UKCIP Adaptation Wizard case study: Red Hill Primary School

This case study was developed by Worcestershire County Council using the UKCIP Adaptation Wizard (Version 1.0). The Adaptation Wizard was used by the County Council's architect to assess the impacts of climate change on a new school and to provide an initial outline adaptation strategy for the design and construction phases, and throughout the design life of the building.

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Scoping the impacts of climate change

Are climate impacts important to me?

Red Hill Primary School is currently at the site survey stage in its development. The current school occupying the site was built in 1965, and will be completely re-built. The new school has a 60-year design life, and therefore, decisions made will have long-term consequences.

Climate impacts are important to the building and construction sector because of the long timescales involved. The impact of climate change on the school building and on the services such as drainage will need to be considered at an early stage.

How will climate change?

Over the coming century we expect that in the UK:

- temperatures will increase;
- winter rainfall will get heavier;
- summer rainfall may reduce considerably;
- sea levels will rise;
- changes in extremes, such as more very hot days and intense rainfall;
- may also be more storms crossing UK, though we are not yet sure about this;
- and at any given point in time natural variations could add to, or act against, the climate change effect.

Climate information for Worcestershire based on the UKCIP02 climate change scenarios (for Medium-low & High Emissions):

	Medium-low emissions	High emissions
Average annual temperature increase		
2020s	0.9°C	1.0°C
2080s	2.5°C	4.1°C
Average winter temperature increase		
2020s	0.7°C	0.9°C
2080s	1.9°C	3.1°C
Average summer temperature increase		
2020s	1.2°C	1.2°C
2080s	3.1°C	5.1°C
Average winter precipitation increase		
2020s	5%	5%
2080s	13%	22%
Average summer precipitation reduction		
2020s	-11%	-11%
2080s	-29%	-48%
Average summer cloud cover reduction		
2020s	-3.3%	-3.5%
2080s	-8.7%	-14.4%

What are the climate impacts on my sector/area?

Extreme events such as storms or heatwaves will intensify impacts following events whereas gradual change in conditions (e.g. year by year rise in annual temperature) will exacerbate the impacts in the longer term.

Higher rainfall in winter, more intense periods, driving rain

- The site is not located in a floodplain but managing rainfall needs consideration as the site is in a marshy dip - SUDS schemes, grey-water recycling and green roofs are being considered to decrease the amount of run-off from the site.

- Use of level thresholds for better access needs some thought due to increased problems of flooding - slopes and step drains could be used.

- Windows could be set inside frames (Scottish approach) to adapt to possible increased problems of driving rain. This method is also beneficial as the seal is more airtight and less heat loss results.

- Durability of materials - consideration of use of more durable timber cladding such as red cedar, which does not need treating against decay.

Milder winters

- Possible problems of increased mould growth in buildings - natural & mechanical ventilation will help this, but conflicts with heat loss - could use heat exchangers or extractor fans.

Hotter drier summers

- Increased temperatures - Strict controls on indoor temperatures in schools are set by DfES BB87. Natural ventilation will be used, but noise may be a problem (close proximity of site to roads and railway). Orientation of buildings and classrooms, acoustically lined ventilation stacks, phase cooling and shade structures could provide solutions, especially in computer rooms. Mechanical ventilation may be needed in areas of high heat load (e.g. ICT room) to ensure regulations in BB87 are met, especially with regard to temperature regulations and possible changes in school terms (schools may then be occupied during hottest summer days).

- Subsidence - soil type of site currently unknown - a tree survey has been carried out and has identified redundant or insignificant trees that need to be removed from the site, as well as those which must be retained. Foundation design will be considered carefully with subsidence in mind e.g. deeper, short-bore piled or raft foundations.

- Lower cloud cover and higher temperatures - the design brief includes outdoor classroom spaces, and therefore shading is very important. Over- sailing roofs and trees could provide solutions.

- Ground contaminants - soil testing will identify any problems, and use of suitable foundation materials.

Increased wind speeds/extreme storms
- Safety concerns and increased damage to building - County Council does not insure buildings, so it bears all risks and costs of repairs. The roof or building could be designed with an aerodynamic shape.

Will climate impacts be more or less important than the other risks I face?

Other risks that are important include:
- Legal and regulatory - the design of schools is controlled by DfES regulations. Any changes to these, such as the recent changes in acoustics regulations will affect the design of the school directly e.g. acoustic regulations have recently been tightened and windows can no longer open into corridors for ventilation. Some of these regulations include climate considerations, such as indoor temperature regulations in BB87, requiring that the temperature does not exceed 28°C more than 10 days a year.

- Environmental risks - these are also included in regulations provided by DfES, e.g. concerning carbon emissions in schools.

- Financial risks - Budgetary constraints are an important risk. Climate impacts are an important risk and methods built into the design to adapt to climate change could be used as extra leverage in applying for the highest budget possible.

Could there be indirect climate impacts too?

An indirect impact may be possible delays to construction work due to the weather. These timescales are shorter, as the school will be built within the next two years, and therefore, construction work may be vulnerable to short-term weather extremes. This is related to the financial risks and budgetary constraints.

What are my priority risks?

Priority risks relate to those risks that cannot be changed within the lifetime of the building. These risks are too expensive to change later, and include the following:

- Location of building
- Building orientation
- Thermal mass of building
- Structural building materials

It is very important to consider climate change in these risk areas because they are permanent structures, and as the school has a design life of 60 years, decisions have long-term planning horizons. These risks could potentially be adaptation constraining decisions if they are implemented wrong at the design stage e.g. if the building orientation allows south-facing windows in classrooms, future adaptation strategies such as shading and natural ventilation will be more difficult and constrained.

Quantifying risks

What is my attitude to risk?

The critical thresholds are socially constructed, and included in strict regulations set by the DfES, e.g. with regard to temperature and ventilation. If exceeded, these will cause unacceptable risks e.g. health and safety risks to occupants of the school. Poor internal environment (e.g. overheating) reduces the potential performance of the pupils, by reducing the ability to concentrate etc.

How significant are the climate risks on my area/sector?

Climate risks are very significant on the construction of Red Hill School.

How do these compare to the non-climate risks?

Non-climate risks were identified as:
- Legal and regulatory - DfES guidelines are constantly changing. Temperature regulations for schools could be relaxed upwards.
- Environmental risks - it is likely that these regulations will become more stringent in the future e.g. with regard to reducing carbon emissions.
- Financial risks - future changes will affect budgets for maintenance and retrofitting.

How much could climate impacts cost?

Costs of climate impacts could be considerable if no adaptation planning is done. This could include costs from subsidence, flooding, higher summer temperatures (costs of installing and using air conditioning if natural ventilation is ineffective). As the school would not be insured, the County Council would bear all costs of maintenance and repairs necessary due to climate impacts. Costs of retrofitting due to climate impacts will probably be more if they are not included at the design stage.

Do I need to adapt to climate risks?

Yes. The school is expected to have a design life of 60 years, which is within the expected timeframe of significant changes in climate. Climate risks affect the school building and the occupants inside. If the school is not built with climate change considerations, for e.g. warmer temperatures, the critical thresholds will not be met.

How confident am I about this assessment?

Confident that climate risks will be significant compared to other risks, and that these have been considered. Also confident about how the development will respond to the predicted changes in climate e.g. warmer temperature and rainfall.

Decision-making & action planning

How should I adapt to climate risks?

Actions will be focussed on priority risks, as identified earlier, including location of building, orientation, construction materials, and thermal massing. These will be balanced with other risks, such as financial risks and budgetary constraints.

Other climate risks, which can be dealt with later at a relatively low cost and inconvenience, such as more trees for shading, will be given less priority. However, it should be noted that choosing the correct tree species to cope with climate change is important, especially since many species take a long time to grow.

What adaptation strategy is most appropriate?

No-regret adaptation strategies are most appropriate. These include window sealing and natural ventilation which will have many advantages, including cost savings, and will be beneficial even if the climate does not change from today.

Climate headroom is also important, and contingencies for future adaptation could include planning to ensure that phase change packs could be installed where there is mechanical ventilation in the school at a later date if natural ventilation is ineffective due to higher summer temperatures, especially in vulnerable areas such as computer suites. This is a win-win adaptation strategy, as it would fit economic budgets today and improve ability to adapt in the future.

A win-win strategy would be to include substantial roof overhangs - this provides protection of the building from driving rain, solar shading to windows to reduce the risk of overheating, as well as providing sheltered and shaded outdoor classroom areas. There are cost implications to providing this facility, however.

Adaptation constraining decisions need to be avoided, especially in decisions regarding permanent structures of the school.

What level of adaptation is required?

The level of adaptation required will depend on regulations provided by DfES and budgetary constraints.

What will happen if I over- or under-adapt?

Over-adaptation will result in overspending. Under-adaptation may mean more costs in the future for example, maintenance costs.

When do I need to take action?

Action needs to be taken straight away. The site survey, planning and design stages of the school will all need to incorporate climate change considerations and adaptation options.

How can I minimise the cost of adapting?

Costs of adapting to climate change can be minimised if adaptation is built into the early stages of planning for the new school. These adaptation measures can then be included in budgets, which will minimise the costs of maintenance or retrofitting in the future.

Adaptation strategy review

Do I have a sensible adaptation strategy?

Yes. The adaptation strategy takes a balanced approach with consideration of other risks such as budgetary, and legal and regulatory risks.

No-regret and win-win options have been identified, and will be implemented where possible to provide benefits regardless if the climate changes.

How often should I review my strategy?

If circumstances fundamentally change during the construction process, the strategy will need to be reviewed.

The strategy will be reviewed be at the maintenance stage. Details on climate adaptations used need to be written into maintenance details included at hand over.

The strategy review will be included in the Asset Management Plan - currently they react to incidences of flooding & overheating in existing building stock rather than anticipating these events. The effectiveness of the review will therefore depend on the users of the school and reporting of problems.

When should I change my strategy?

Strategy should be monitored through energy management systems and general property management systems and any problems identified should be changed.

Update on UKCIP Adaptation Wizard case study: Red Hill Primary School

This update reviews the effect the use of the UKCIP Adaptation Wizard had on the completed design of Red Hill Primary School in Worcester.

The original case study was developed by Gina Cavan and Worcestershire County Council using the UKCIP Adaptation Wizard (Version 1.0). The County Council's architect took part in a pilot of the Adaptation Wizard to assess the impacts of climate change on a new school in the early design stage and to provide an initial outline adaptation strategy for the design and construction phases, and throughout the design life of the building. The building is now completed, and due to be handed over in June 2007.

Following the analysis of the possible climate impacts, the original case study went on to look at options for building and site design for mitigating the following climate change impacts.

Higher rainfall in winter, more intense periods, driving rain

- A sustainable urban drainage scheme has been implemented on site using swales, ponds and underground box storage.
- A rainwater harvesting scheme, used for flushing toilets, takes rain from approximately half the roof area.
- Other roof areas have a planted roof finish (sedum) to reduce run-off.
- Large overhangs on the roof and canopies have been provided to protect level thresholds (required for disabled access) from heavy rain.
- We chose not to set the windows behind the cladding (Scottish approach) but instead used a polythene membrane to provide a seal between the window and wall for airtightness.
- Durability of materials – areas of cedar boarding are protected by the larger roof overhangs. Other cladding materials are brickwork to external walls and low-maintenance zinc standing seam roofing.
- Wide gutters with emergency overflow points provide for periods of sudden intense rain. All gutters are protected by zinc mesh gutter guards to reduce risk of blockage from leaves.

Milder winters

- To avoid problems of mould growth, we have tried to ensure that there are no cold spots (‘thermal bridges’) in the building fabric, by ensuring continuity of insulation.
- All vulnerable areas are well ventilated, particularly wet areas like toilets and showers. We are using proprietary extract vents powered by small photovoltaic panels.
- The building is heated using a ground source heating system feeding an underfloor system. The heat pumps will run on electricity purchased on a green tariff. Overall, this provides a heating system with low carbon emissions.

Hotter drier summers

- Shade is provided by overhanging eaves and external canopies to the classrooms.

- Due to external noise problems (close proximity of site to roads and railway), acoustically lined ductwork is used for incoming and exhaust ventilation. This provides enough ventilation for normal summer temperatures. In extremes, additional windows and patio doors can be opened to provide additional ventilation.

- The ICT suite, which is the area of highest heat load, has air cooling which uses a heat pump linked to the ground source heating system, operating in reverse.

- Foundation design: the location of trees was taken into account in designing the raft foundation for the building, which was thickened at the perimeter where clay heave could have caused problems.

Increased wind speeds/extreme storms

- The profile of the building is relatively aerodynamic having a low double pitch with a smooth curve over the roof of the hall.

- Roof coverings are zinc sheet with standing seams which may be less vulnerable to high winds than roofing tiles.

Priority risks

Priority risks were also identified. These are recognised as those risks that cannot be changed within the lifetime of the building. These risks are too expensive to change later, and include the following:

- Location of building

- Building orientation

- Thermal mass of building

- Structural building materials

Reviewing these again after completion of the detailed design, it is interesting to note that a number of decisions were driven primarily by other site constraints and environmental consideration rather than climate impact concerns. However, we have sought to

mitigate some of the effects of these decisions by other means to assist resilience against climate change impacts.

Location of building – we used the lowest part of the site, though this was potentially prone to flooding. This was because, on this long, narrow site, only this part of the grounds was wide enough to accommodate the school building and provide suitable access. However, raising the floor level by 150 mm compared to the previous building on the site, and implementing the sustainable urban drainage scheme mitigated the risk.

Building orientation – the classrooms face south away from the main noise sources of the road and railway. However, the classrooms now benefit from south facing terraces, which are shaded by existing mature trees. External canopies and blinds provide further solar shading.

Thermal mass and structural building materials

These items are clearly interrelated. The main framing material for the building is steel, which helps form the curved geometry of the building and provides some future flexibility, as internal walls are non-loadbearing. Internal and external walls are mainly timber framed, which was chosen as a renewable resource with low embodied energy content. This was used in conjunction with high levels of insulation, using materials of high recycled content. For robustness and for added thermal mass, a double layer of plasterboard is used on both sides of every internal wall. As is normal for a zinc roof, this is fully ventilated beneath the timber boarded substrate which supports the zinc, allowing warm air to naturally circulate in summer reducing heat transfer into the building. An underlayer of bitumen impregnated fibreboard provides further insulating separation between external and internal conditions.

The school hall and kitchen areas have the greatest building mass as these are constructed in concrete blockwork. A block of high recycled content was used to reduce its embodied energy. Blockwork was chosen in these areas for its robustness as well as its thermal mass.

Conclusions

Reviewing the effect the use of the UKCIP adaptation wizard had on the completed design of the school, I note that it had a positive impact in shaping the design in many ways, for instance in terms of shading, roof overhangs and rainwater management. Site constraints have also tended to shape the building in many other important respects, for instance orientation. Summer overheating remains a concern in much of the building stock, given recent and predicted summer temperatures. We have found some conflict between providing thermal mass and using materials of low embodied energy, chosen for environmental reasons. It has therefore been particularly important to provide sufficient natural stack ventilation in the building, not only to cater for fresh air needs but also to boost cooling when the weather produces higher temperatures outside.

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