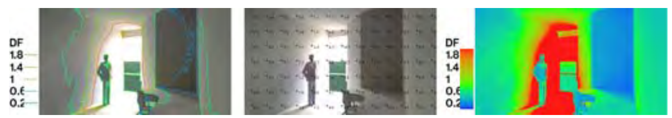
Gifford mind maps

Visual communication of technical information

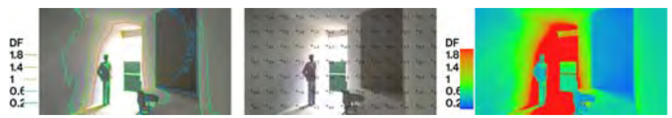
Gifford



In a complex world

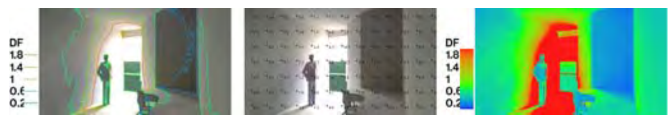
- Information overload
- Regulations changing too fast
- Rules of thumb long gone
- Design compromise

How to achieve good architecture and functional buildings…?



…Gifford mind maps

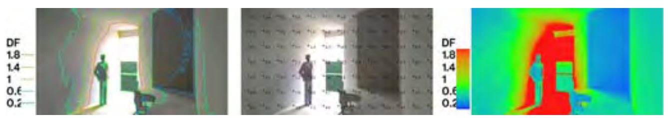
- A superset of experience and relevant standards
- Brief summaries for key topics
- Suitable for RIBA Stage C concept design
- Help clarify brief and route through the issues
- Give difficult issues a sense of scale and significance

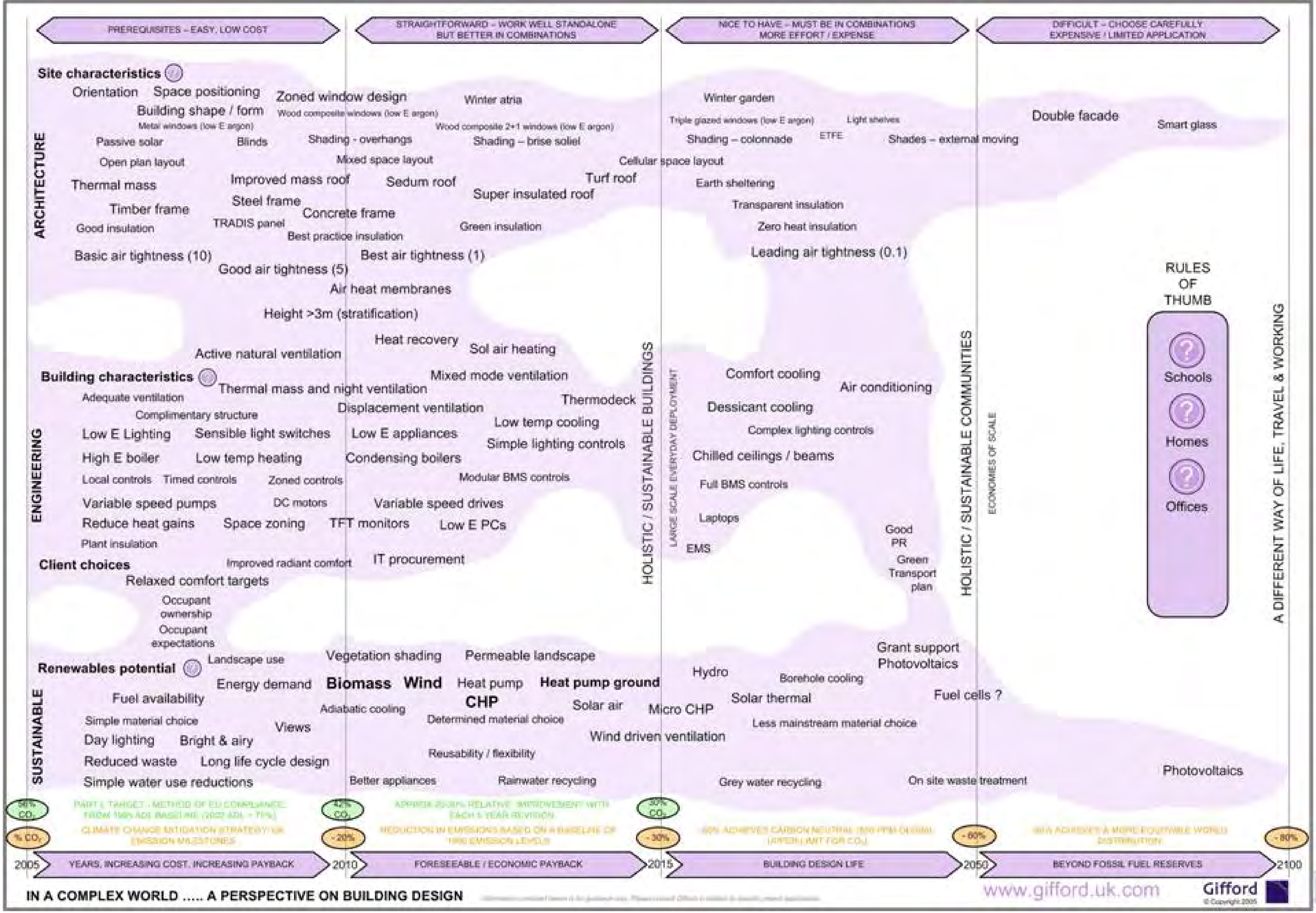


Topics covered

- Generic building design
- Renewable energy
- Legislation and consequences
- Building characteristics
- Site characteristics
- Sustainable buildings checklist
- School design
- Housing design

… more to follow




PREREQUISITES – EASY, LOW COST
STRAIGHTFORWARD – WORK WELL STANDALONE BUT BETTER IN COMBINATIONS
NICE TO HAVE – MUST BE IN COMBINATIONS MORE EFFORT / EXPENSE
DIFFICULT – CHOOSE CAREFULLY EXPENSIVE / LIMITED APPLICATION
ARCHITECTURE
Site characteristics
Orientation
Space positioning
Zoned window design
Winter atria
Winter garden
Building shape / form
Wood composite windows (low E argon)
Metal windows (low E argon)
Wood composite 2+1 windows (low E argon)
Triple glazed windows (low E argon)
Light shelves
Double facade
Smart glass
Passive solar
Blinds
Shading - overhangs
Shading – brise soliel
Shading – colonnade
ETFE
Shades – external moving
Open plan layout
Mixed space layout
Cellular space layout
Thermal mass
Improved mass roof
Sedum roof
Turf roof
Earth sheltering
Super insulated roof
Timber frame
Steel frame
Concrete frame
Transparent insulation
Good insulation
TRADIS panel
Best practice insulation
Green insulation
Zero heat insulation
Basic air tightness (10)
Good air tightness (5)
Best air tightness (1)
Leading air tightness (0.1)
Air heat membranes
Height >3m (stratification)
RULES OF THUMB
Schools
Homes
Offices
Heat recovery
Sol air heating
Active natural ventilation
ENGINEERING
Building characteristics
Mixed mode ventilation
Thermal mass and night ventilation
Comfort cooling
Air conditioning
Adequate ventilation
Displacement ventilation
Thermodeck
Dessicant cooling
Complimentary structure
Low temp cooling
Complex lighting controls
Low E Lighting
Sensible light switches
Low E appliances
Simple lighting controls
High E boiler
Low temp heating
Condensing boilers
Chilled ceilings / beams
Local controls
Timed controls
Zoned controls
Modular BMS controls
Full BMS controls
Variable speed pumps
DC motors
Variable speed drives
Reduce heat gains
Space zoning
TFT monitors
Low E PCs
Laptops
Plant insulation
EMS
Good PR
Green Transport plan
Client choices
Improved radiant comfort
IT procurement
Relaxed comfort targets
Occupant ownership
Occupant expectations
HOLISTIC / SUSTAINABLE BUILDINGS
LARGE SCALE EVERYDAY DEPLOYMENT
HOLISTIC / SUSTAINABLE COMMUNITIES
ECONOMIES OF SCALE
A DIFFERENT WAY OF LIFE, TRAVEL & WORKING
SUSTAINABLE
Renewables potential
Landscape use
Vegetation shading
Permeable landscape
Grant support
Photovoltaics
Energy demand
Biomass
Wind
Heat pump
Heat pump ground
Hydro
Borehole cooling
Fuel availability
CHP
Solar thermal
Fuel cells ?
Adiabatic cooling
Solar air
Micro CHP
Simple material choice
Determined material choice
Less mainstream material choice
Views
Day lighting
Bright & airy
Wind driven ventilation
Reduced waste
Long life cycle design
Reusability / flexibility
Photovoltaics
Simple water use reductions
Better appliances
Rainwater recycling
Grey water recycling
On site waste treatment
42% CO_2
APPROX 20-30% RELATIVE IMPROVEMENT WITH EACH 5 YEAR REVISION
30% CO_2
% CO_2
CLIMATE CHANGE MITIGATION STRATEGY/ UK EMISSION MILESTONES
-20%
REDUCTION IN EMISSIONS BASED ON A BASELINE OF 1990 EMISSION LEVELS
-30%
-60%
-80%
2005
YEARS, INCREASING COST, INCREASING PAYBACK
2010
FORESEEABLE / ECONOMIC PAYBACK
2015
BUILDING DESIGN LIFE
2050
BEYOND FOSSIL FUEL RESERVES
2100
IN A COMPLEX WORLD ..... A PERSPECTIVE ON BUILDING DESIGN
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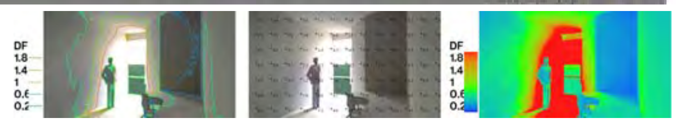
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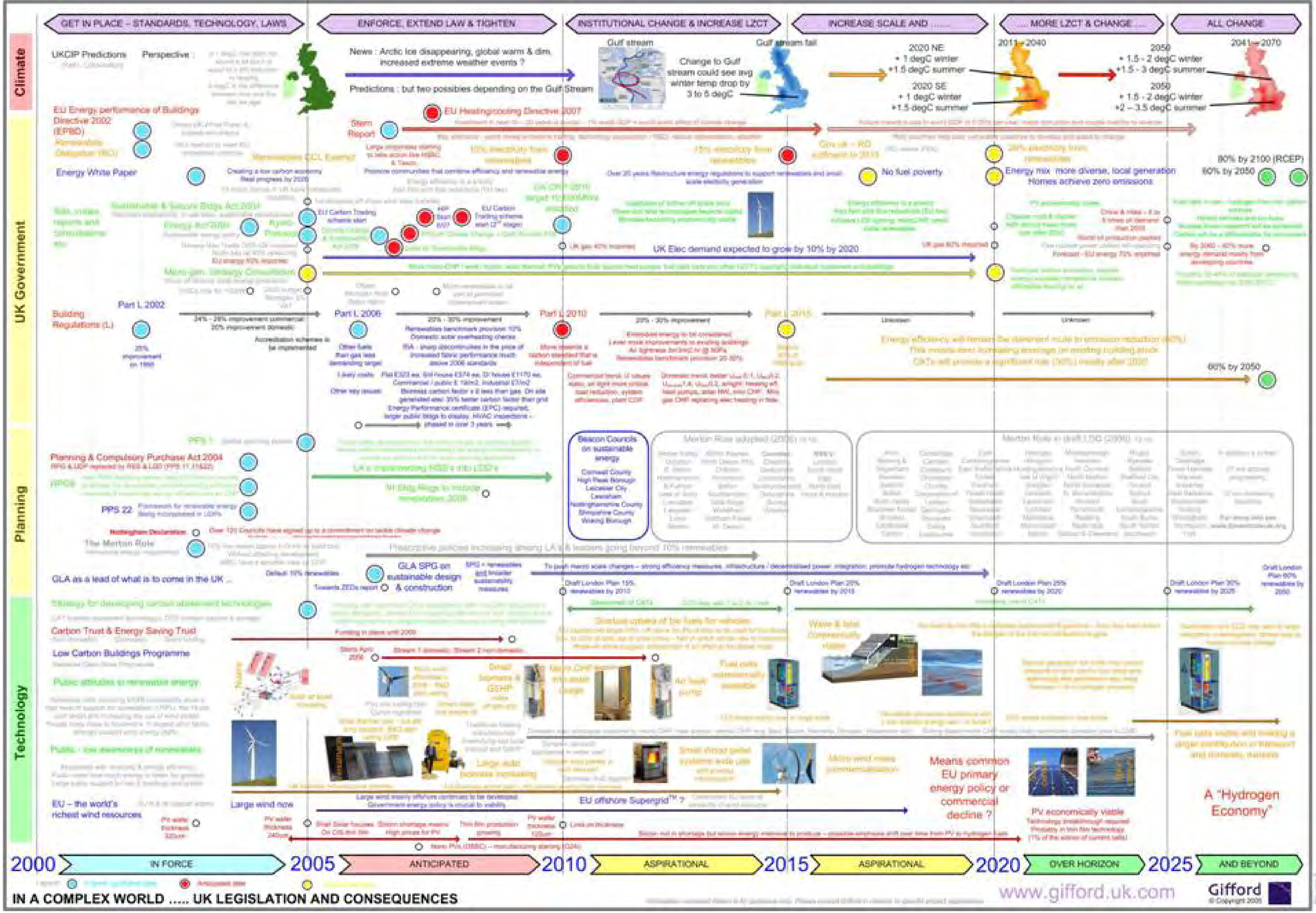
GET IN PLACE – STANDARDS, TECHNOLOGY, LAWS
ENFORCE, EXTEND LAW & TIGHTEN
INSTITUTIONAL CHANGE & INCREASE LZCT
INCREASE SCALE AND ....
..... MORE LZCT & CHANGE .....
ALL CHANGE
Climate
UK Government
Planning
Technology
UKCIP Predictions
Perspective :
News : Arctic ice disappearing, global warm & dim, increased extreme weather events ?
Predictions : but two possibles depending on the Gulf Stream
Gulf stream
Gulf stream fail
Change to Gulf stream could see avg winter temp drop by 3 to 5 degC
2020 NE
+ 1 degC winter
+1.5 degC summer
2020 SE
+ 1 degC winter
+1.5 degC summer
2011 – 2040
2050
+ 1.5 - 2 degC winter
+1.5 - 3 degC summer
2050
+ 1.5 - 2 degC winter
+2 – 3.5 degC summer
2041 – 2070
EU Energy performance of Buildings Directive 2002 (EPBD)
Renewables Obligation (RO)
EU Heating/cooling Directive 2007
Stern Report
Renewables CCL Exempt
10% electricity from renewables
15% electricity from renewables
Gov uk – RO extension to 2015
20% electricity from renewables
80% by 2100 (RCEP)
60% by 2050
Energy White Paper
No fuel poverty
Energy mix more diverse, local generation
Homes achieve zero emissions
Sustainable & Secure Bldgs Act 2004
EU Carbon Trading scheme start
EU Carbon Trading scheme start (2nd stage)
Energy Act 2004
Kyoto Protocol
UK gas 40% imported
UK Elec demand expected to grow by 10% by 2020
UK gas 80% imported
Micro-gen. Strategy Consultation
Building Regulations (L)
Part L 2002
Part L 2006
Part L 2010
Part L 2015
24% - 28% improvement commercial
20% improvement domestic
20% - 30% improvement
20% - 30% improvement
Unknown
Unknown
Accreditation schemes to be implemented
25% improvement on 1995
60% by 2050
PPS 1
Planning & Compulsory Purchase Act 2004
PPG & UDP replaced by RSS & LDD (PPS 11,12&22)
RPG9
PPS 22
LA's implementing RSS's into LDD's
All Bldg Regs to include renewables 2008
Beacon Councils on sustainable energy
Cornwall County
High Peak Borough
Leicester City
Lewisham
Nottinghamshire County
Shropshire County
Woking Borough
Merton Rule adopted (2006) so far
Merton Rule in draft LDD (2006) so far
Nottingham Declaration
Over 120 Councils have signed up to a commitment to tackle climate change
The Merton Rule
Prescriptive policies increasing among LA's & leaders going beyond 10% renewables
GLA as a lead of what is to come in the UK ...
GLA SPG on sustainable design & construction
Default: 10% renewables
Draft London Plan 15% renewables by 2010
Draft London Plan 20% renewables by 2015
Draft London Plan 25% renewables by 2020
Draft London Plan 30% renewables by 2025
Draft London Plan 60% renewables by 2050
Strategy for developing carbon abatement technologies
Carbon Trust & Energy Saving Trust
Funding in place until 2008
Low Carbon Buildings Programme
Starts April 2006
Public attitudes to renewable energy
Wave & tidal commercially viable
Micro-CHP
Air Source pump
Fuel cells commercially available
Public - low awareness of renewables
Small wood pellet systems wide use
Micro-wind mass commercialisation
Means common EU primary energy policy or commercial decline ?
EU – the world's richest wind resources
Large wind now
EU offshore Supergrid™ ?
PV economically viable
A "Hydrogen Economy"
2000
IN FORCE
2005
ANTICIPATED
2010
ASPIRATIONAL
2015
ASPIRATIONAL
2020
OVER HORIZON
2025
AND BEYOND
IN A COMPLEX WORLD ..... UK LEGISLATION AND CONSEQUENCES
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DF
1.8
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DF
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1.4
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MICRO SCALE < 2 kW
SMALL SCALE < 15 kW
MEDIUM SCALE < 250 kW
LARGE SCALE < 2 MW
POWER PLANT SCALE > 2MW
ULTRA LARGE > 50MW
BUILDING INTEGRATED
SITE INTEGRATED
ENERGY FARM – DEDICATED SITE
Carbon offsetting
Grid connected
Off-grid
Photovoltaics
UK £500 - 750/m²
0.057TCO₂/m²/yr grid displaced
£4k
0.6kWp = 5m²
0.29 TCO₂
£10k
2.5 kWp = 20m²
1.1 TCO₂
£60k
10kWp = 80m²
4.6 TCO₂
£120k
20KW = 160m²
9.2 TCO₂
£200 - 300k
50kWp = 400m²
23 TCO₂
£500 - 750k
125kWp = 1000m²
57 TCO₂
500kW = 4000m²
230 TCO₂
2004: global installed capacity = 2500MW
Mojave Desert, Worlds largest PV 5MW
2010: projected annual global capacity installed = 4000MW
Solar
Solar thermal hot water
UK £500/m²
UK £350/m²
0.1TCO₂/m²/yr
0.07TCO₂/m²/yr
£3k
5m² flat plate
0.7 TCO₂
£6k
Solar air + HW + HX
0.6 – 1.4 TCO₂
£11k
12kW, 24m² vacuum tube
2.4 TCO₂
£80k
100kW, 200m² vacuum tube
20 TCO₂
District solar thermal 100kw – 10MW
Concentrating solar thermal (CSP) 2MW dish Australia
10MW power tower, Barstow, California
2006 - 200MW tower, australia
Heat pumps
Air source heat pump COP = 2.5
Ground source heat pump COP = 3 to 5
£3k
1.5kW air source heat pump for apartments
0.4 TCO₂
£8k
6kW ground source heat pump with 6kW electric backup, slinky collector
1.3 TCO₂
£50k
35kW ground source heat pump with boreholes
4 TCO₂
£170k
200kW ground source heat pump for 50 apartments
30 TCO₂
ICAX
Interseasonal heat transfer system, heating and cooling 12,000m² school
110 TCO₂
Ground coupled cooling with COP > 100 Still in development
CHP
Prototype solid oxide fuel cell 1kW electrical 1kW thermal 80% efficiency
£1.3k/unit
£3k/unit
Domestic gas CHP 1.2kW electrical 12kW heat
1.6 TCO₂
Mini CHP 5.5kW electrical 12.5kW heat
5.2 TCO₂
£42k
Reciprocating gas engine, 80kW thermal, 50kW electrical
36 TCO₂
£220k
Combined cycle gas turbine, 300kW thermal, 200kW electrical
150 TCO₂
£300k
Woodfuel CHP
£960k
Combined cycle gas turbine, 1.5MW thermal, 2MW electrical
1500 TCO₂
£2.5m
Combined cycle gas turbine, 9MW thermal, 4.5MW electrical
9000 TCO₂
Biomass
Logs
Wood chip 1p/kWh
Wood pellet 3 to 4p/kWh
£3k
6kW domestic log stove
1 TCO₂
£4-6k
8kW domestic pellet stove
2 TCO₂
£8-10k
20kW domestic log boiler
4 TCO₂
£30k
40kW auto pellet boiler
10 TCO₂
50 TCO₂
264 TCO₂
0.5 - 1MW auto chip boiler
Process heat, cost effective, consider CHP
£1.8m
Biomass CHP 8MW thermal, 1MW electrical
6000 TCO₂
£60m
Biomass Power station 38MW, 270Gwhr/yr
115k TCO₂
Wind
£600
400W dc 600kWh/yr
0.25 TCO₂
£1.5 to 2k
1kW ac 1,500kWh/yr
0.8 TCO₂
£7k
1.5 kW ac 2,000kWh/yr
1TCO₂/ratedkW/yr
£12k
2.5kW 4,000kWh/yr
2TCO₂
£18k
5kW 9,000kWh/yr
5TCO₂
£40k
15kW 30,000kWh/yr
17TCO₂
100kW 200,000kWh/yr
100+TCO₂
£0.5M
330kW 600,000kWh/yr
340TCO₂
500kW 1M kWh/yr
570 TCO₂
1.5MW 4.5M kWh/yr
2.5k TCO₂
2MW 8M kWh/yr
4.5k TCO₂
3MW 14M kWh/yr
8k TCO₂
5MW ?
4.5MW developed 2006
90MW offshore wind farm
220k TCO₂
560MW onshore wind farm Altamont, California
450k TCO₂
Large single turbines
Other
£500
0.53m dia light pipe
0.1TCO₂/yr
£4-10k/kW
Micro-hydro, < 1kW; domestic
Reed beds, grey-water, rainwater
Saves extract, process, waste process
£20k
Small-hydro, typical 5kW
<4k/kW
Medium-hydro, >10kW
75kW wave, air based,1.8 Mkwhr
£80-160k
100kW hydro, low head
£50-130k
100kW hydro, high head
Phosphoric acid fuel cell CHP Demonstration stage 50-200kW + some up to 5MW
2.2MW wave Portugal
7.5k TCO₂
Geothermal
240MW tidal France 640M Kwhr
480k TCO₂
Equivalents
£30
10 Fluorescent light bulbs saves 0.2TCO₂
1000km journey 0.2TCO₂
15km/ workday saves 0.75TCO₂
200m² low-e house htg & hw < 1TCO₂
Typical home lights & appliances 1 - 2TCO₂
80m² apartment htg & hw 1.5TCO₂
Equitable global citizen 2TCO₂
120m² typ house htg & hw 3-5TCO₂
Annual 20,000 km 4TCO₂
Average resident UK 10TCO₂
Average resident US 20TCO₂
Primary school 1600m² 40TCO₂
Gifford low energy office, 1500m² 85TCO₂
Annual 150,000 km 125TCO₂
Secondary school 9000m² 300TCO₂
50 million cups of coffee / day, UK 650TCO₂
10,000km flight 800TCO₂
Typical prestige office, 10,000m² 1500TCO₂
500MWe gas power station per day 10,000TCO₂
UK Household standby appliances per day 20,000TCO₂
UK emissions per day 1.6M TCO₂
0
10⁰
10¹
10²
10³
10⁴
10⁶
HOW MUCH CARBON ?
TONNES CARBON DIOXIDE TCO₂ / YEAR
IN A COMPLEX WORLD ..... A PERSPECTIVE ON LOW & ZERO CARBON TECHNOLOGIES (LZCT)
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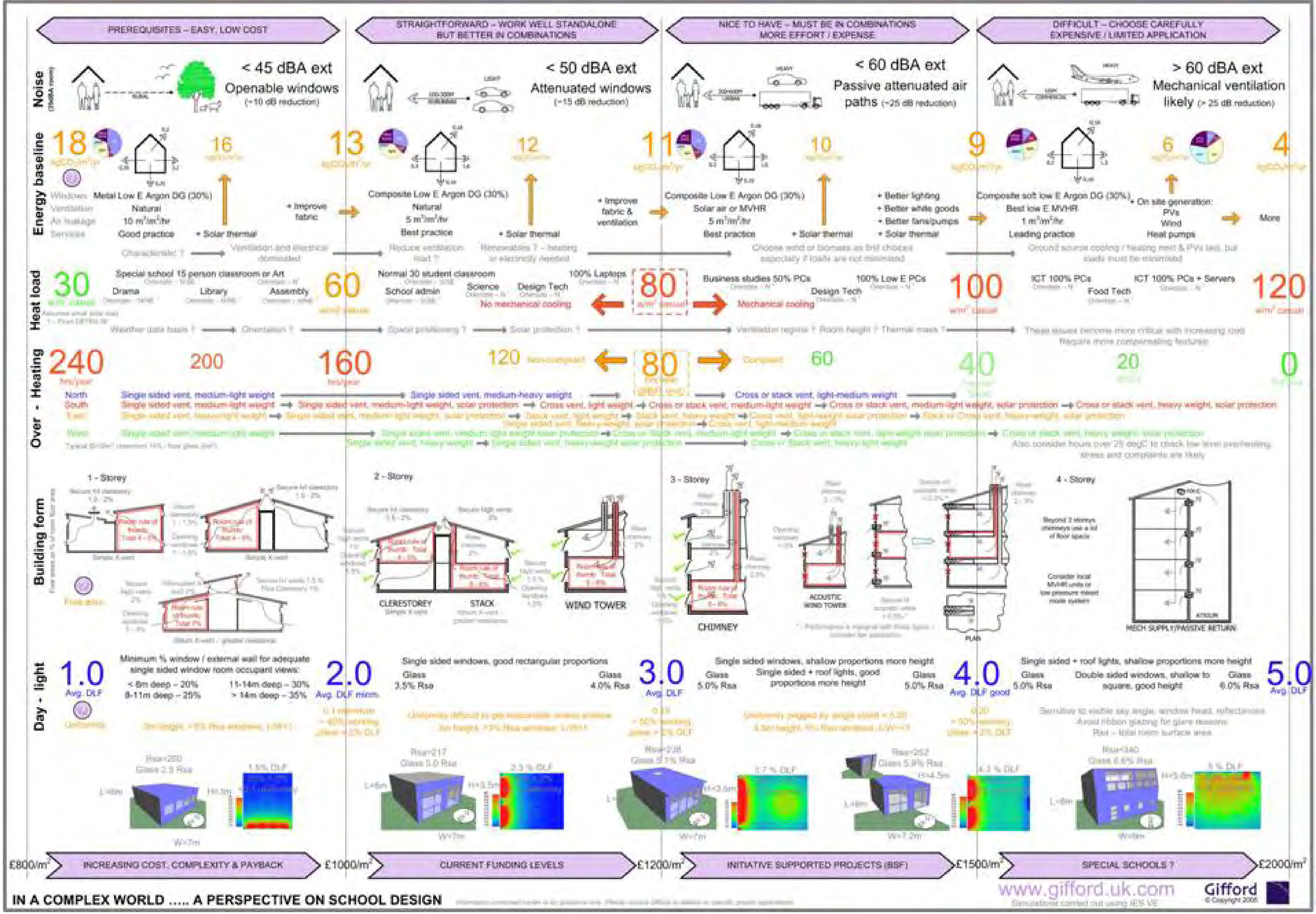

PREREQUISITES – EASY, LOW COST
STRAIGHTFORWARD – WORK WELL STANDALONE BUT BETTER IN COMBINATIONS
NICE TO HAVE – MUST BE IN COMBINATIONS MORE EFFORT / EXPENSE
DIFFICULT – CHOOSE CAREFULLY EXPENSIVE / LIMITED APPLICATION
Noise
< 45 dBA ext
Openable windows
(~10 dB reduction)
< 50 dBA ext
Attenuated windows
(~15 dB reduction)
< 60 dBA ext
Passive attenuated air paths (~25 dB reduction)
> 60 dBA ext
Mechanical ventilation likely (> 25 dB reduction)
Energy baseline
18
16
13
12
11
10
9
6
4
Metal Low E Argon DG (30%)
Natural
10 m³/m²/hr
Good practice
+ Solar thermal
+ Improve fabric
Composite Low E Argon DG (30%)
Natural
5 m³/m²/hr
Best practice
+ Solar thermal
+ Improve fabric & ventilation
Composite Low E Argon DG (30%)
Solar air or MVHR
5 m³/m²/hr
Best practice
+ Solar thermal
+ Better lighting
+ Better white goods
+ Better fans/pumps
+ Solar thermal
Composite soft low E Argon DG (30%)
Best low E MVHR
1 m³/m²/hr
Leading practice
+ On site generation:
PVs
Wind
Heat pumps
More
Heat load
30
Special school 15 person classroom or Art
Drama
Library
Assembly
60
Normal 30 student classroom
School admin
Science
Design Tech
100% Laptops
No mechanical cooling
80
Business studies 50% PCs
100% Low E PCs
Design Tech
Mechanical cooling
100
ICT 100% PCs
ICT 100% PCs + Servers
Food Tech
120
Over - Heating
240
200
160
120
80
60
40
20
0
North
South
East
West
Single sided vent, medium-light weight
Single sided vent, medium-heavy weight
Cross or stack vent, light-medium weight
Building form
1 - Storey
2 - Storey
3 - Storey
4 - Storey
CLERESTOREY
STACK
WIND TOWER
CHIMNEY
ACOUSTIC WIND TOWER
MECH SUPPLY/PASSIVE RETURN
PLAN
Day - light
1.0
Avg. DLF
Minimum % window / external wall for adequate single sided window room occupant views:
< 8m deep – 20%
8-11m deep – 25%
11-14m deep – 30%
> 14m deep – 35%
2.0
Avg. DLF minm
Single sided windows, good rectangular proportions
Glass 3.5% Rsa
Glass 4.0% Rsa
3.0
Avg. DLF
Single sided windows, shallow proportions more height
Glass 5.0% Rsa
Single sided + roof lights, good proportions more height
Glass 5.0% Rsa
4.0
Avg. DLF good
Single sided + roof lights, shallow proportions more height
Glass 5.0% Rsa
Double sided windows, shallow to square, good height
Glass 6.0% Rsa
5.0
Avg. DLF
£800/m²
INCREASING COST, COMPLEXITY & PAYBACK
£1000/m²
CURRENT FUNDING LEVELS
£1200/m²
INITIATIVE SUPPORTED PROJECTS (BSF)
£1500/m²
SPECIAL SCHOOLS ?
£2000/m²
IN A COMPLEX WORLD ..... A PERSPECTIVE ON SCHOOL DESIGN
www.gifford.uk.com
Simulations carried out using IES VE
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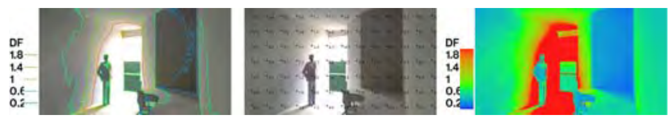

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1.4
1

Excerpt from legislation map

Part L 2006 → **Part L 2010**

20% - 30% improvement

Renewables benchmark provision 10%
Domestic solar overheating checks

Other fuels than gas less demanding target

RIA - sharp discontinuities in the price of increased fabric performance much above 2006 standards

Move towards a carbon standard that is independent of fuel

Likely costs: Flat £323 ea, S/d house £574 ea, D/ house £1170 ea, Commercial / public £ 19/m2, Industrial £7/m2

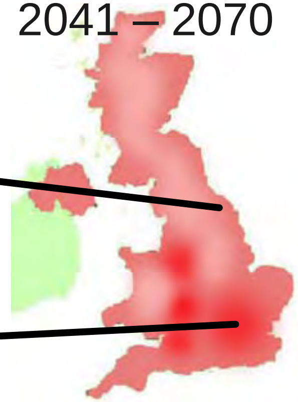
Other key issues: Biomass carbon factor x 8 less than gas. On site generated elec 35% better carbon factor than grid

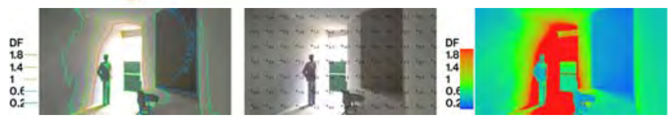
2011 - 2040

2050
+ 1.5 - 2 degC winter
+1.5 - 3 degC summer

2050
+ 1.5 - 2 degC winter
+2 – 3.5 degC summer

2041 – 2070





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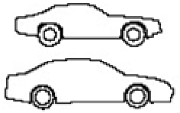
Excerpt from renewables map

Equivalents

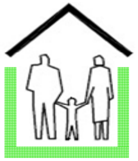
£30

10 Fluorescent light bulbs **saves** **0.2TCO$_2$**



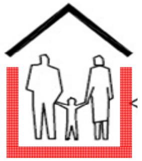
1000km journey **0.2TCO$_2$**

15km/ workday **saves** **0.75TCO$_2$**



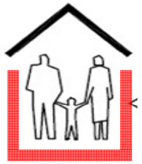
200m^2 low-e house htg & hw **< 1TCO$_2$**

Typical home lights & appliances **1 - 2TCO$_2$**

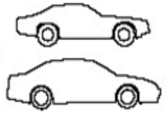


80m^2 apartment htg & hw **1.5TCO$_2$**

Equitable global citizen **2TCO$_2$**



120m^2 typ house * htg & hw **3-5TCO$_2$**



Annual 20,000 km **4TCO$_2$**

0 HOW MUCH CARBON ? 10^0 TONNES CARBON DIOXIDE TCO$_2$ / YEAR 10^1

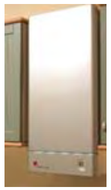
£8k
6kW ground source heat pump with 6kW electric backup, slinky collector
1.3 TCO$_2$

£50k
35kW ground source heat pump with boreholes
4 TCO$_2$

£500 - 750k
125kWp = 1000m^2
57 TCO$_2$

500kW = 4000m^2
230 TCO$_2$

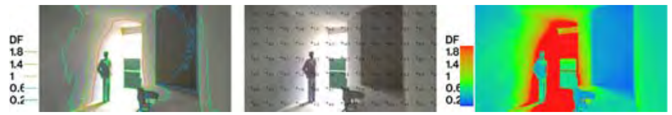
£1.3k/unit supply only (bulk)
£3k/unit installed one-off
Domestic gas CHP
1.2kW electrical
12kW heat
1.6 TCO$_2$



Mini CHP
5.5kW electrical
12.5kW heat
5.2 TCO$_2$

£80k
100kW, 200m^2 vacuum tube
20 TCO$_2$

District solar thermal
100kw – 10MW



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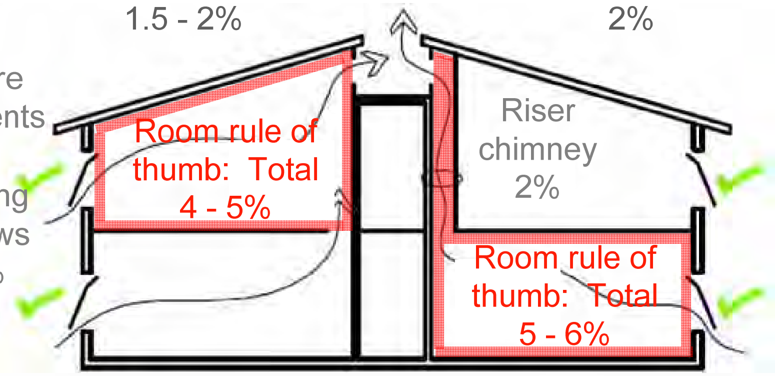
Excerpt from schools map

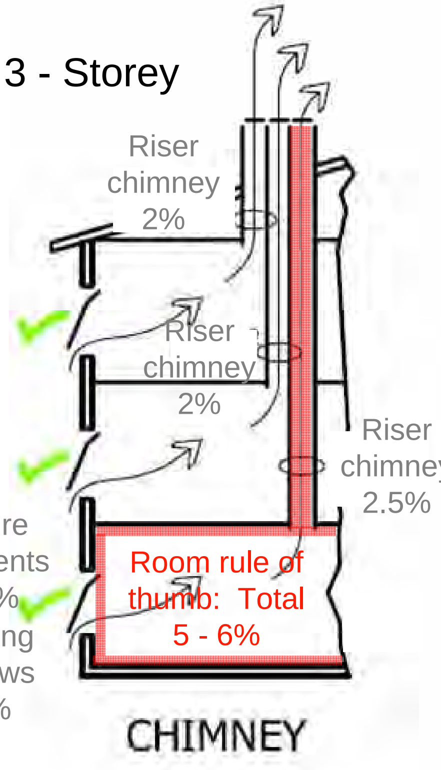
2 - Storey



CLERESTOREY
Simple X-vent

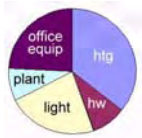
STACK
Atrium X-vent – greater resistance

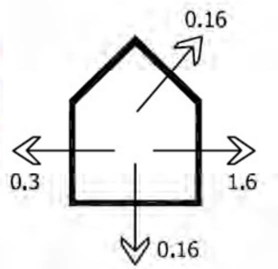
3 - Storey



CHIMNEY

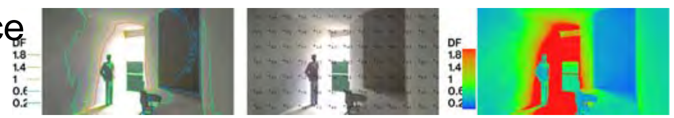
11
$kgCO_2/m^2/yr$





+ Improve fabric & ventilation

Composite Low E Argon DG (30%)
Solar air or MVHR
5 $m^3/m^2/hr$
Best practice



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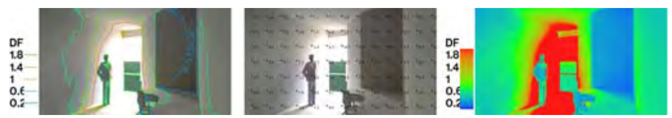
The next stage

- At RIBA Stage D, more detail is required
- Deliver results of studies in related A3 visual format
  - Easier understanding and dissemination
  - More likely to be read by team



Example case studies

1. Large secondary school;
   - Overheating
   - Daylighting
   - Part L and BREEAM
2. Classroom daylight study

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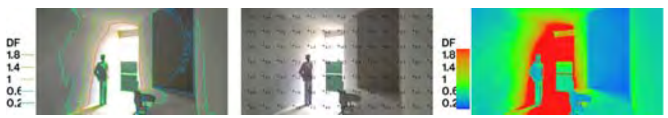
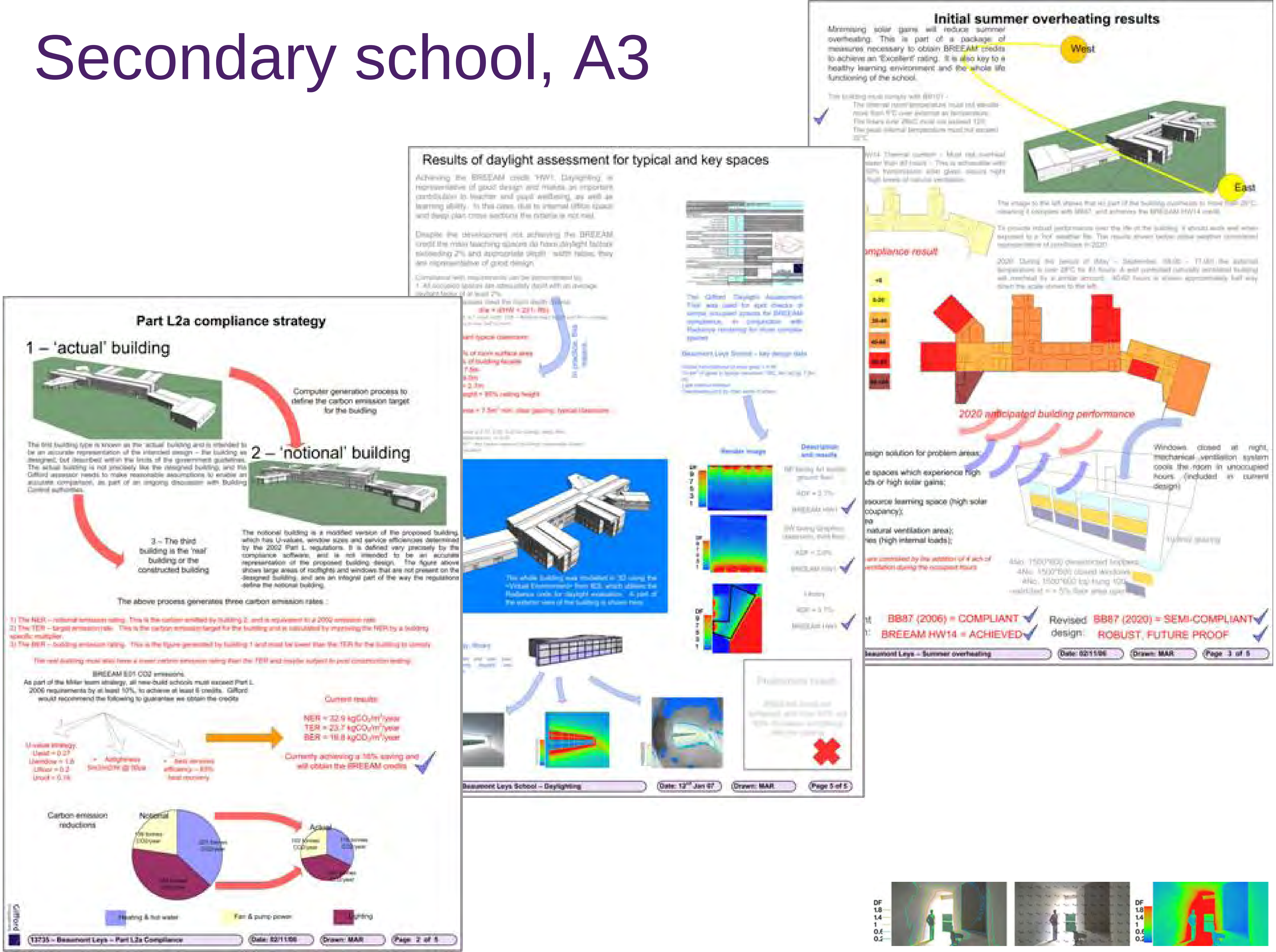
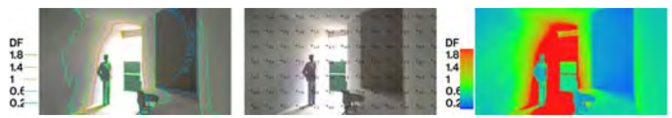


Secondary school, A3

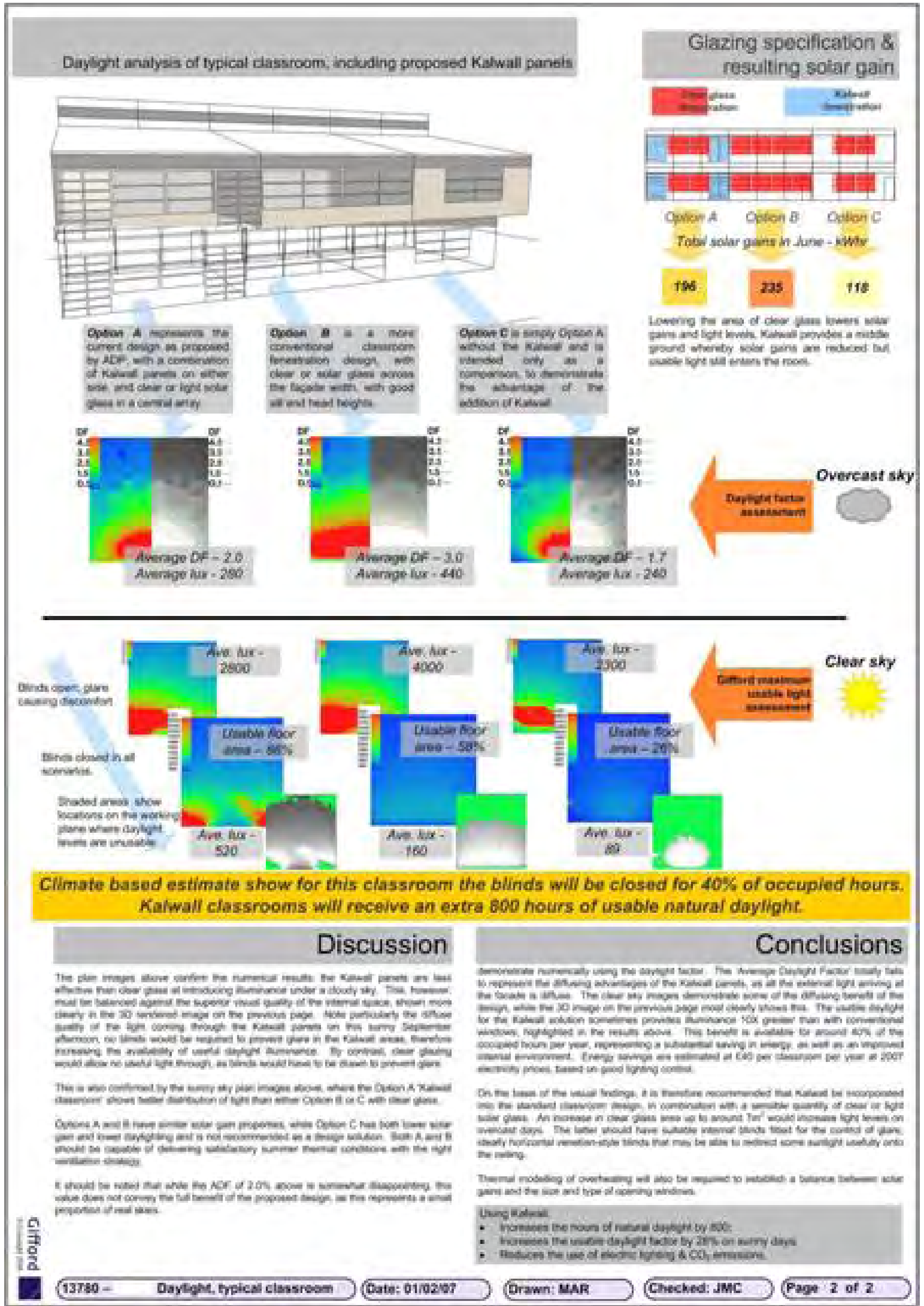


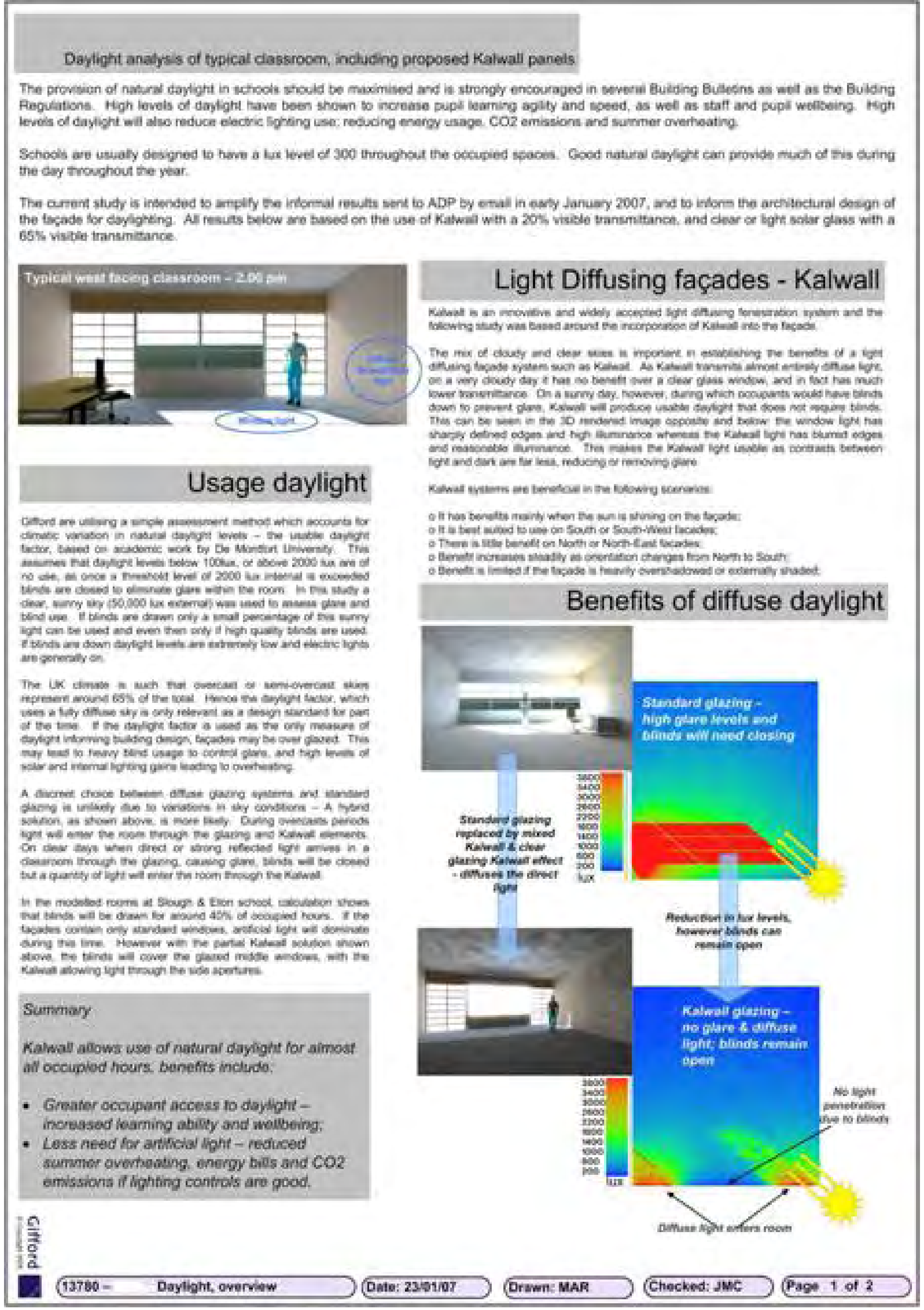
A demonstration of the visual approach: How to daylight a classroom

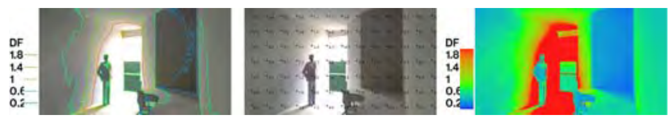
- Must use both cloudy and sunny light
- Must control glare with blinds
- Needs light diffusing element
  - Diffusing panels
  - Light shelves
  - External shading



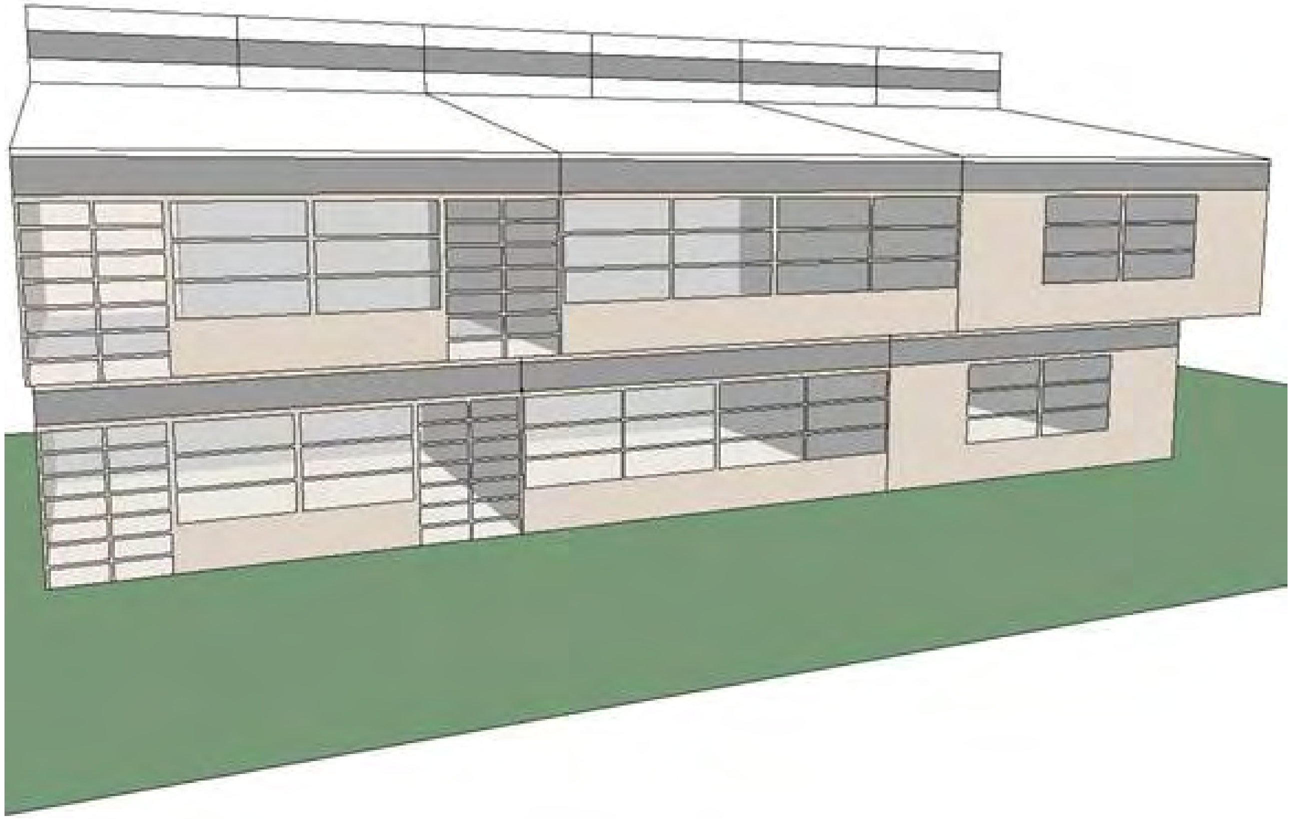
A3 sheets: daylight study







3D building model + Kalwall



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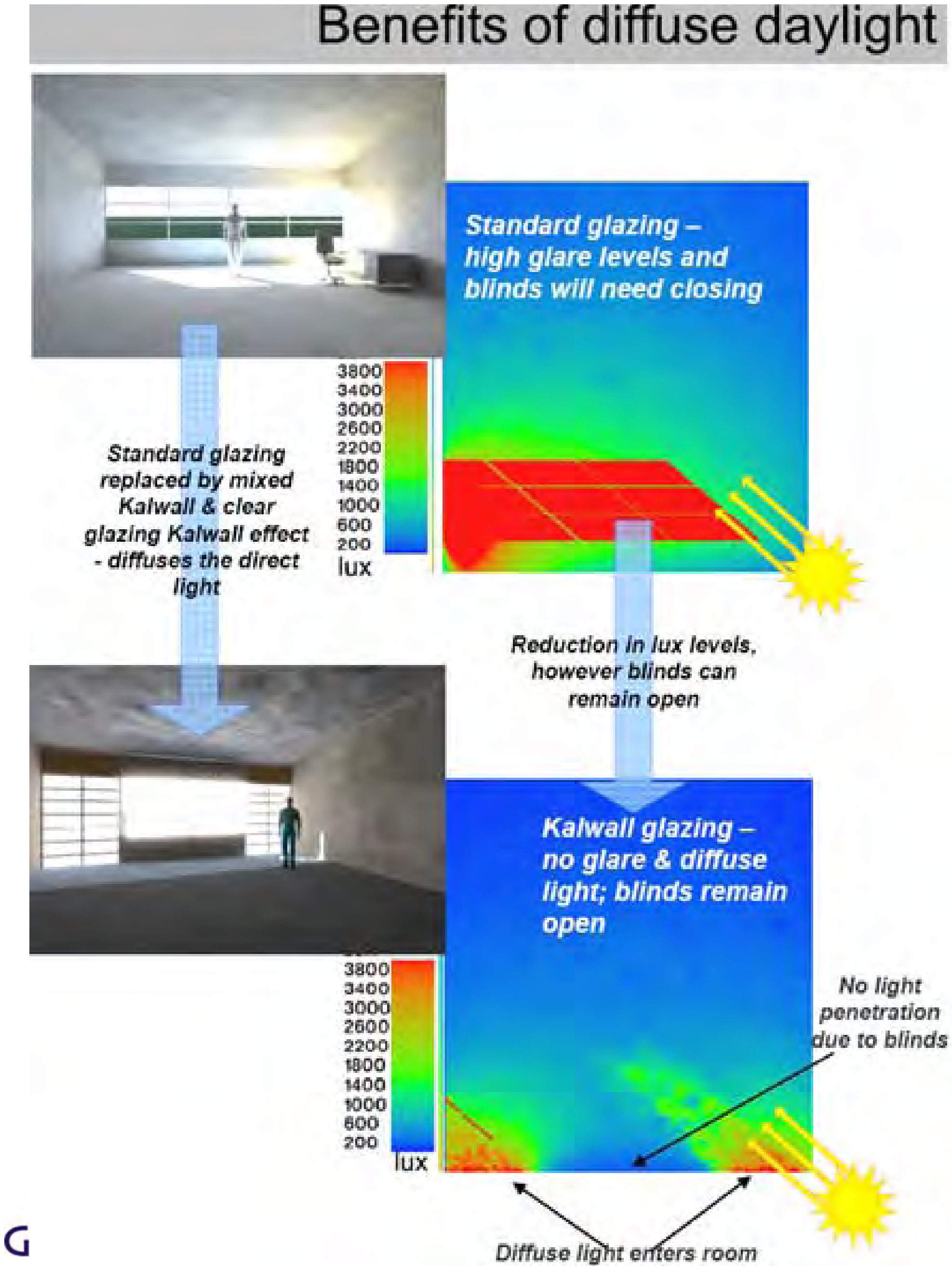
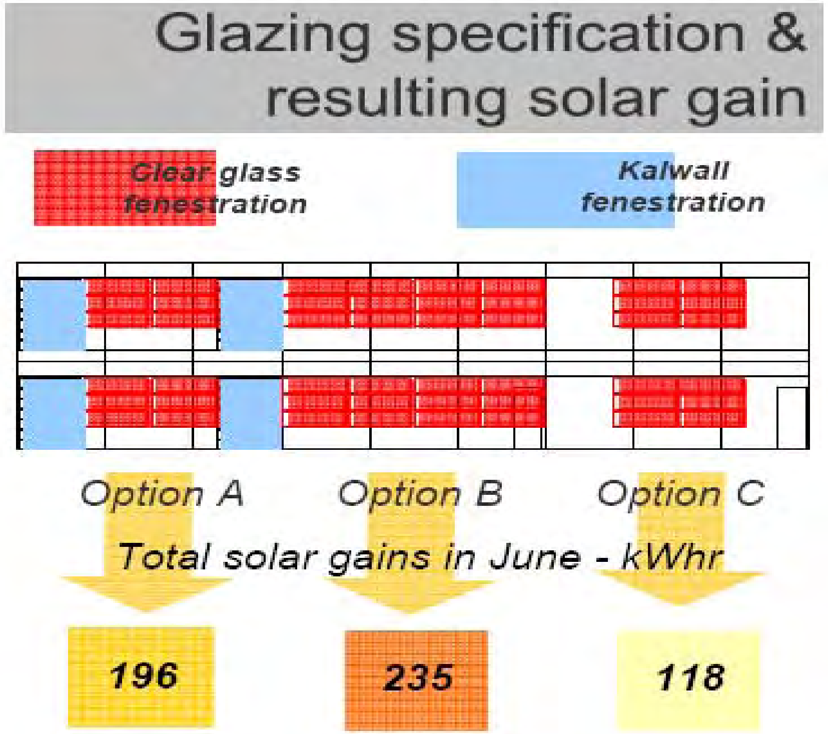
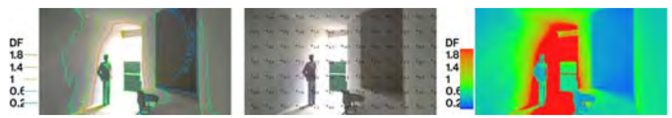
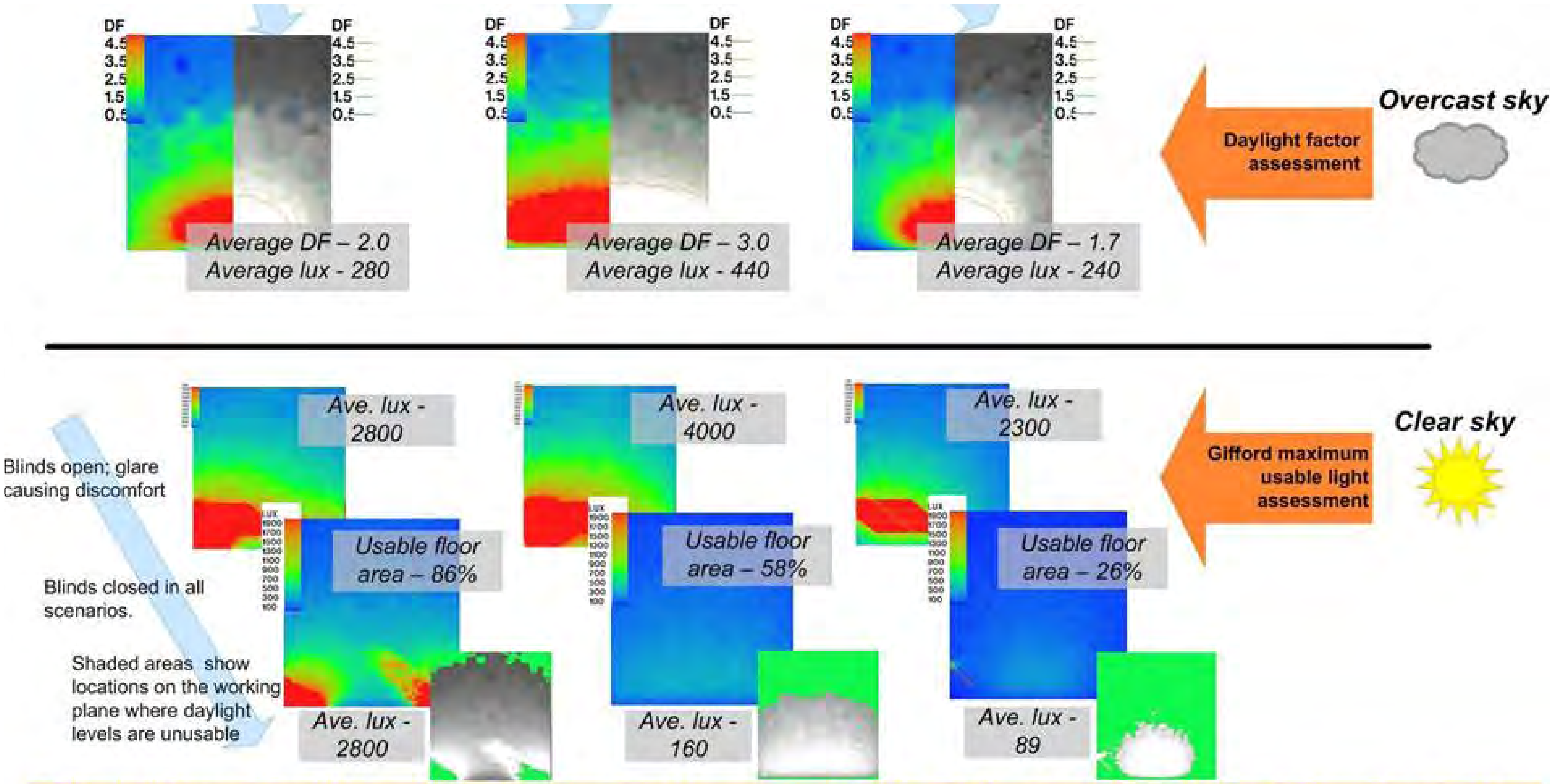
Daylight study results







Why is sunny light important?



Climate based estimate show for this classroom the blinds will be closed for 40% of occupied hours. Kalwall classrooms will receive an extra 800 hours of usable natural daylight.

Conclusions

- A complex world requires clear communication
- Visual, map-based tools simplify design
- Early input enables correct route to sustainability
- A new rule of thumb