Adapt or Suffer

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On not shedding a tear
Two Questions:

1. How much are we willing to suffer?
2. How much grief are we willing to cause others?
Two Types of Pain

1. Mitigation

2. Adaptation

£ $ ¥ €
Tropical by 2040s; cool by 2060s

- Observations
- Medium-High Emissions

Temperature anomaly

Year:
- 1900
- 1950
- 2000
- 2050
- 2100
But where are the error bars?
Tipping Points

"Society must not be lulled into a false sense of security by smooth projections of global change," Prof Tim Lenton of the University of East Anglia

If $+ > 8\text{Gt}$

“We have to accept that changes are inevitable and start to adapt now.” Prof. Peter Cox, University of Exeter
Kingsmead Primary (White Design / Arup + Mitie)
Venerable Bede, Secondary (Napper / Gregory)
Academy of St Francis of Assisi Academy (Capital Percy Thomas / Buro Happold)
South-facing atrium brings passive solar gain in winter but risks overheating in summer.

Most classrooms face north.

Years 7 and 8 have gentler single-story accommodation.

Main hall and sports hall are submerged below ground level.
Riverhead Infants (Architects Design Practice / Slender Winter)
Solutions without Compromise

An example: a 350 pupil primary
The Parameters

- Where is the energy used to heat the building coming from? The boiler? From sunlight through the windows? Or from the pupils themselves?
- Will the design use less energy if we re-orientate it?
- Does it matter if we follow a lightweight or a heavyweight philosophy (i.e. use concrete and blocks, or use lightweight thermal panels and plaster board)?
- Are big windows or small windows a good idea?
- Does it make sense to super-insulate a school?
- How important is it to ensure heating and lighting systems are designed and controlled such that energy is not unnecessarily used.
- How much attention to detail, both in design and construction, is it worth applying to minimising infiltration through the fabric?
- **How little energy does a school really need to use?**
- What size of photovoltaic array or wind turbine might be needed to power the school, and how much might this cost?
Design 1: pretty much as drawn

- heavyweight
- classrooms facing south
- large windows
- heating controlled to 22°C
- U-values meet current regulations
- gas boiler

128 MWh = 46 kWh/m²
Where is the energy used?

- **Fabric loss**: 70%
- **Natural vent loss**: 15%
- **Infiltration loss**: 15%
- **Classrooms**: 35%
- **Hall, library etc.**: 18%
- **Circulation and admin**: 47%

Total energy use: 46 kWh/m²
Design 2: 18 deg. C

- Temp
- Solar
- Gas ↓ 34%
- People
- Boiler

Load (kW)

Air temperature
People gain
Solar gain
Heating plant sensible load
## Building orientation and thermal mass

<table>
<thead>
<tr>
<th>Orientation of classrooms</th>
<th>Thermal mass</th>
<th>Occupied Hours above 25°C</th>
<th>Occupied Hours above 28°C</th>
<th>Heating (MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>High</td>
<td>197</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>East</td>
<td>High</td>
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</tr>
<tr>
<td>West</td>
<td>High</td>
<td>310</td>
<td>10</td>
<td>99</td>
</tr>
<tr>
<td>South</td>
<td>Low</td>
<td>480</td>
<td>75</td>
<td>58</td>
</tr>
</tbody>
</table>
Smaller Windows

For the South facing design, reducing the window area from 77% of the main facade to 23% reduces heating energy consumption by 33%

Reducing the U-values

Halving the mean U-value reduces heating energy consumption by 50% - much more than some might think
Well designed lighting

Specifying 7 W/m² not 12 W/m² reduces the total CO₂ emissions by 9%

Reducing infiltration

Reducing the night-time infiltration rate (from 0.25 ac/h to 0.1 ac/h) reduces gas consumption by 17%
Putting it all together (Design 16)

- Solar gain 25%
- Heating plant 3%
- Lighting gain 10%
- Equipment gain 12%
- People gain 50%

10 MWh heating per annum, down 92% on design 1

Note: this has been achieved without heat recovery or redistribution
So, who is going to be the first to build a zero-carbon, *unheated*, school?
Energy is not the only question
\[ \frac{d\delta T_{\text{max, internal}}}{d\delta T_{\text{max, external}}} = C_{T_{\text{max}}} \]
Conclusions

1. If we are to stand any chance of not displacing large populations or reaching a tipping point, we need to keep the temperature increase to <2°C.

2. This will require us to cut our carbon emissions by around 80%; they are currently growing.

3. As this cut is for the whole economy, including transport and existing buildings, there is only one possible conclusion – all new buildings from TODAY must have zero carbon emissions.

4. Historically we have shown ourselves very poor at cutting energy consumption.

5. We should expect change and not assume we will get away with 2°C; we should plan for 4°C.

6. This means new buildings need to be above the water line and not overheat during our new super-hot summers (i.e. $C_T$ needs to be < 1).