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Parametric Design for Building Structures

CitA Tech Trend Series

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Contents

- Parametric Design – What, Why and How?
- Workflow Automation

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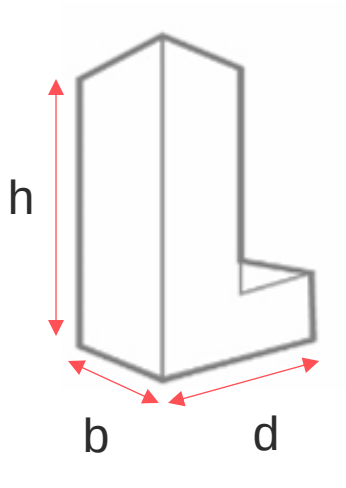
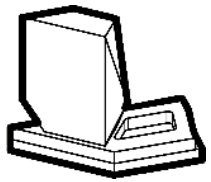
What is Parametric Design?

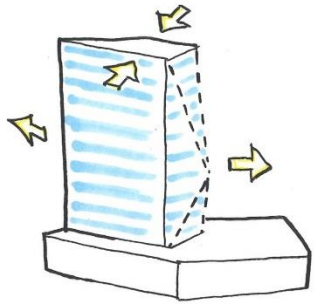
Key Performance Indicators



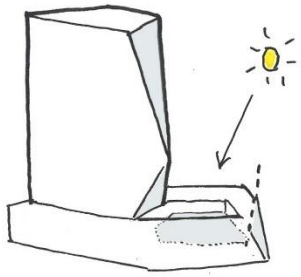
Input Parameters

Building





Daylight
The form ensures increased daylight for the building and it's neighbours



Sun Exposure
The form ensures increased sun exposure for the building and it's neighbours

KPIs

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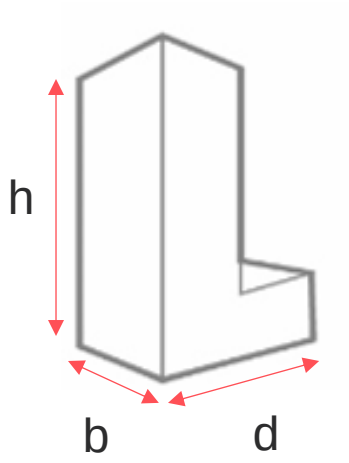
What is Parametric Design?

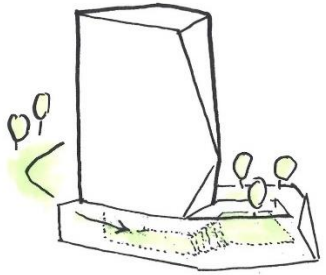
Key Performance Indicators



Input Parameters

Neighbourhood

Wind
The designed balconies and the building's form reduce wind hinderance

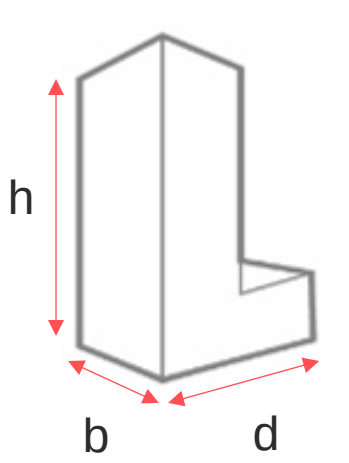


Green
The green plinth and atrium contributes to the neighbourhood's quality

KPIs

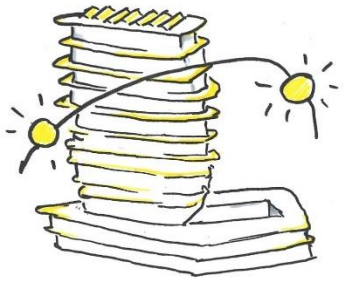
What is Parametric Design?

Key Performance Indicators

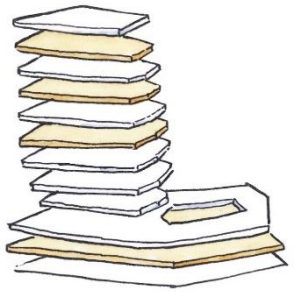


Input Parameters

Planet



Energy
Strategically placed PV panels integrated in balconies and roof



Embodied CO_2
Hybrid timber and concrete structure with reduced carbon footprint

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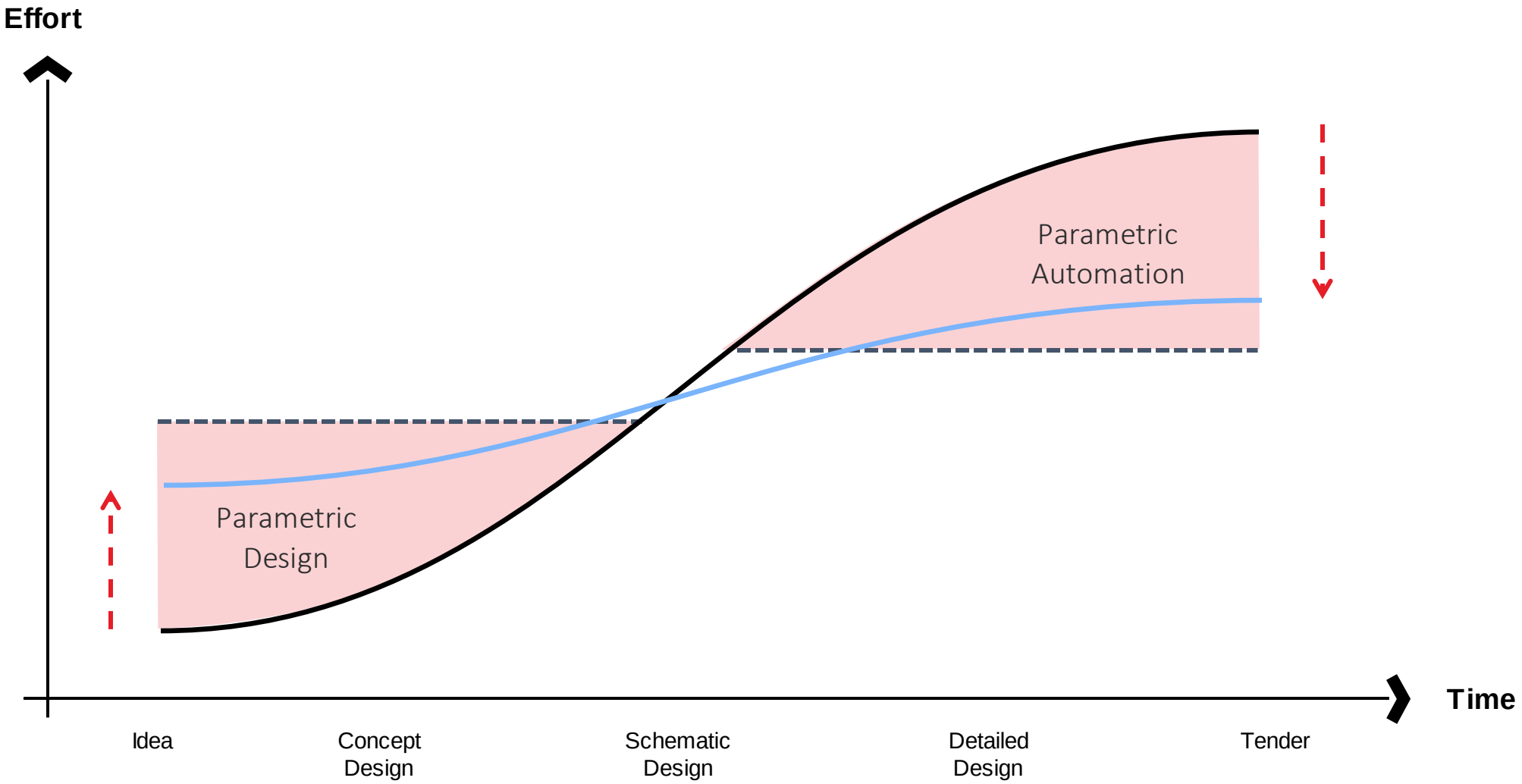
Why do we use Parametric Design?

Throughout Different Stages



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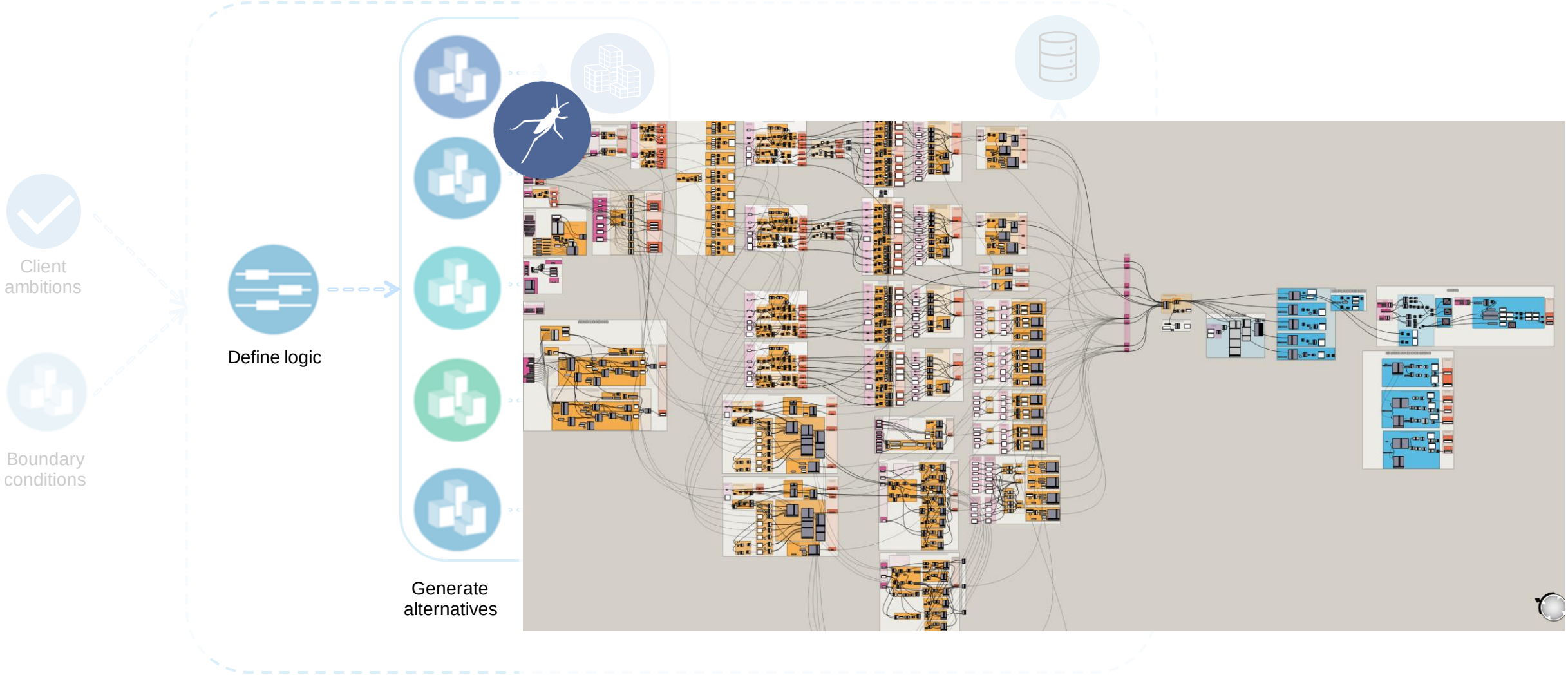
How do we use Parametric Design?

Integral Design Process



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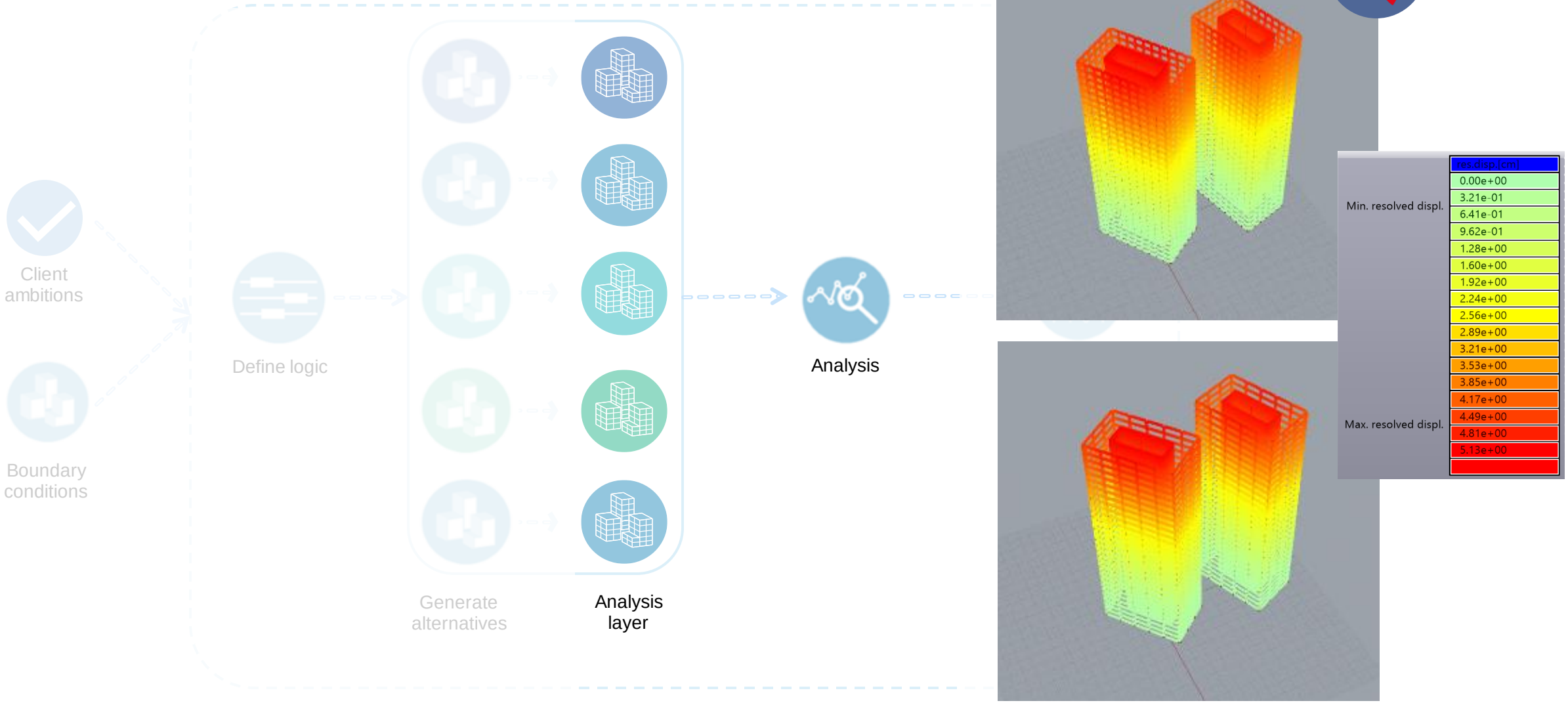
How do we use Parametric Design?

Tirana, Albania

Imagery: © MVRDV, 2021

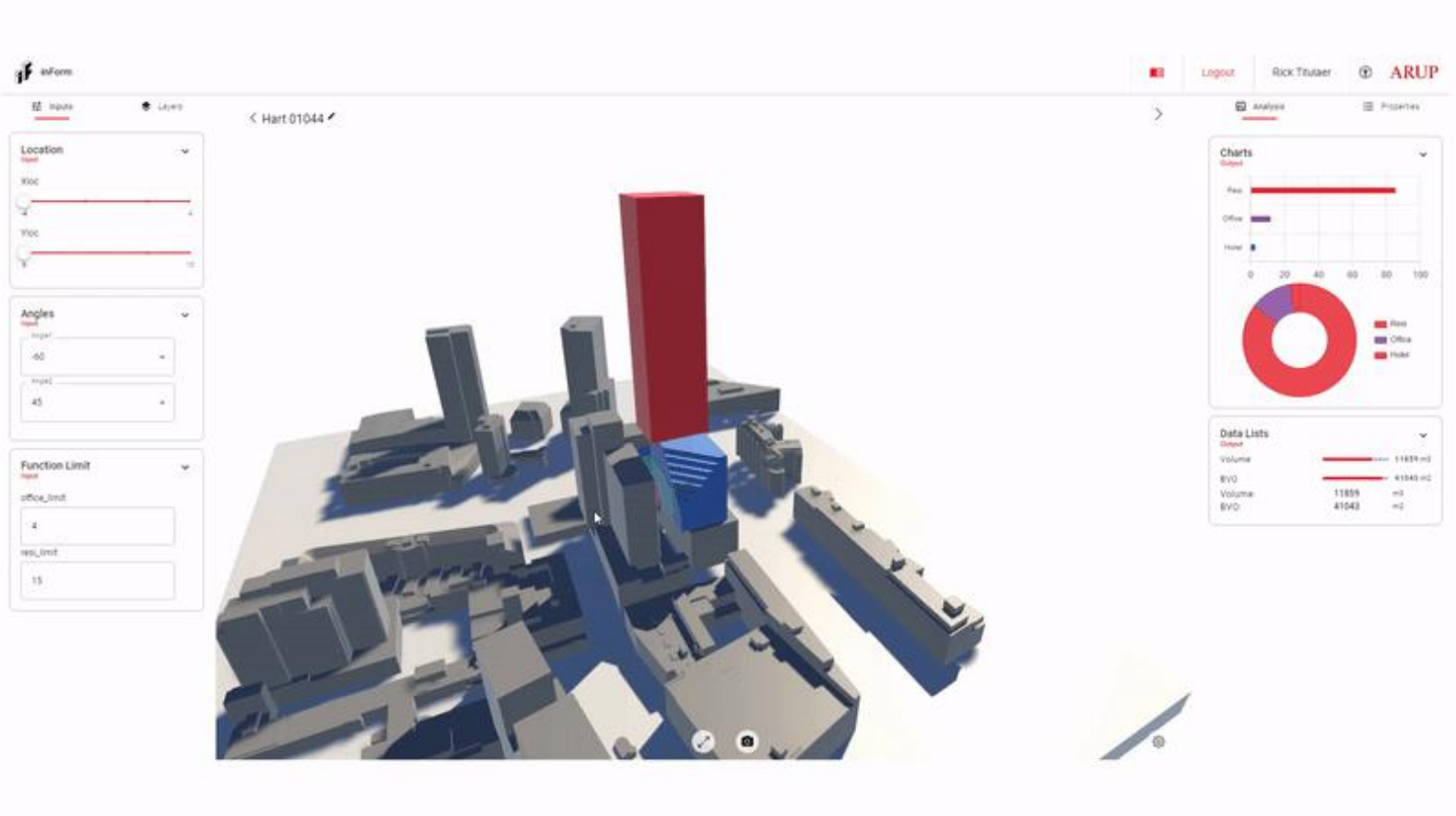
How do we use Parametric Design?

Integral Design Process



How do we use Parametric Design?

Integral Design Process



Cloud based
Data storage

Evaluated
options

Dashboard for
informed decisions

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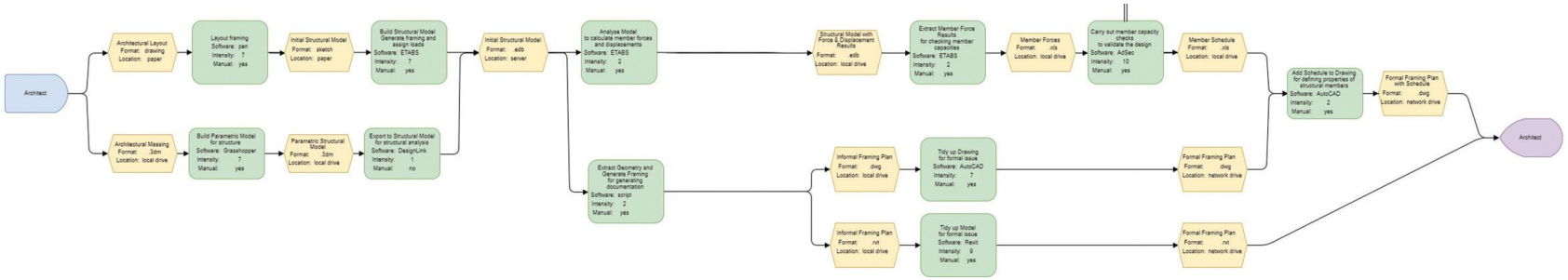
Automated Workflows

Benefits

- Review our workflows to identify opportunities for automation
- Reduce the amount of manual work
- Focus on high value decisions
- Increase adaptivity to design changes
- Ensure consistency across design iterations
- Free up time for optioneering



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Automated Workflows

Standardisation and interoperability: issues

- Many of our calculations are carried out in commercial software packages
  - Often do not allow for data to be integrated within a wider workflow

- Other calcs use spreadsheets
  - Not standardised
  - Difficult to be peer-reviewed if not familiar with them

```
=IF(L28<0,MAX(-$C$10,200000*L28),MIN(200000*L28,$C$10)-IF(AND($C14<$C$8*L17,$C14>0),$C$9,0))
```

?

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Automated Workflows

DesignCheck

DesignCheck

In-house development of cloud-based calculations with line-by-line output

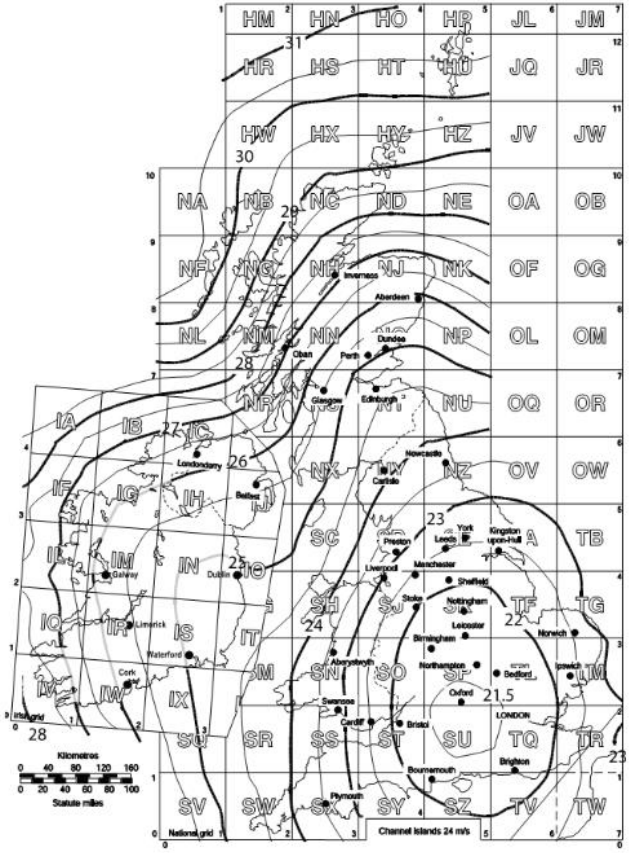
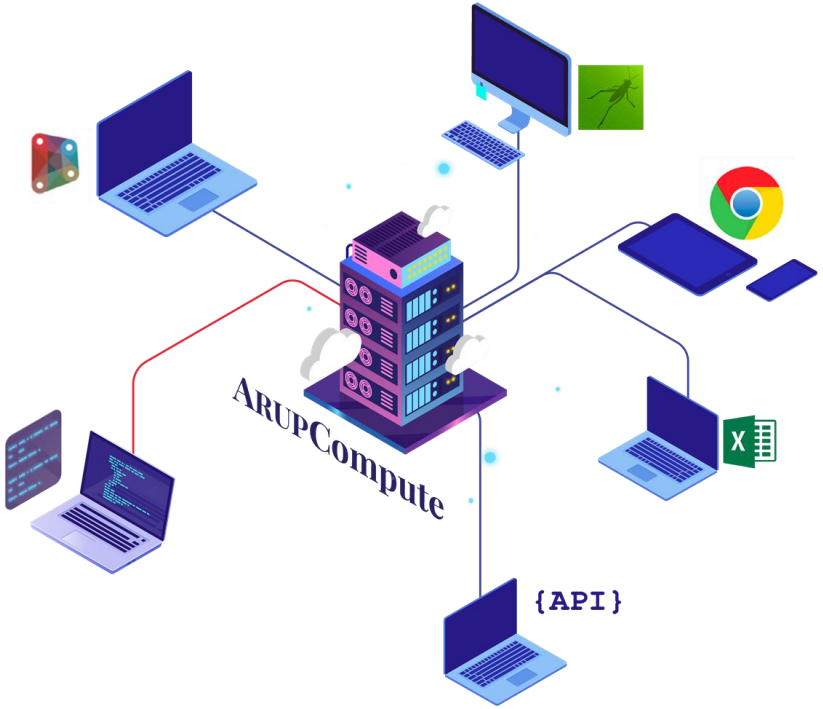


Figure NA.1

EC1-1-4 UKNA Eq NA.2b	Altitude factor	$c_{alt} = 1 + 0.001 \times A \times \left(\frac{10}{z}\right)^{0.2}$ $= 1 + 0.001 \times 14\,m \times \left(\frac{10}{13\,m}\right)^{0.2}$ $= 1.01$
EC1-1-4 UKNA Eq NA.1	Fundamental value of the basic wind velocity	$v_{b,0} = v_{b,map} \times c_{alt}$ $= 24.3\,m/s \times 1.01$ $= 24.6\,m/s$
EC1-1-4 UKNA NA.2.8	Shape parameter for probability factor	$K = 0.2$ $= 0.2$ $= 0.2$
EC1-1-4 UKNA NA.2.8	Exponent for probability factor	$n = 0.5$ $= 0.5$ $= 0.5$
EC1-1-4 Eq 4.2	Probability factor	$c_{prob} = \left(\frac{1 - K \times \ln(-\ln(1-p))}{1 - K \times \ln(-\ln(0.98))}\right)^{n}$ $= \left(\frac{1 - 0.2 \times \ln(-\ln(1-0.02))}{1 - 0.2 \times \ln(-\ln(0.98))}\right)^{0.5}$ $= 1$
EC1-1-4 Eq 4.1	Fundamental value of the basic wind velocity	$v_{b,0} = c_{dir} \times c_{season} \times c_{prob} \times v_{b,0}$ $= 0.829 \times 1 \times 1 \times 24.6\,m/s$ $= 20.4\,m/s$
EC1-1-4 UKNA NA.2.18	Air density	$\rho = 1.23$ $= 1.23$ $= 1.23\,kg/m^3$
EC1-1-4 Eq 4.10	Reference mean velocity pressure	$q_b = 0.5 \times \rho \times {v_{b,0}}^2$ $= 0.5 \times 1.23\,kg/m^3 \times (20.4\,m/s)^2$ $= 255\,Pa$
EC1-1-4 Eq A.15	Displacement height	$h_{dis} = \min(0.8 \times h_{ave}, 0.6 \times z)$ $= \min(0.8 \times 0\,m, 0.6 \times 13\,m)$ $= 0\,m$



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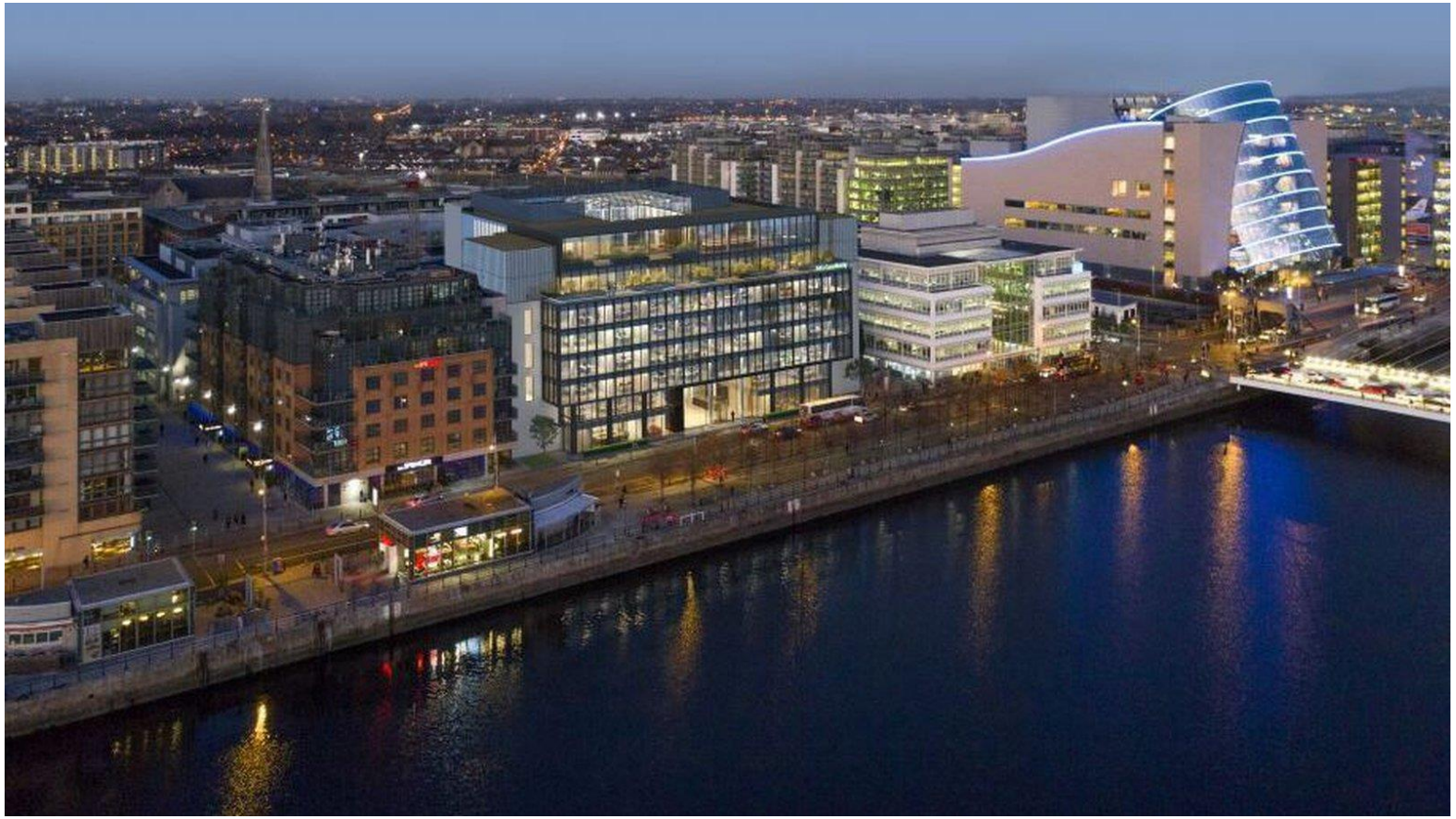
Automated workflows

Office refurbishment, Dublin



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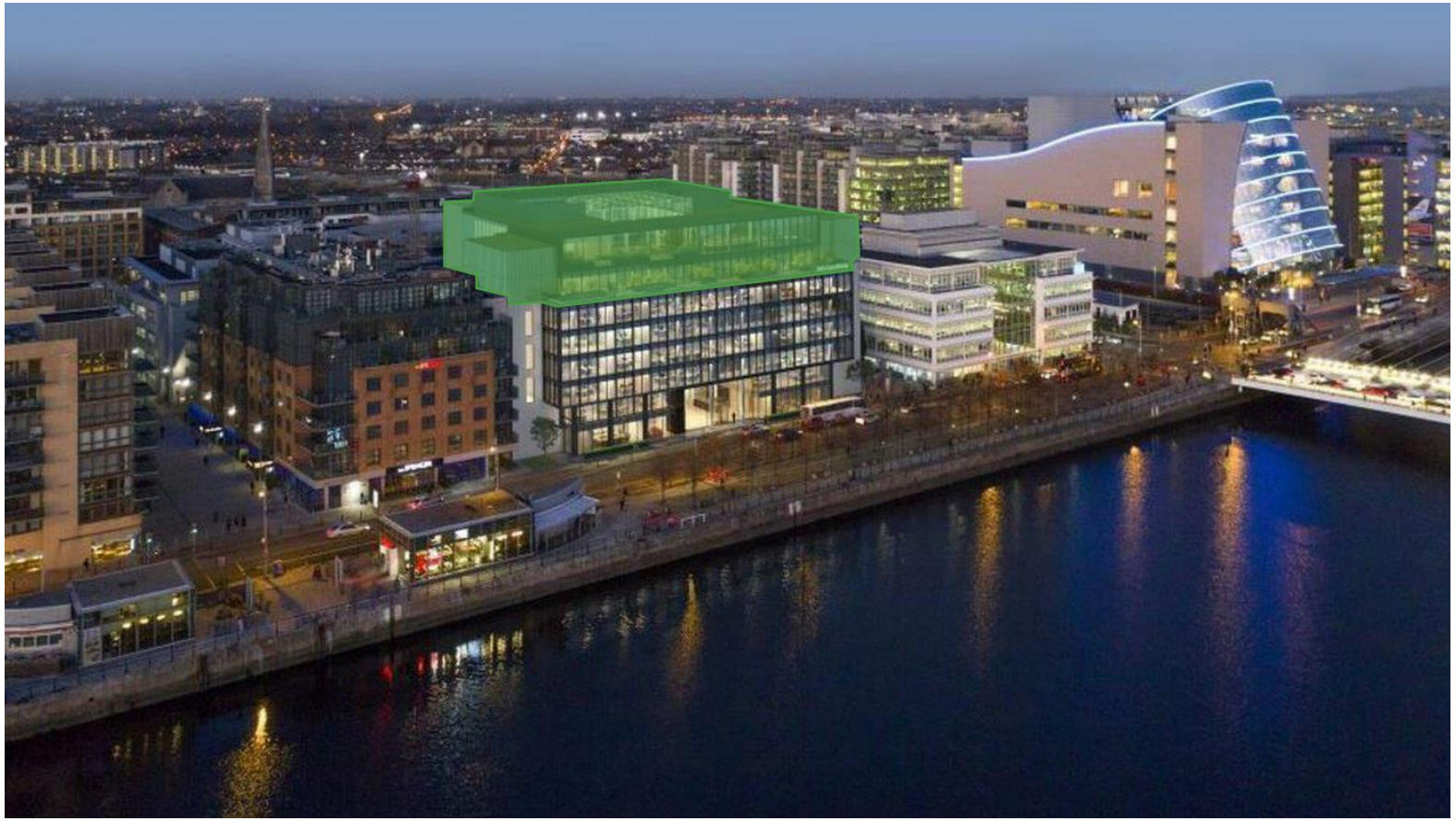

2 storeys added to existing 6-storey office building

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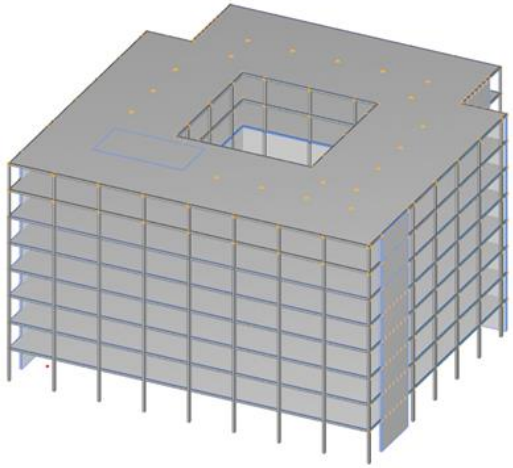
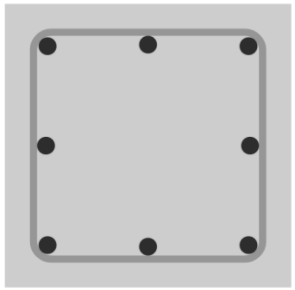
Automated workflows

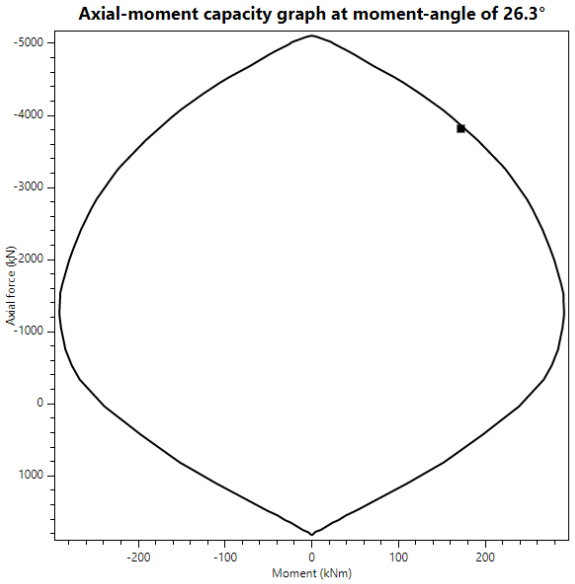
Office refurbishment, Dublin

GSA (Structural Analysis) → Grasshopper → DesignCheck → PDF deliverable

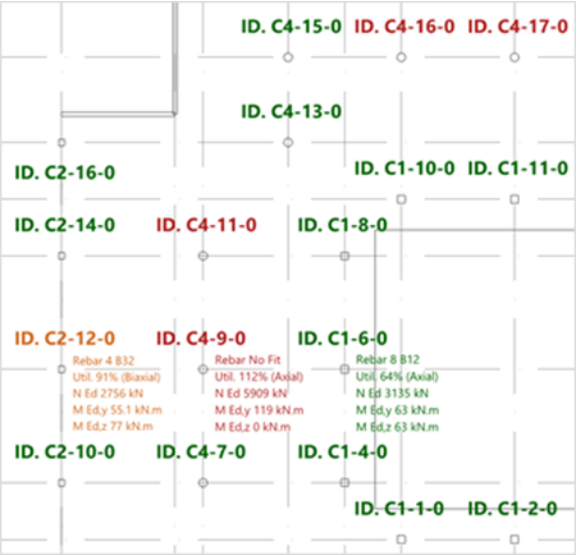




Equivalent first order moment



$$M_{Ed,0e} = |M_{0e}| + (|N_{Ed}| \times e_i)$$
$$= |42\,kNm| + (|-3815\,kN| \times 8.29 \times 10^{-3}\,m)$$
$$= 73.6\,kNm$$



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