

A User-friendly Optimisation Tool for Industry Use



DesignBuilder...Simulation Made Easy

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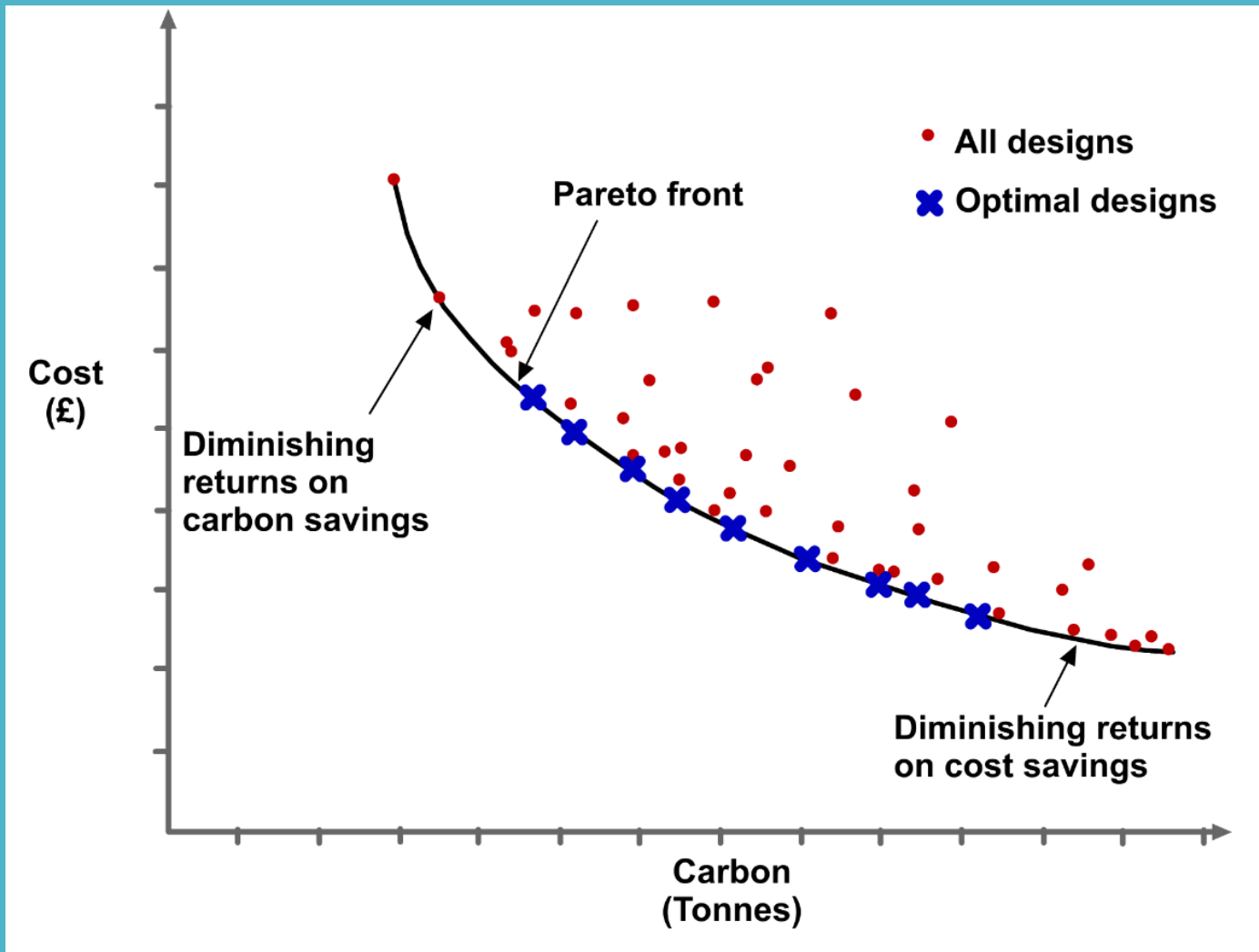
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Introduction

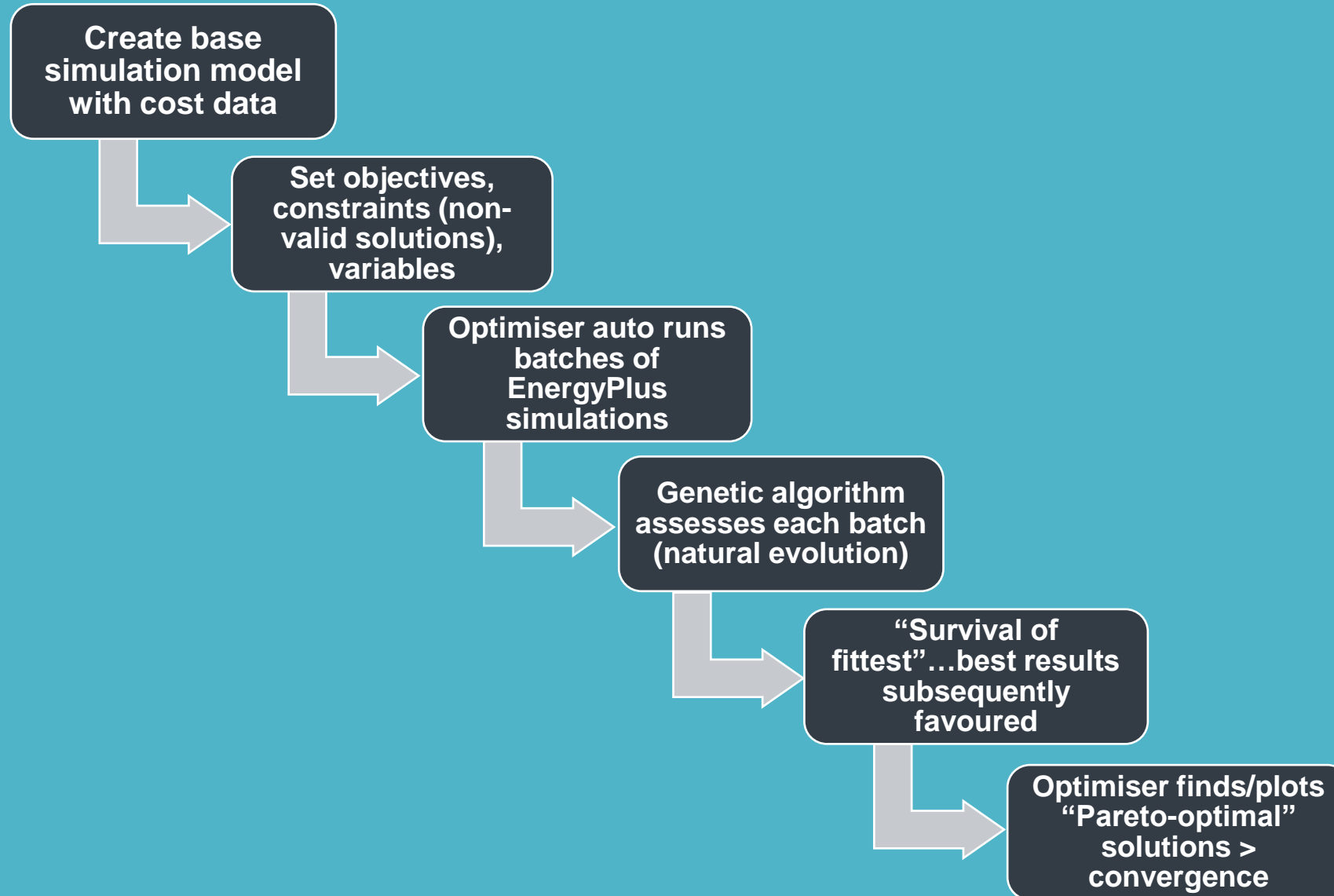
- **DesignBuilder: User-friendly GUI for EnergyPlus, Radiance, CFD, compliance engines.**
- **“Advances in building simulation” – optimisation at cutting edge.**
- **Optimisation uptake outside academia limited...too difficult?**
- **UK Government recognised problem – ADOPT research project funded by TSB to stimulate development of user-friendly tools suitable for industry.**
- **Aim: develop user-friendly tool fully integrated into GUI – set up optimisation with minimal changes.**
- **Finally a tool viable for wide-scale industry use...much simpler and quicker with no specialist knowledge writing code or text-based files.**

Optimisation Concepts



- Optimisation: a technique to efficiently search for and find the best solutions.
- Those best matching design objectives...cost, CO2, comfort.
- Results plotted as cloud of points.
- Optimal designs shown on the leading edge or the “Pareto front”.

The automated optimisation process



The Genetic Algorithm (GA)

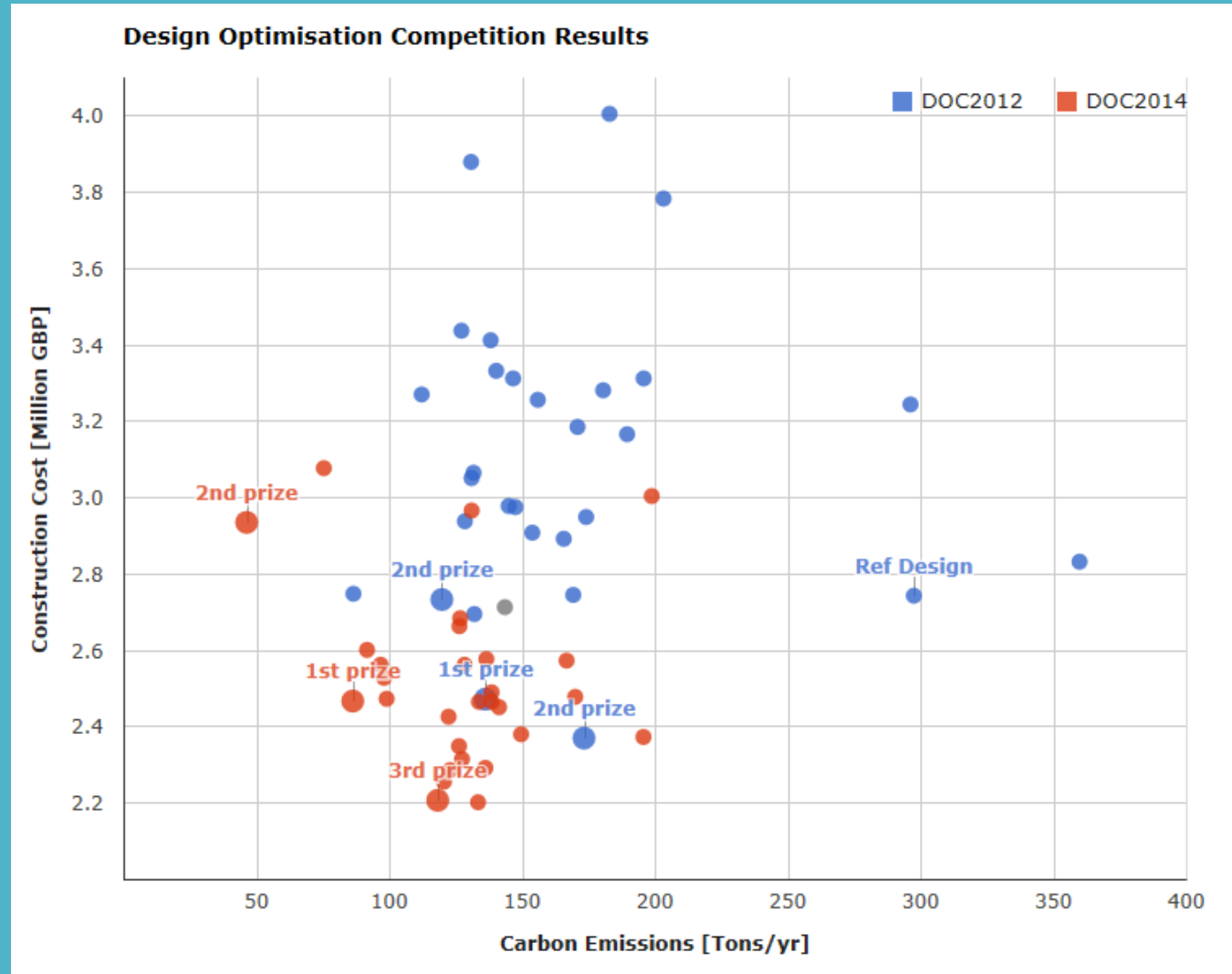
- **NSGA-II algorithm “tuned” to work in DesignBuilder.**
- **Efficient search techniques...quicker than traditional or parametric methods...but!**
- **Improve speed during set-up – careful selection of variable limits and constraints prevent optimiser considering non-valid solutions.**
- **Best run in parallel using network simulation servers or cloud computing.**

Developing the “user-friendly” tool

- Ongoing development since the ADOPT project, including projects and competitions.
- Competitions in 2012 and 2014...great opportunity to “play” (and break).
- Worldwide entries ~ 50/50 industry/academia.
- Realistic problem to optimise cost-performance balance for office...experience of conflicting variables.

Clear improvement from 2012 to 2014

More information on OptimisationCompetition.org

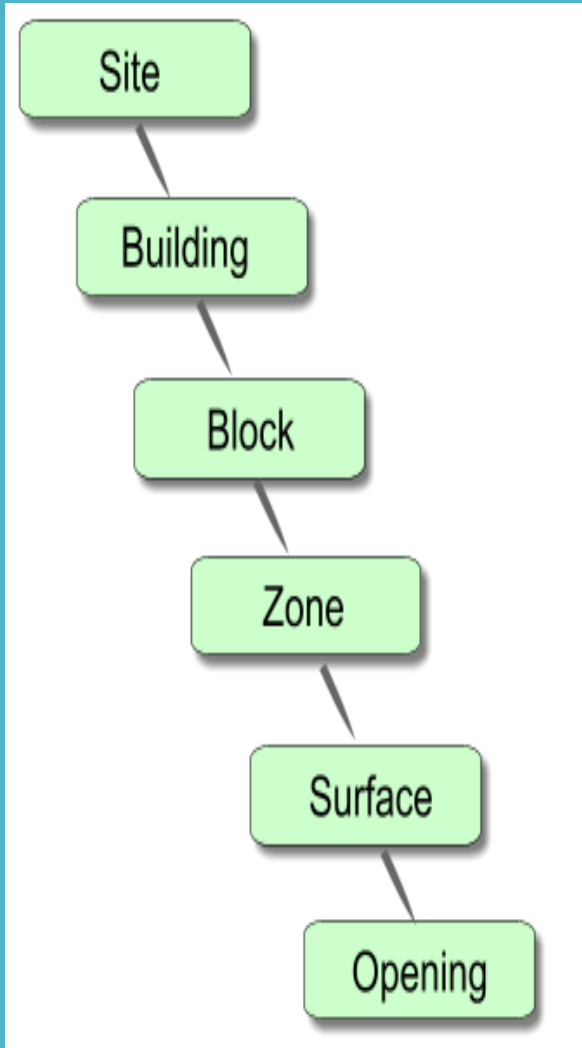


A passive dwelling optimisation case-study



- Projects as development strand...rich data.
- Passive design – max passive solar gain without overheating.
- Objectives: min cost and carbon.
- Constraint: 200 hrs discomfort – wider tolerance.

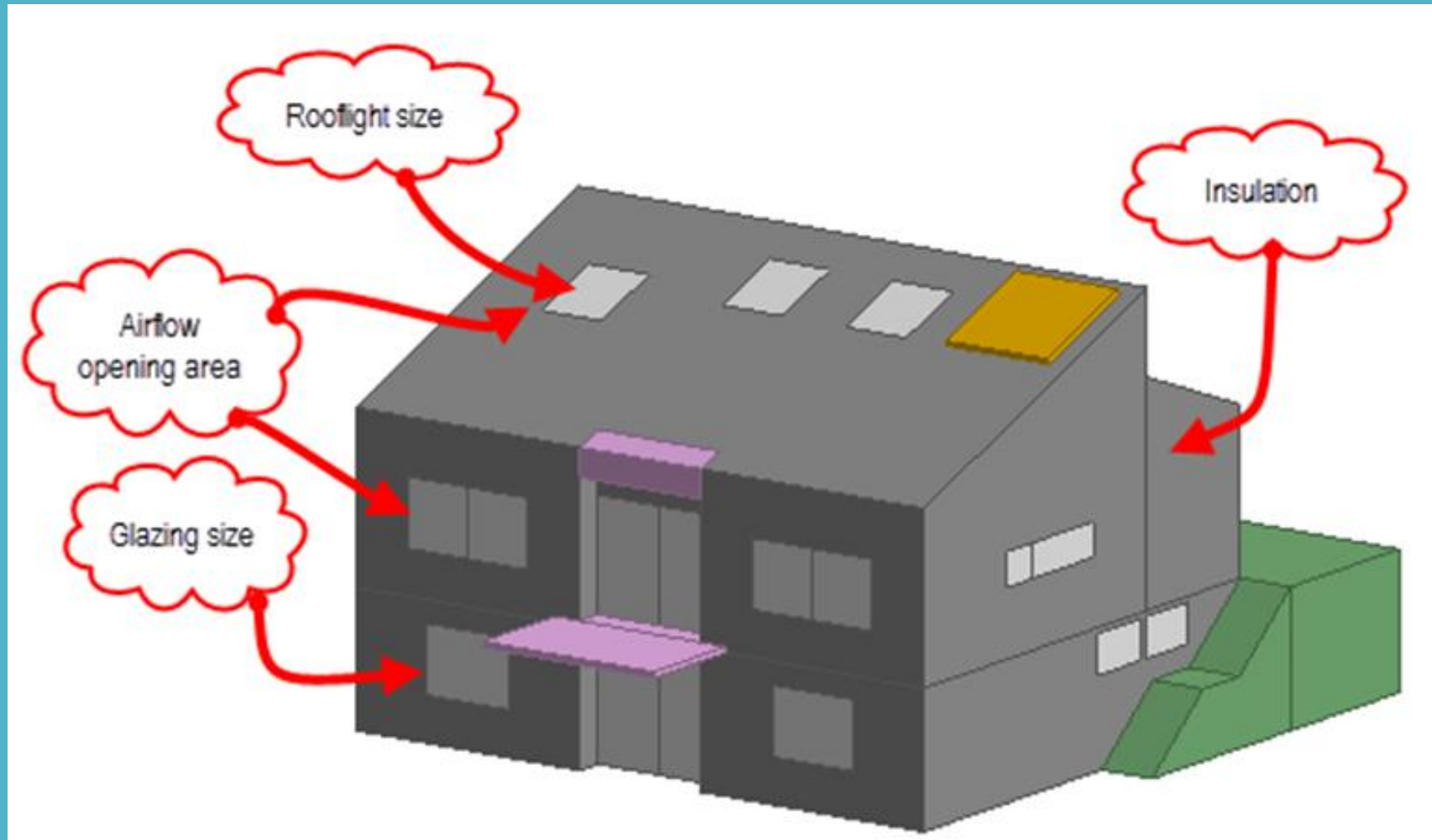
Data entry via modeller: user-friendly, fast, efficient



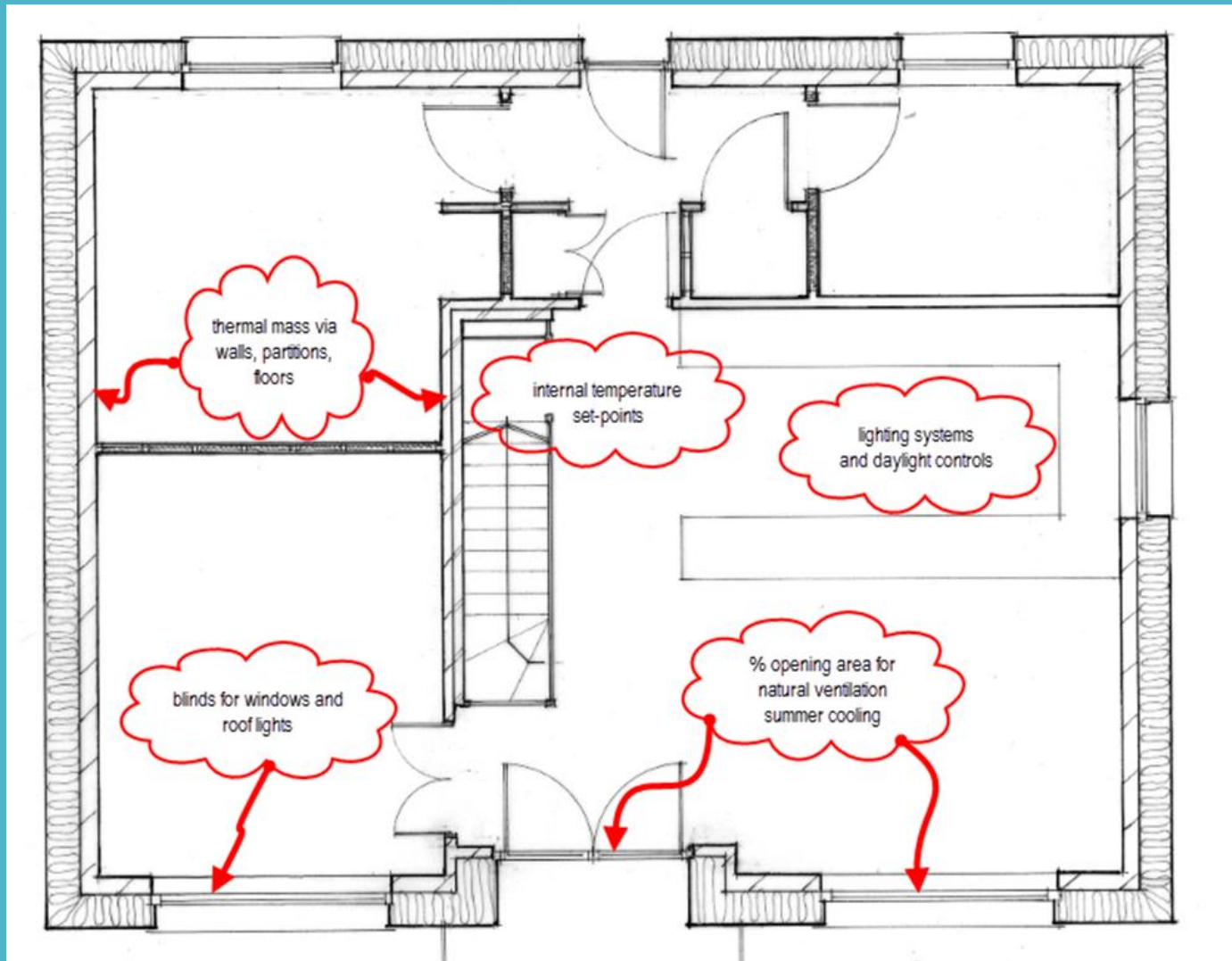
The screenshot shows the DesignBuilder software interface for 'Highwell 2.0, Plot 1'. The left pane displays a project tree with a hierarchy: Highwell 2.0 > Plot 1 > IL0 GF > Bed 1. Under Bed 1, there are several elements: Ground floor - 19.927 m2 (Ground), Ceiling - 19.927 m2, Wall - 10.441 m2 - 40.0°, Partition - 9.085 m2 (IL0 GF, E-S W), Partition - 1.955 m2 (IL0 GF, Circul), Partition - 9.230 m2 (IL0 GF, Circul), Wall - 0.360 m2 - 130.0°, Wall - 1.200 m2 - 220.0°, Wall - 10.680 m2 - 130.0°, External - 8.206 m2, and Window (External) 2.474 m2. Below this are other rooms like Bed 3, Circulation, E-S WC-shower, Gym, Office, Stairs, Utility, IL1 Front, Bed 2, Kitchen-diner, Lounge, IL1 Rear, Bed 2, Circulation, and L1 Bathroom, along with four component blocks.

The right pane shows the 'Openings' configuration for a window. The 'Glazing Template' is set to 'Project glazing template'. The 'External Windows' section shows 'Glazing type' as 'LoSpec Triple, Argon, LoE' and 'Layout' as 'Preferred height 1.5m, 30% glazed'. Under 'Dimensions', the 'Type' is '3-Preferred height' and 'Window to wall %' is set to 30.00. Other dimensions include 'Window height (m)' at 1.50, 'Window spacing (m)' at 5.00, and 'Sill height (m)' at 0.80. The 'Reveal' section shows 'Outside reveal depth (m)' at 0.150, 'Inside reveal depth (m)' at 0.350, and 'Inside sill depth (m)' at 0.450. The 'Frame and Dividers' section is empty. The 'Shading' section has 'Window shading' checked, with 'Type' set to 'External Blinds Diffusing T= 0.99', 'Position' at '3-Outside', and 'Control type' at '3-Schedule'. The 'Operation' section shows 'Operation schedule' set to 'External Shading Jun-Sep' and 'Local shading' unchecked.

External variables optimised in this case study



Internal variables optimised in this case study



Simple optimisation problem definition...user-friendly

- Fully integrated...inheritance.
- Simple dialog set-up.
- Consistent with model data.

The image displays three overlapping windows from the DesignBuilder software interface. The top window, titled 'Edit Optimisation/Parametric Analysis Settings', shows a table of design variables. The middle window, 'Edit Optimisation variables', shows the configuration for a specific variable, 'Window to wall %'. The bottom-left window, 'Select the target(s)', shows a tree view of building components with 'Plot 1' selected. The bottom-right window, 'Help', provides instructions on how to use design variables.

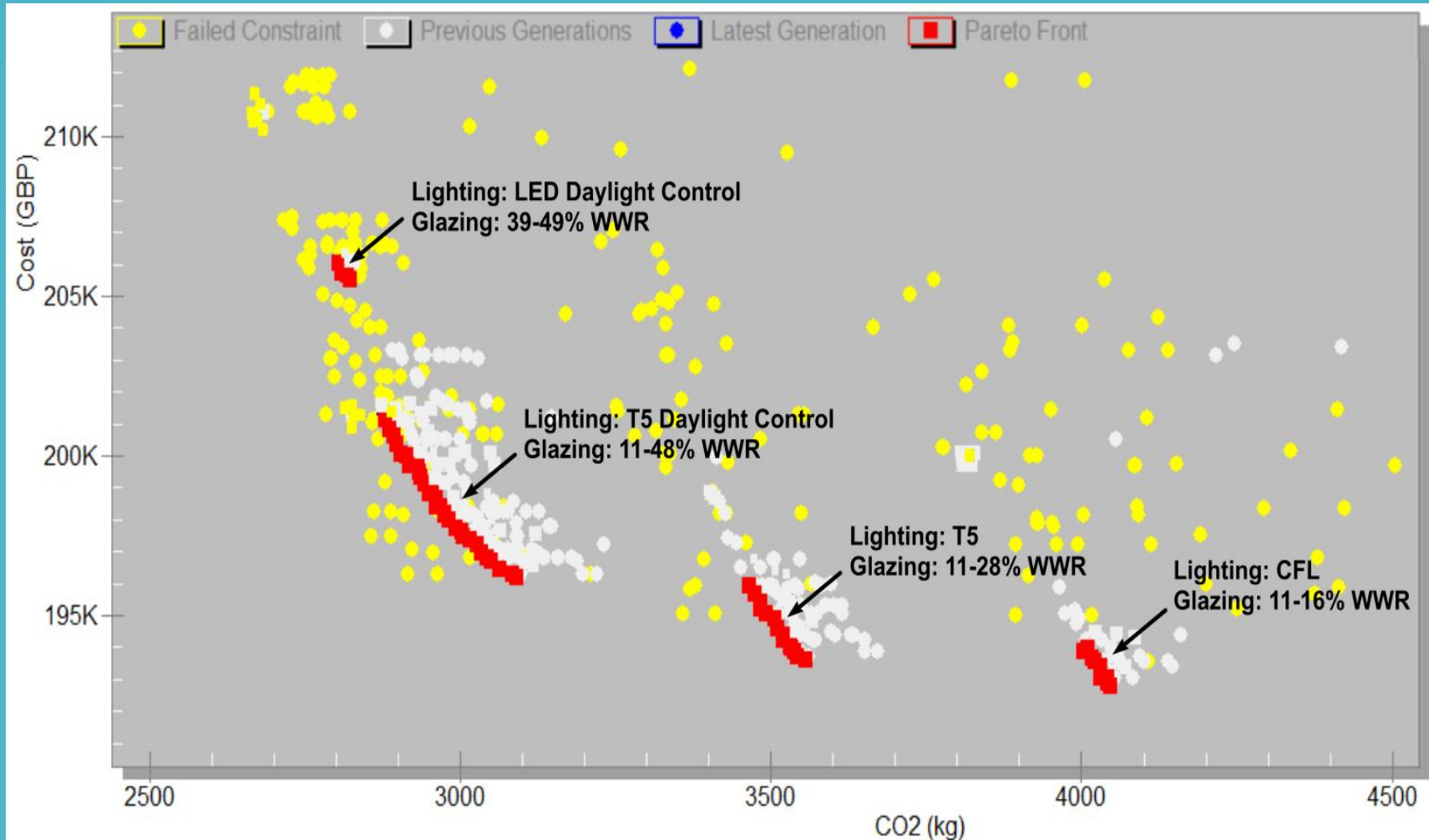
Variable type	Min Value	Max Value	Step	Options List	Target objects
Heating set-point te...	19.00	23.00	0.10	-	Building
Nat vent set-point te...	18.00	26.00	5.00	-	Building
% External window ...	0.00	10.00	20.00	-	Building
Window to wall %	10.00	100.00	20.00	-	Building
Partition construction	0.00	0.00	0.00	3 options	Building
External wall constr...	0.00	0.00	0.00	4 options	Building
Ground construction	0.00	0.00	0.00	4 options	Selected Targets
Glazing type	0.00	0.00	0.00	2 options	Selected Targets
Lighting template	0.00	0.00	0.00	5 options	Selected Targets
Window to wall %	0.00	100.00	20.00	-	Building

Design variables	Target
Variable type	Window to wall %
Min Value	0.00
Max Value	100.00
Step	20.00
Target objects	Building

Design Variables
Select the design variables, i.e. the aspects of the design that can be allowed to vary. Some variables have lists of options to be defined, other numeric inputs have minimum, maximum values and the iteration step to be used. You can add up to 10 variables.
Use the Add and Delete buttons to add options to the list and remove them.
You can select the scope of the variable to allow options to be applied to particular parts of the building. By default variables are applied to the building level.
Design variables are used in both Optimisation and Parametric Analysis calculations but note that only the top 2 variables are used for parametric analysis.

Data Report (Not Editable)
Window to wall %
Min Value: 20
Max Value: 100.0000
Step: 20
Options List:

Clear indication of the most cost-effective solutions



- Powerful overview...visualise
- Clustered Pareto front
- Sort & analyse
- Overheating eliminated
- Lighting CO2 dominant

Conclusions and Summary

- **The absence of user-friendly optimisation tools has hindered industry uptake.**
- **True multi-criteria analysis via optimisation is now commercially viable to enable greater confidence in your final design.**
- **Optimisation provides deeper (and highly visible) insights into where the most cost-effective solutions lie – identify the “sweet spot”.**

**DesignBuilder are running a free introductory workshop in UCL at
10:30 am tomorrow morning**

Please let us know if you'd like to attend

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