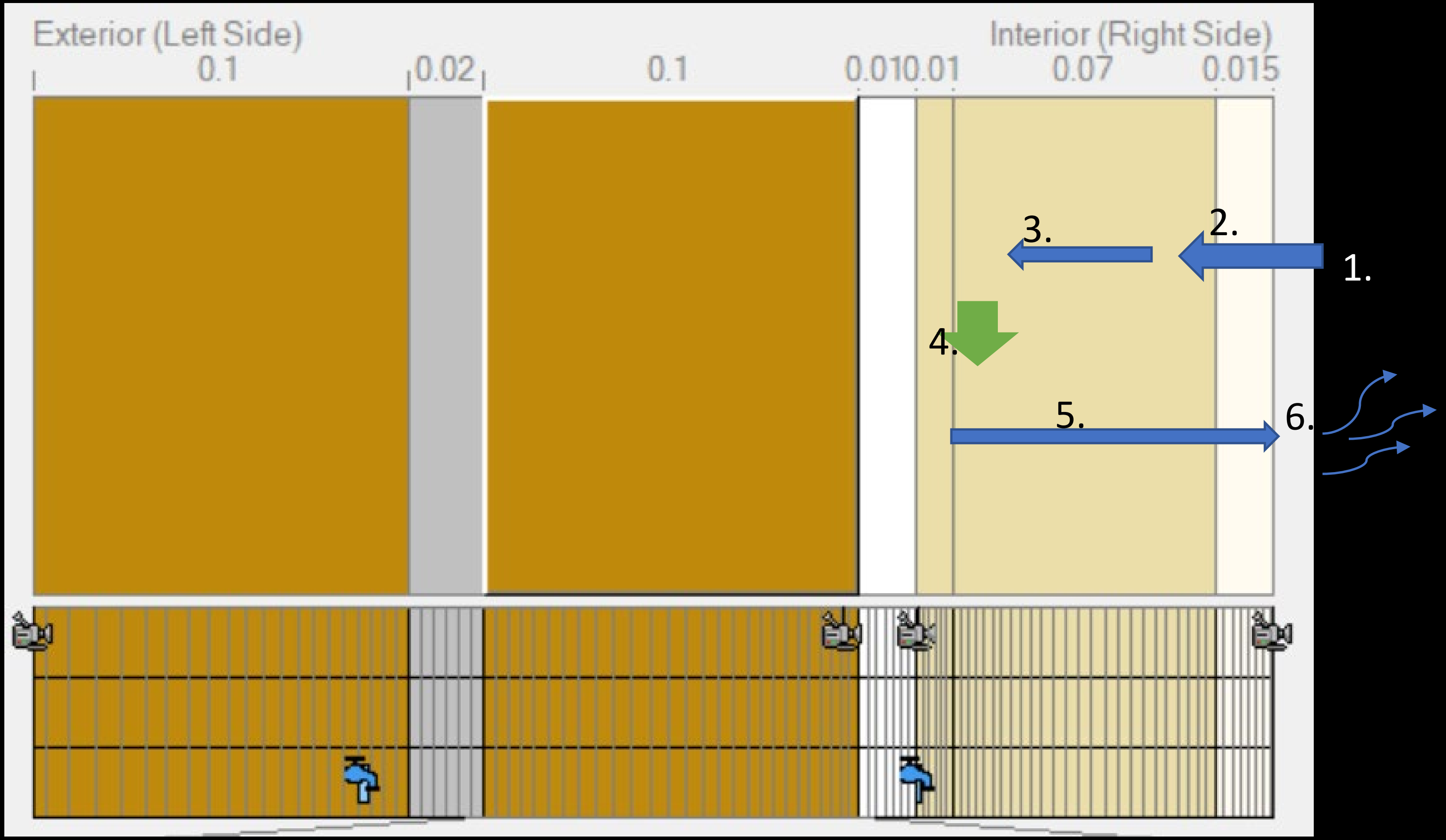
Image: Historic England (2017) *Energy efficiency and historic buildings*

Sub-system: Ventilation and moisture generation



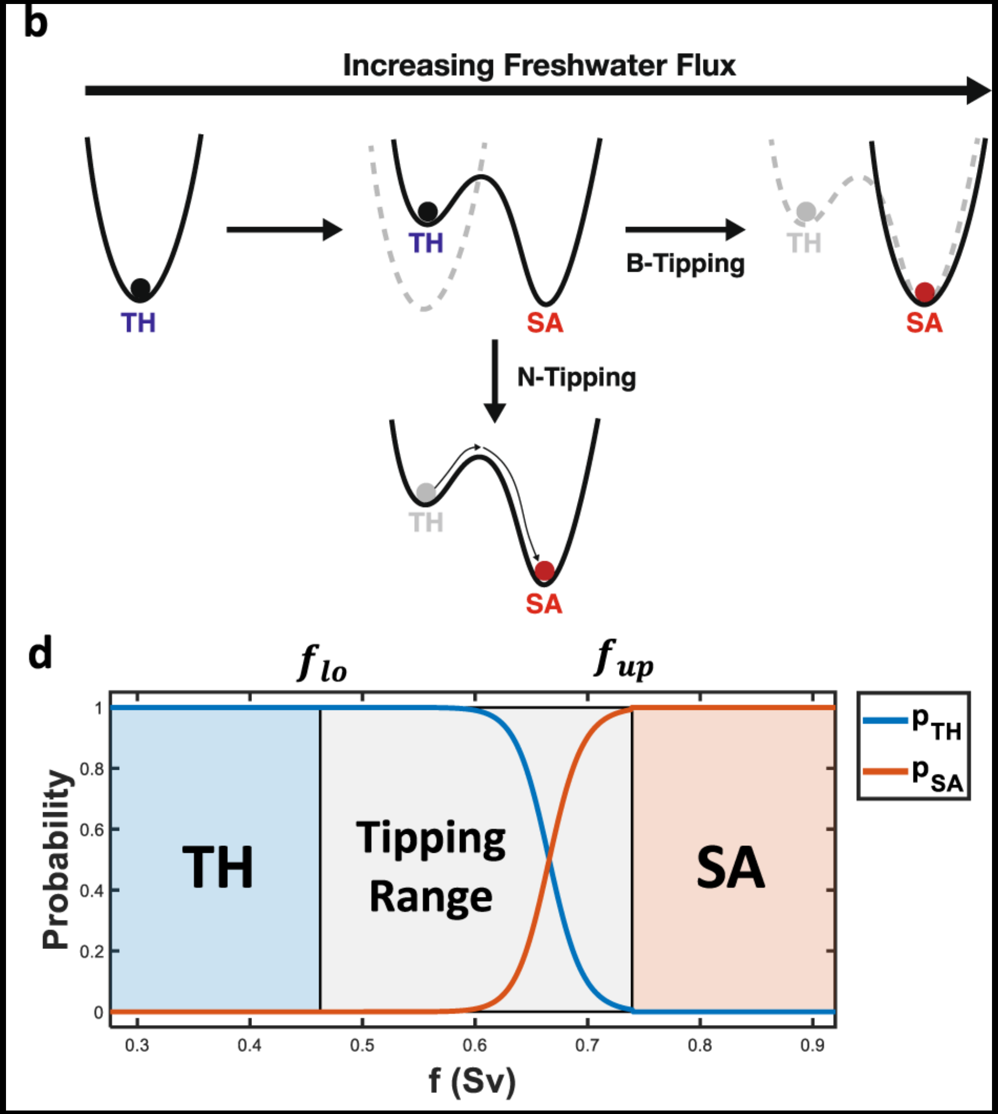
More Detail here: https://www.passivhaustrust.org.uk/guidance_detail.php?gId=65
And here https://www.passivhaustrust.org.uk/event_detail.php?eId=1268

Sub-System: wall with insulation



1. Higher vapour pressure internally causes **vapour diffusion** outwards.
2. A plaster coat (maybe a moderate or variable resistance membrane) slows the **vapour diffusion** to manageable levels (but doesn't stop it).
3. The temperature drops across the insulation, which increases the **relative humidity**.
4. The insulation is **hygroscopic**, so it adsorbs moisture which occupies the pores as liquid.
5. There is then a liquid potential or gradient between the cold side of the insulation, which causes liquid to move by **capillary suction** back towards the dry internal surface.
6. The surface dries (by **evaporation**) to the internal environment (so ventilation is important!)

Stability of systems: Running AMOC



https://doi.org/10.1038%2Fs41612-022-00236-8

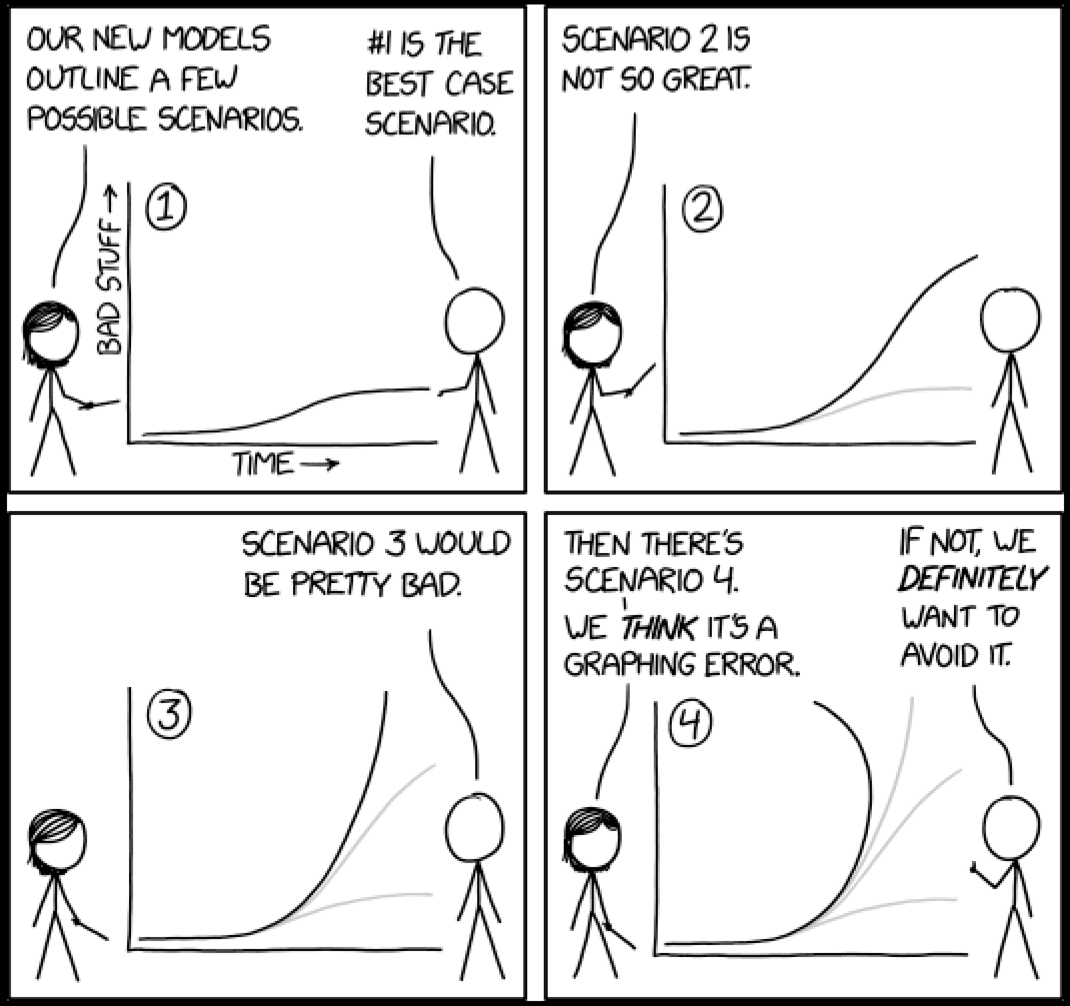
Beware unintended consequences

- Care required when altering a system
- Adequate understanding of the components and how they interact
- How to consider all the complex interactions at once?

https://www.linkedin.com/feed/update/urn:li:activity:7211292990990942208/

Outside the (George) Box

- All Models are wrong, some models are useful
- Mental models
  - of mathematical models
    - of isolated systems



We know enough to start

- Risks are higher in wet areas and/or buildings in poor condition
- Be more Hawaiian: 200 words for rain
- Modest layers of fairly dense, hygroscopic, capillary active and somewhat vapour open materials are generally OK
- Vapour diffusion needs to be carefully managed, not blocked: a little vapour resistance goes a long way.
- Ventilate purposefully
- Join things up – in your head, in the design, and on site

Push the envelope – very carefully

- Understand the components
  - Sample, test, characterise
- Build wrong models
  - That approximate the interconnections between components and boundaries
  - With an acute awareness of limitations
- Use models responsibly – communicate risk
- Measure and reflect