Configurations and qualities of new office buildings in Barcelona to meet current and new regulatory requirements. A parametric study

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Introduction

- As a part of the effort of reducing CO_2 in the EU, new regulatory requirements regarding energy use and energy efficiency has been implemented since 2010

- Near zero energy buildings (nZEB) was defined in the Spanish building code in 2019

- Zero energy buildings (ZEB) was a proposed EU directive for 2027*

*not implemented

Main objectives

- What are the minimum configurations and qualities in newoffice buildings in Barcelona in relation to the requirements of:

  - CTE-HE 2019 (nZEB)

  - The planned European directive (ZEB)

- How do the regulatory frameworks promote buildings with low energy demand and consumption?

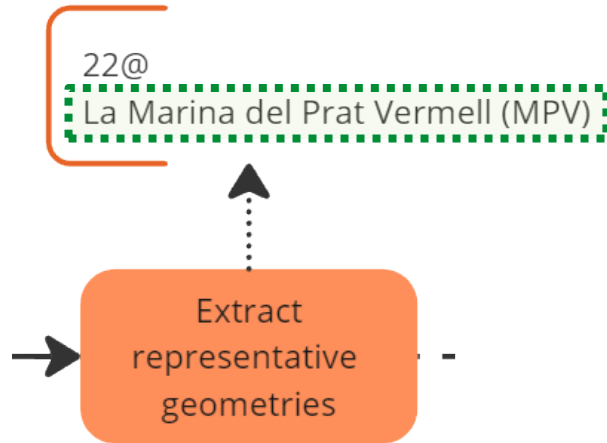- What is currently a feasible best case scenario configuration?

Methodology:
1) Identification of building types and reference geometries

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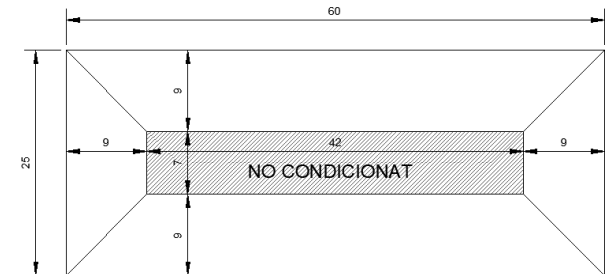
22@
La Marina del Prat Vermell (MPV)
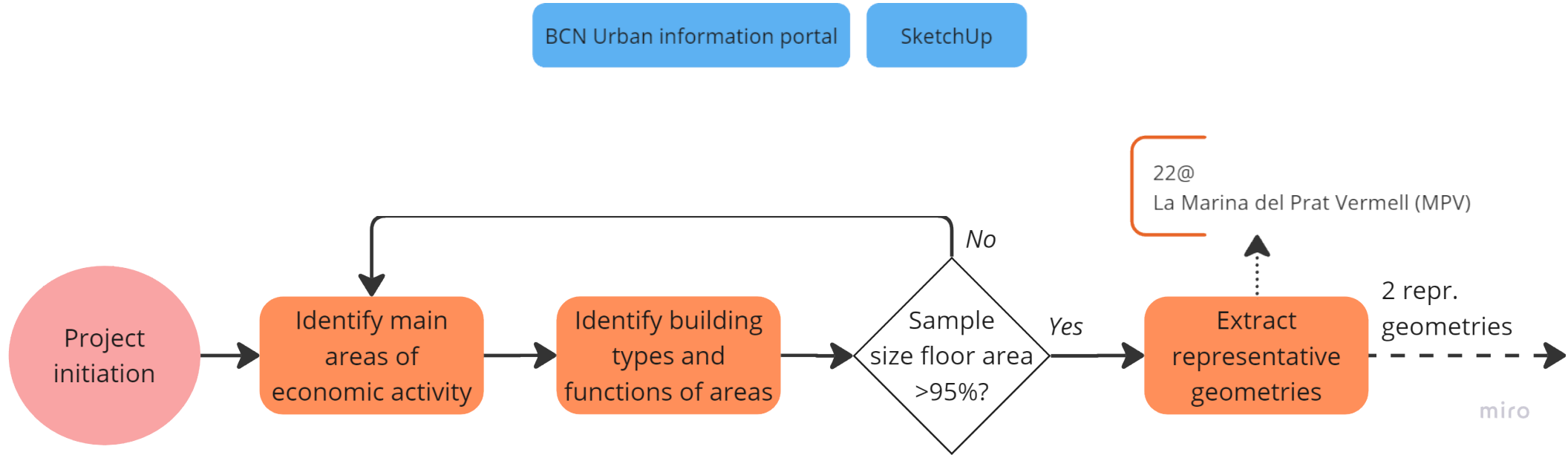
Extract representative geometries
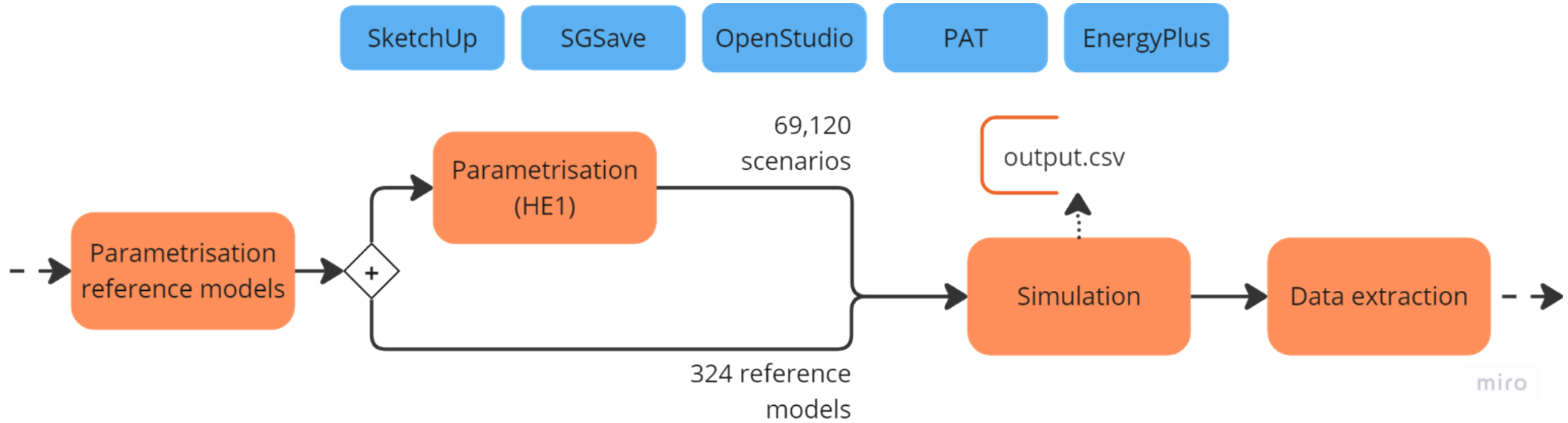
La Marina del Prat Vermell (MPV)

Free-standing

Floor area: 875 m²

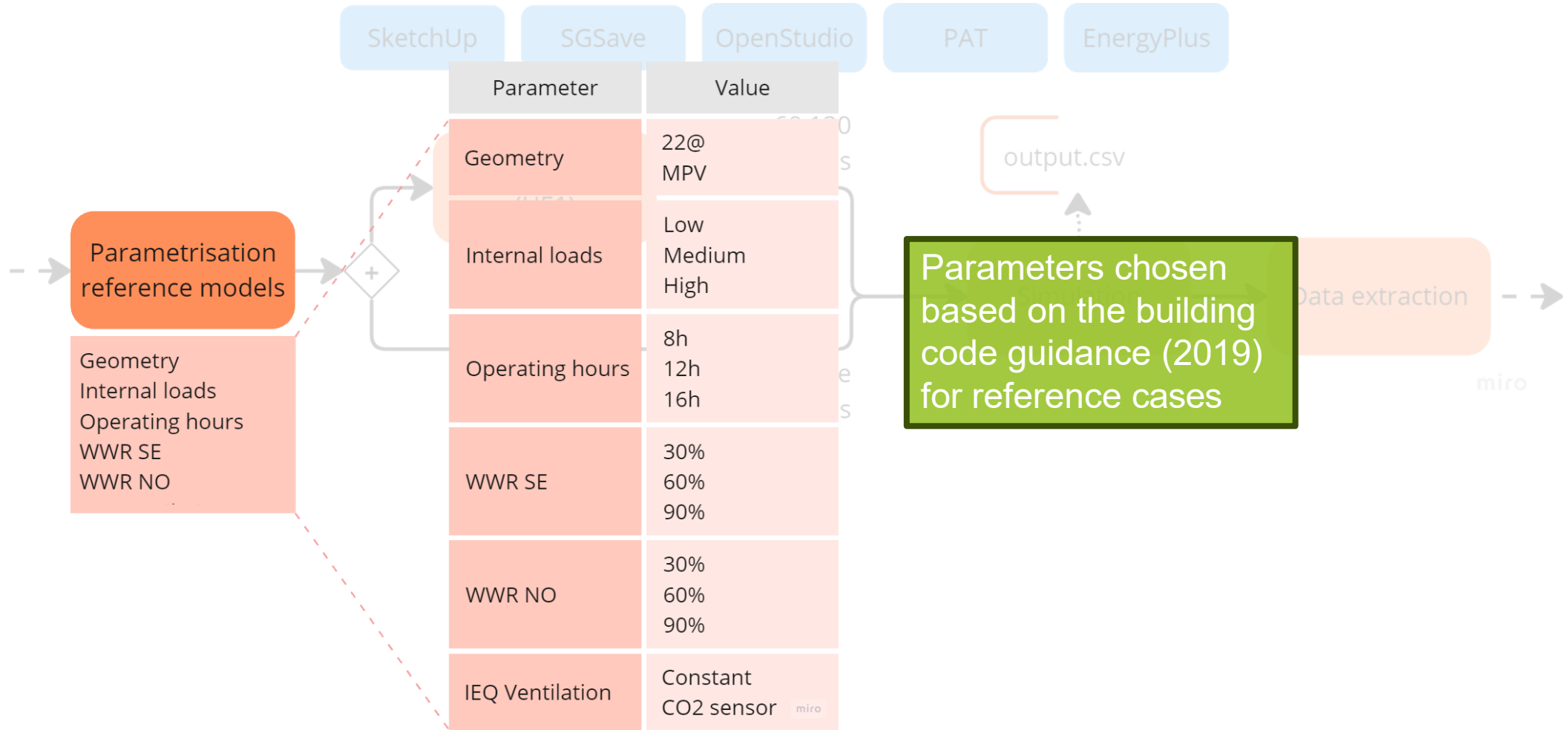**Main orientations:** NW - SE

Building type: GF+6, h = 3.5 m

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Methodology:
2) Parametrisation and simulation

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2) Parametrisation and simulation

SketchUp SGSave OpenStudio PAT EnergyPlus

Parametrisation reference models

Geometry
Internal loads
Operating hours
WWR SE
WWR NO

output.csv

Parameter	Value
Geometry	22@ MPV
Internal loads	Low Medium High
Operating hours	8h 12h 16h
WWR SE	30% 60% 90%
WWR NO	30% 60% 90%
IEQ Ventilation	Constant CO2 sensor

Data extraction

Parameters chosen based on the building code guidance (2019) for reference cases

miro

Methodology:
2) Parametrisation and simulation

SketchUp   SGSave   Op...

Parametrisation
(HE1)

Parametrisation
reference models

Thermal envelope
Solar protection
Natural ventilation
Thermal mass
Lighting sensor
Lighting efficiency

324 references

raction

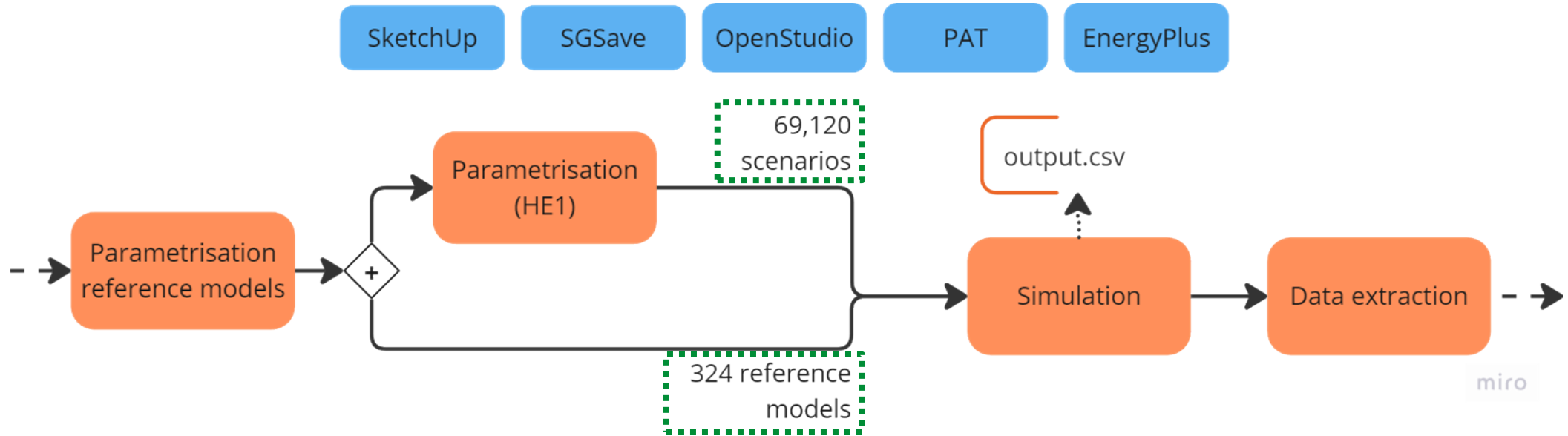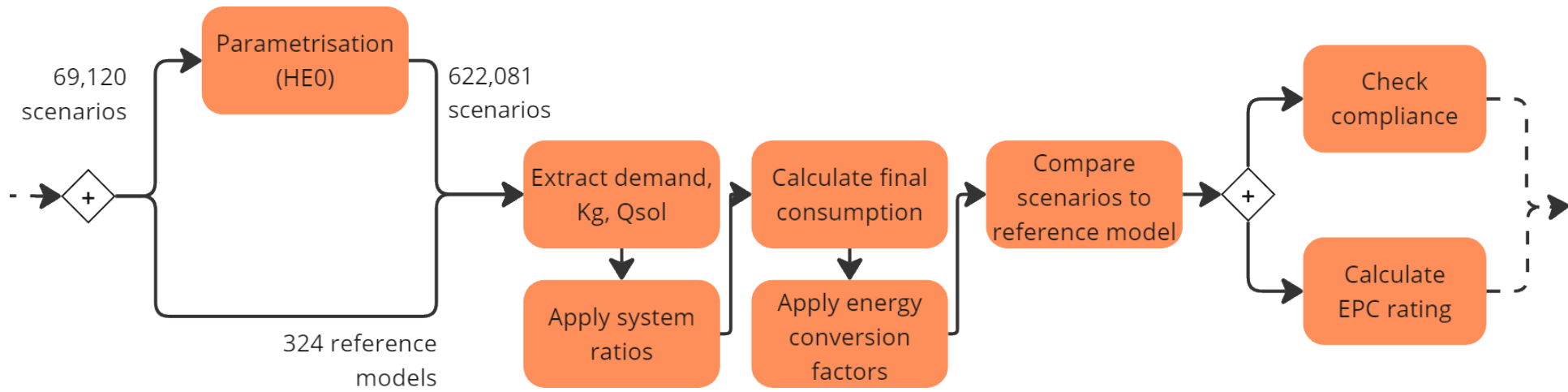| Parameter	Value
Thermal envelope	CTE DB HE1 Minimum CTE DB HE Appendix E Improved envelope, g = 0.6 Improved envelope, g = 0.3
Solar protection	Without solar protection Fixed exterior, minimum effect (0.55) Mobile interior, small effect (0.4) Fixed exterior, moderate effect (0.25) Mobile exterior, large effect (0.15)
Natural ventilation	Without natural ventilation 5 ach 10 ach
Thermal mass	Without thermal mass With themal mass
Lighting sensor	Without lighting sensor With lighting sensor
Lighting efficiency	VEEI minimum (5 W/m2) VEEI optimised (10 W/m2)

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Methodology:
2) Parametrisation and simulation

Methodology:
3) Post-processing of results and extraction of indicators

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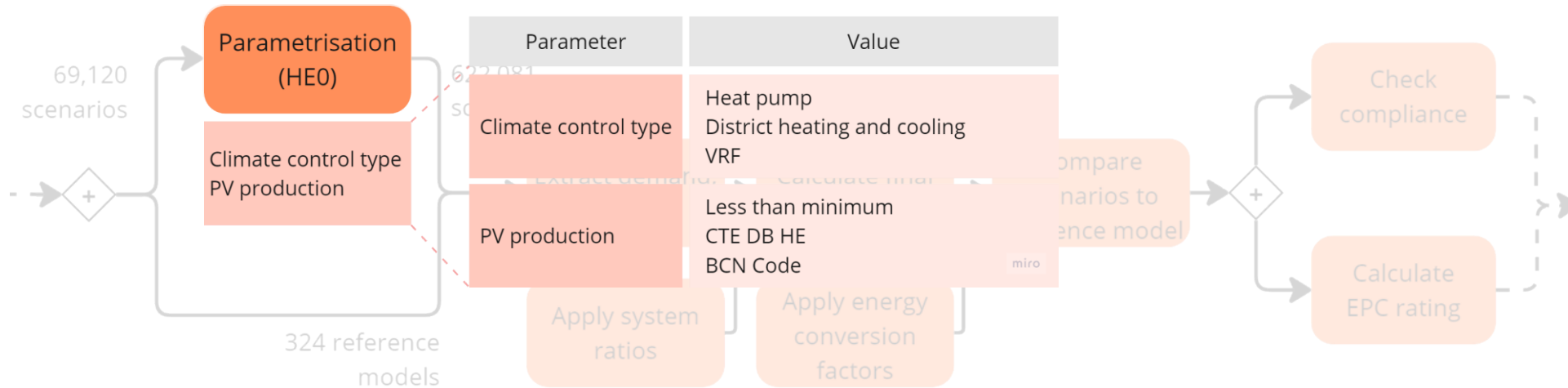## 3) Post-processing of results and extraction of indicators

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3) Post-processing of results and extraction of indicators

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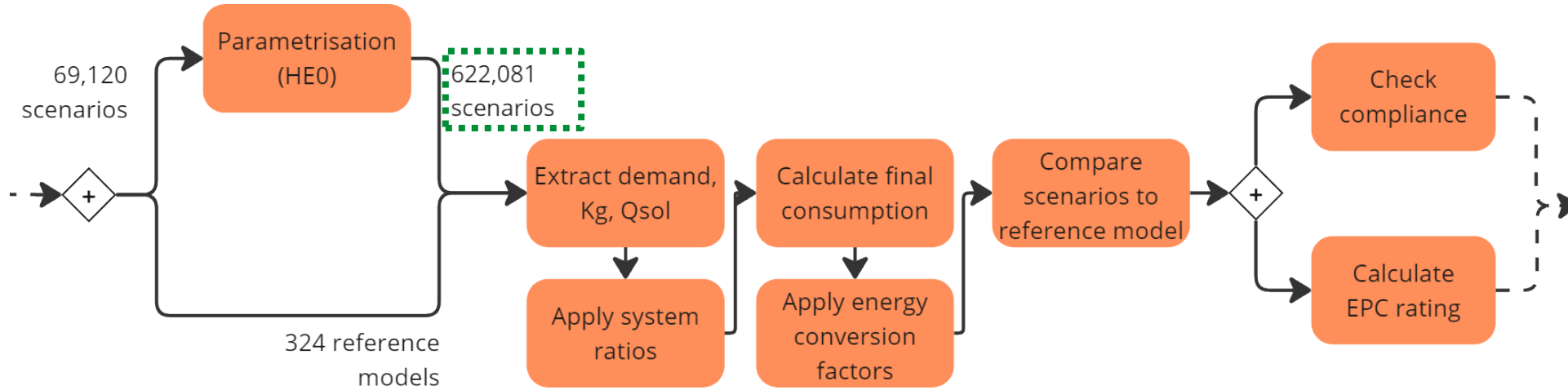# 3) Post-processing of results and extraction of indicators

Methodology:
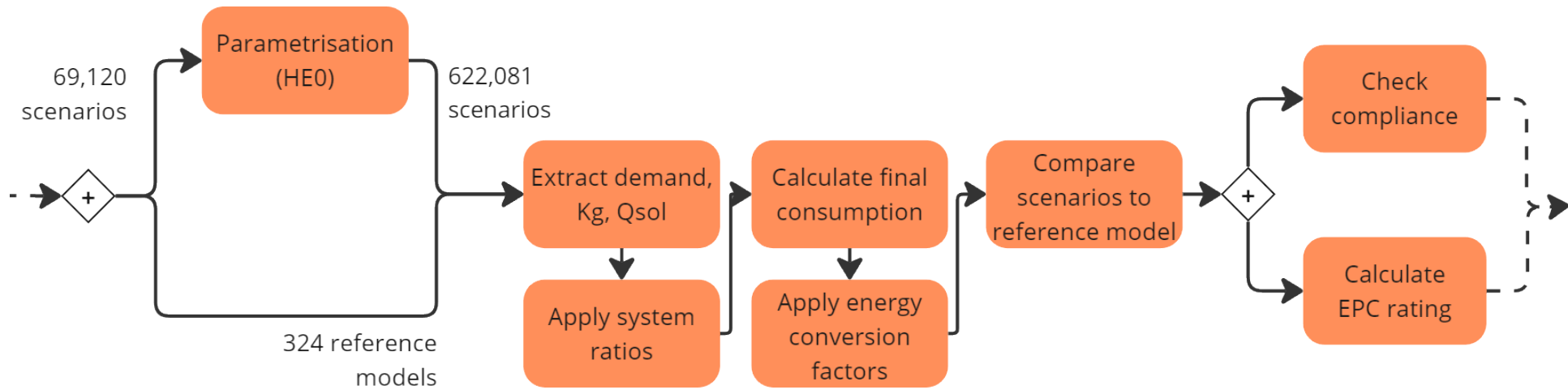# 3) Post-processing of results and extraction of indicators

Python   **Excel**

Check compliance

CTE DB HE 2019 (nZEB)
    HE0:
    Total Primary Energy (Cep,tot)
    Non-renewable Energy (Cep,nren)
    HE1:
    Global Envelope Coefficient (Kg)
    Solar Control (Qsol)
    Heating demand (kWh/m2)
    Cooling demand (kWh/m2)
EU Directive ZEB (EPDB Recast)
    Total Primary Energy (Cep,tot)

Calculate EPC rating

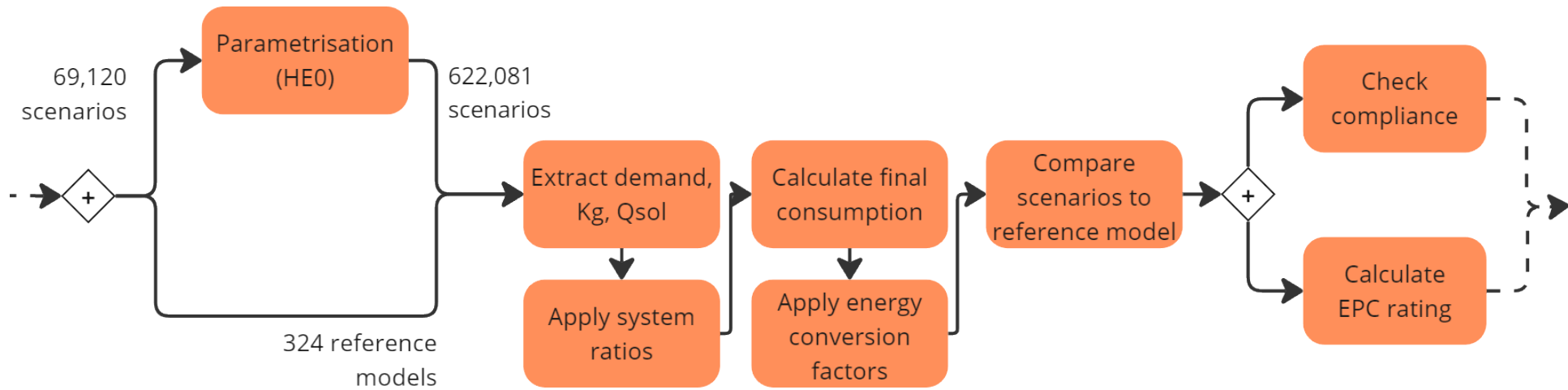**EPC rating:**
CO2 emissions
Non-renewable Energy (Cep,nren)
Heating demand (kWh/m2)
Cooling demand (kWh/m2)

Methodology:
4) Analysis of results, 5) Synthesis and conclusions
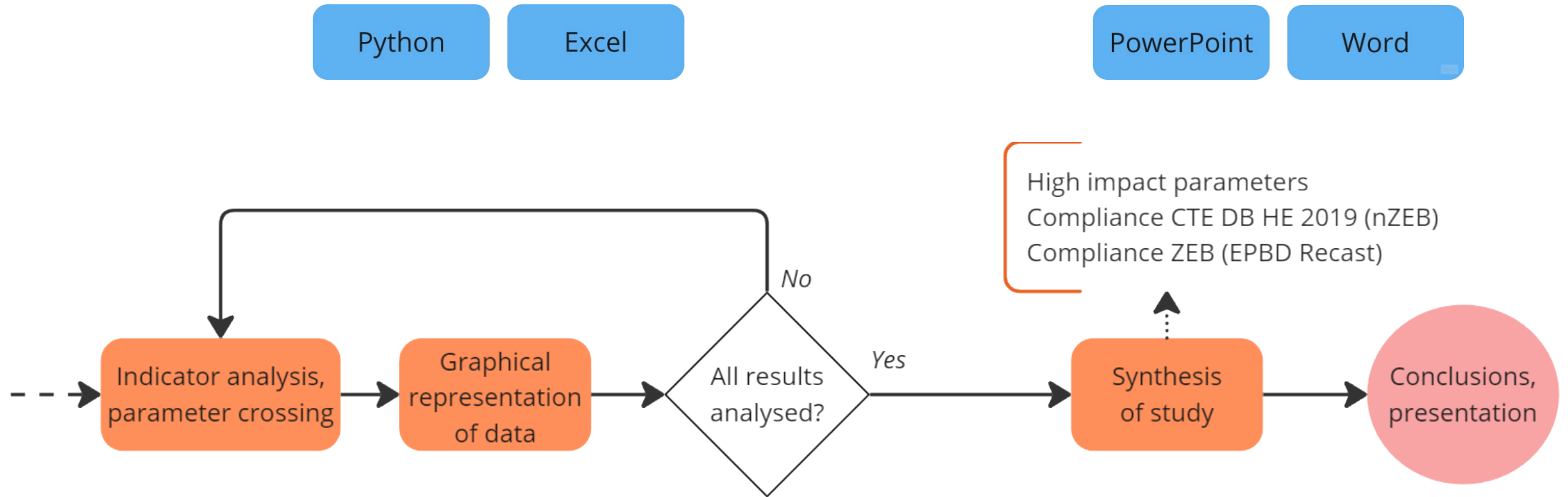
Results & discussion

- Compliance distribution

- Parameter analysis

Compliance nZEB vs ZEB

Distribution by occupancy hours and internal loads intensity

Compliance nZEB vs ZEB

Distribution by occupancy hours and internal loads intensity
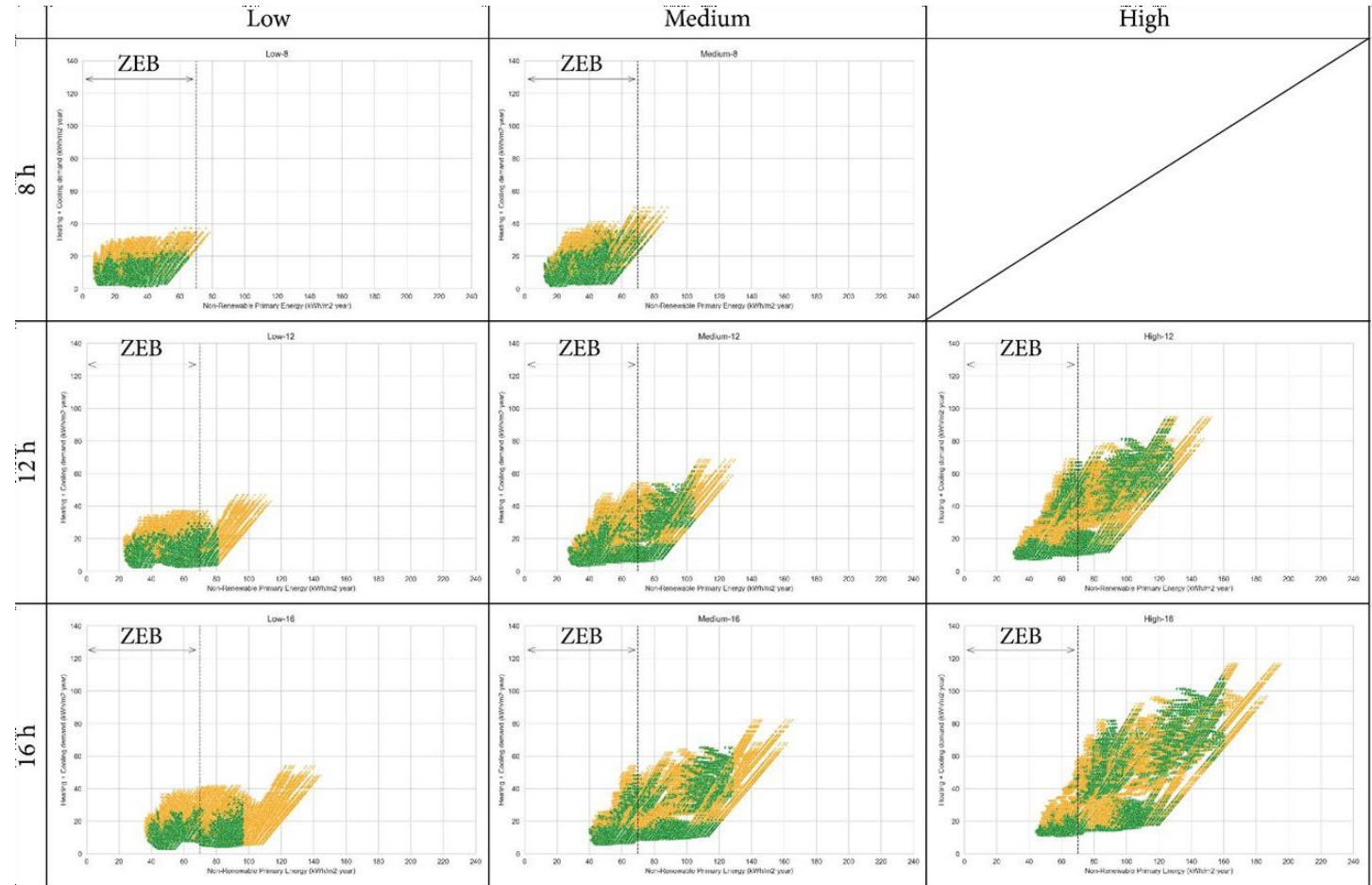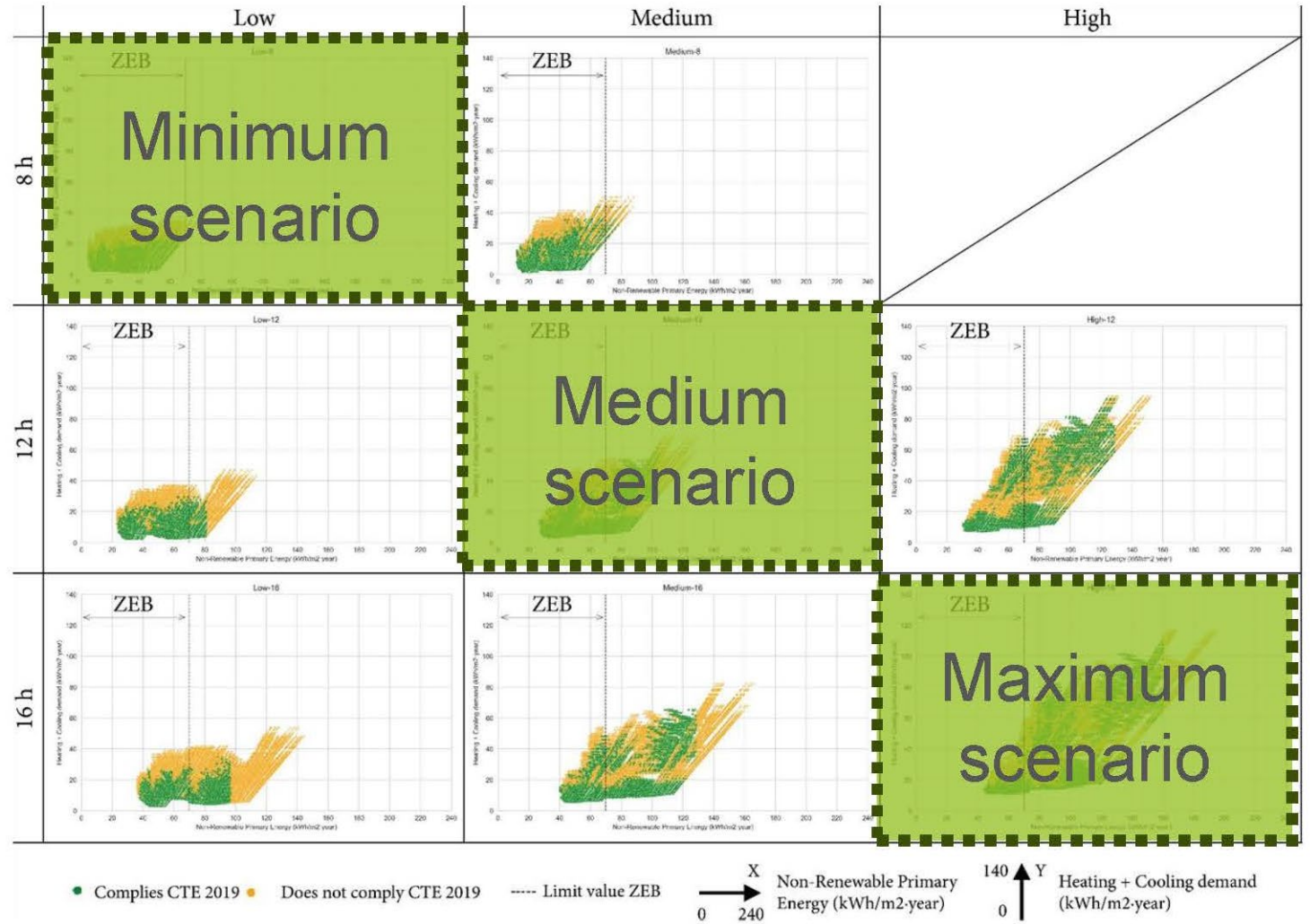
Compliance nZEB vs ZEB

Minimum scenario · Medium scenario · Maximum scenario

Y-axis: Demand Cooling + Heating (kWh/m2·year), 0 to 140
X-axis: Non-Renewable Primary energy (kWh/m2·year), 0 to 200

Legend:
- Complies nZEB
- Does not comply nZEB
- Complies ZEB
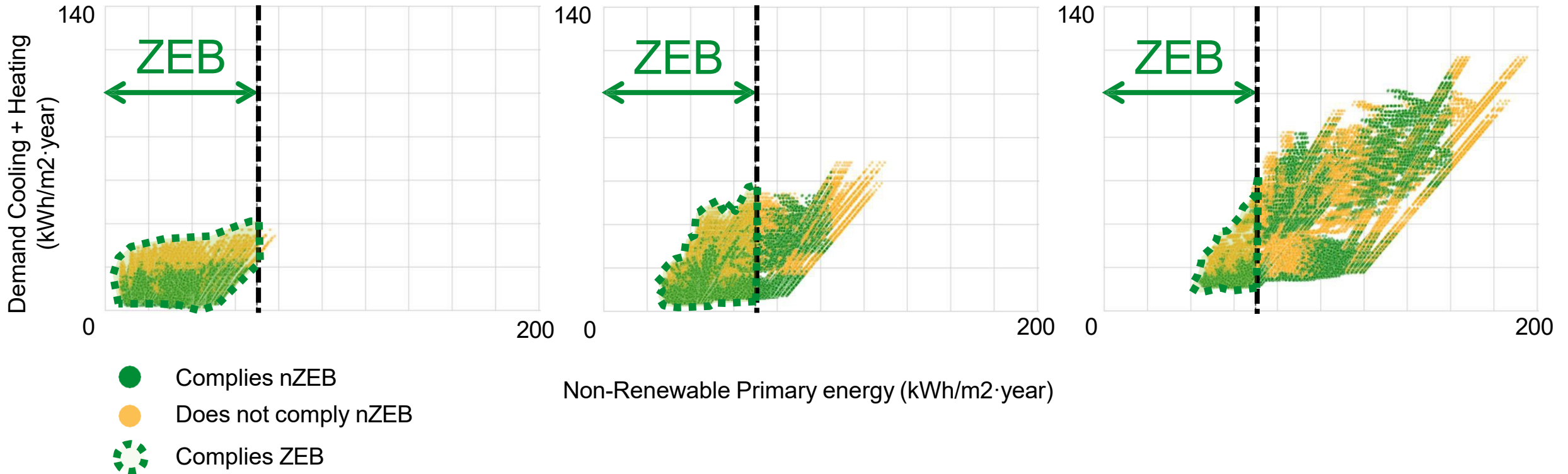
Compliance nZEB vs ZEB

nZEB takes intensity in use into account when it comes to compliance, allowing a higher demand and consumption depending on building use type

ZEB only recommends limitation to Total Primary Energy Consumption (Cep,tot), and does not regulate demand

Minimum scenario

Medium scenario

ZEB

ZEB

ZEB

140

140

140

Demand Cooling + Heating (kWh/m2·year)

0

200

0

200

0

200

Non-renewable primary energy (kWh/m2·year)

● Complies nZEB

● Does not comply nZEB
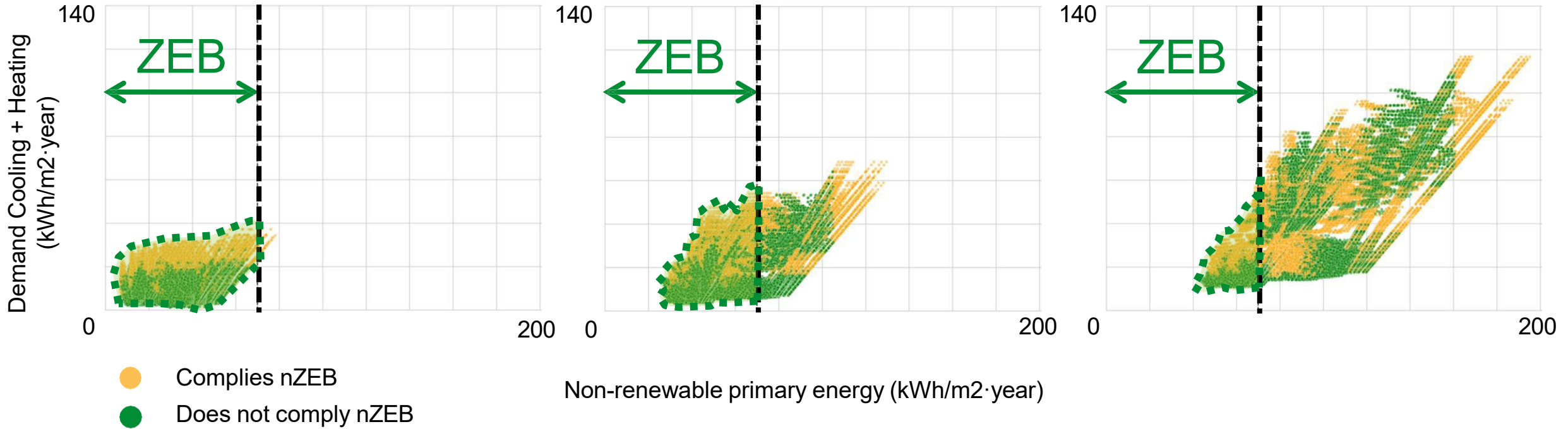
Parameter analysis

Percentage of compliance by parameter value

Percentage of cases that comply and the parameter definition appears		Compliance HE0 (Cep,tot,lim - kW·h/m²·year)	Compliance HE0 Cep,nren,lim (kW·h/m²·year)	Compliance Qsol;jul	Compliance Kg	Compliance CTE 2019	Compliance EU Directive 2021/0426 (COD)
Lighting sensor	With lighting sensor	100	99	86	84	75	54
	Without lighting sensor	100	88	86	82	66	39
IEQ ventilation	CO2 sensor	100	95	86	84	72	52
	Constant	100	92	86	82	69	42
Thermal mass	With thermal mass	100	94	86	84	71	48
	Without thermal mass	100	93	86	82	69	46
Solar protection	Fixed exterior minimum effect (0.55)	100	93	100	84	79	46
	Fixed exterior moderate effect (0.25)	100	95	100	86	82	48
	Mobile exterior large effect (0.15)	100	95	100	86	82	49
	Mobile interior small effect (0.40)	100	93	78	82	65	46
	Without solar protection	100	92	53	77	45	45
Natural ventilation	10 ACH	100	96	86	90	76	53
	5 ACH	100	96	86	88	75	51
	Without natural ventilation	100	89	86	72	60	36
Lighting efficiency	VEEI minimum (10 W/m2)	100	88	86	82	65	26
	VEEI optimised (5 W/m2)	100	99	86	84	75	68
Thermal envelope	CTE DB HE Appendix E	100	94	80	71	58	48
	Improved envelope, g = 0.3	100	94	100	96	90	46
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	CTE DB HE1 Minimum	100	94	80	70	57	47
WWR NO	30% NO	100	94	95	86	78	47
	60% NO	100	94	85	85	71	47
	90% NO	100	93	78	77	62	47
WWR SE	30% SE	100	93	97	100	90	45
	60% SE	100	94	87	80	68	48
	90% SE	100	94	75	69	53	48

Parameter analysis

Percentage of compliance by parameter value

All scenarios comply with the limit of total primary energy consumption defined in HE0

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Parameter analysis

Percentage of compliance by parameter value

Qsol;jul varies with solar protection and WWR, whilst Kg varies with Thermal envelope and WWR SE

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Parameter analysis

Percentage of compliance by parameter value

Compliance with CTE 2019 globally is at 67%. Use of natural ventilation, VEEI optimisation and proper solar control significantly improve the likelihood of compliance

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Parameter analysis

Percentage of compliance by parameter value

Compliance with the EU Directive globally is at 47%. Lighting efficiency has a higher significance for compliance, whilst solar control has a lower significance, compared to CTE 2019

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Conclusions

Compliance:

- No clear trend is observed where nZEB guarantees a building with low demand and consumption, mainly due to prescriptive limitations and indicators rather than performance-based ones

- The HE0 primary energy consumption limit needs to be restricted further to have relevance

- ZEB could be revised to offer flexibility with an increased intensity of use, to avoid favouring low-occupancy buildings
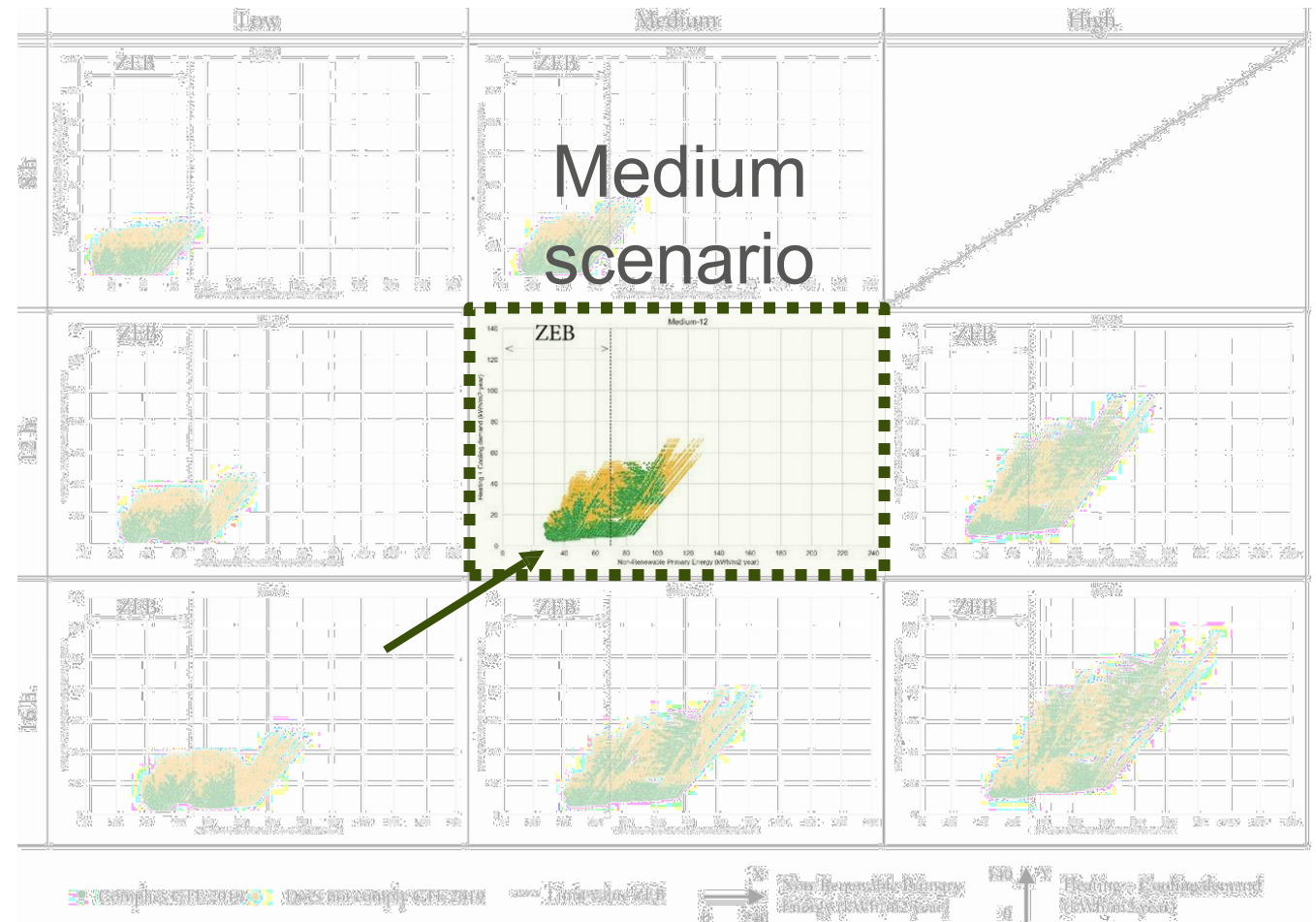
Conclusions

Parameter analysis:

Desirable configurations to comply with nZEB and ZEB:

- Reducing internal loads with lighting control and lighting efficiency
- Reducing solar gains with efficient solar protection and/or optimised WWR
- Free cooling using natural ventilation

Conclusions

- High efficiency lighting with sensor

- CO_2 sensor for ventilation

- High thermal mass and natural ventilation

- Improved thermal envelope, g=0.6, combined with effective, exterior adjustable solar shading

- 60% WWR towards north and 30% WWR towards south

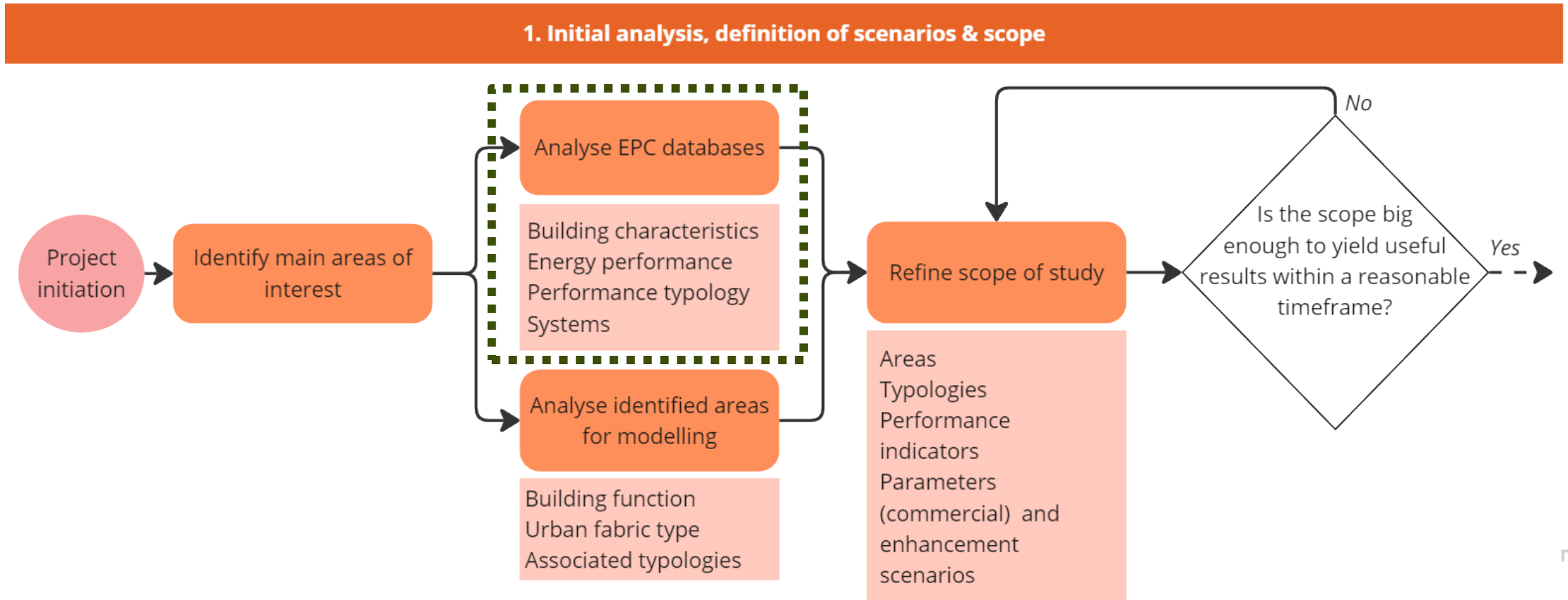- Efficient systems (VRF) and maximised PV production

Medium scenario

Conclusions: Best-case scenario

- High efficiency lighting with sensor

- CO_2 sensor for ventilation

- High thermal mass and natural ventilation

- Improved thermal envelope, g=0.6, combined with effective, exterior adjustable solar shading

- 60% WWR towards north and 30% WWR towards south

- Efficient systems (VRF) and maximised PV production

Medium scenario

Cooling + heating demand: < 4 kWh/m2·year

Total primary energy: ~40 kWh/m2·year

Total non-renewable energy: ~33 kWh/m2·year
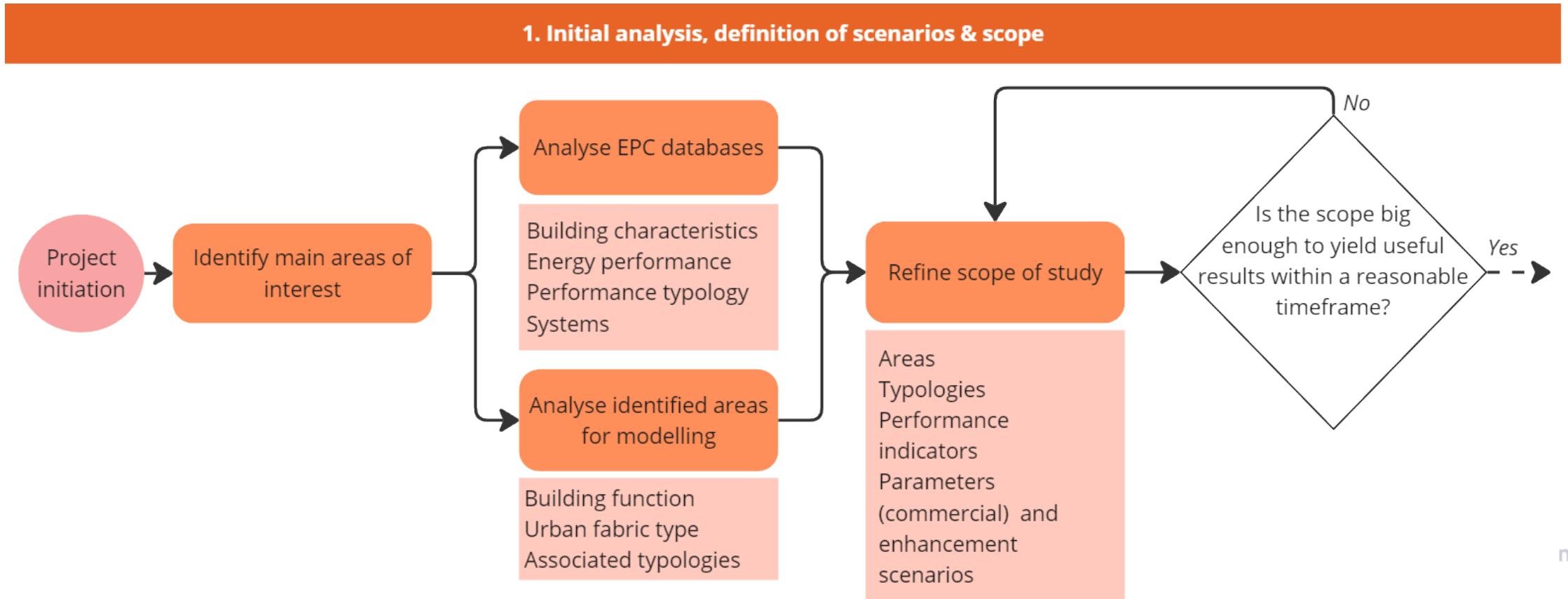
Future application: Existing buildings and renovations

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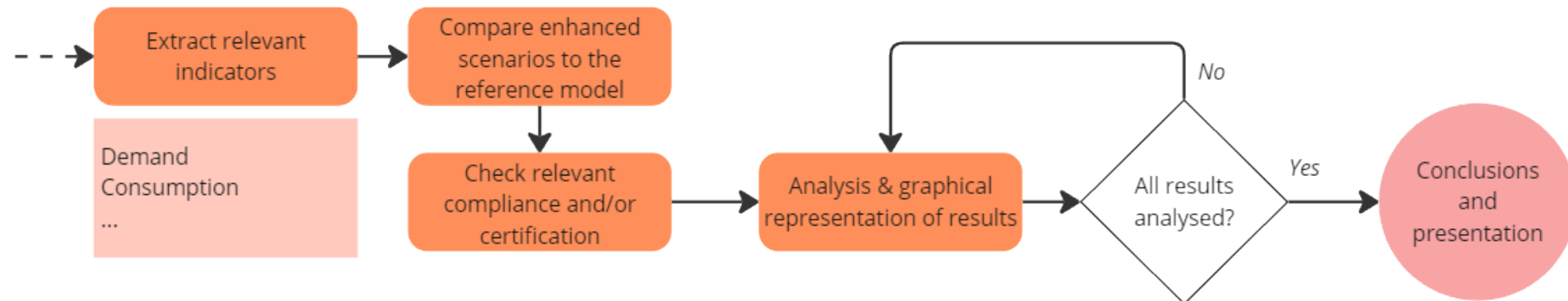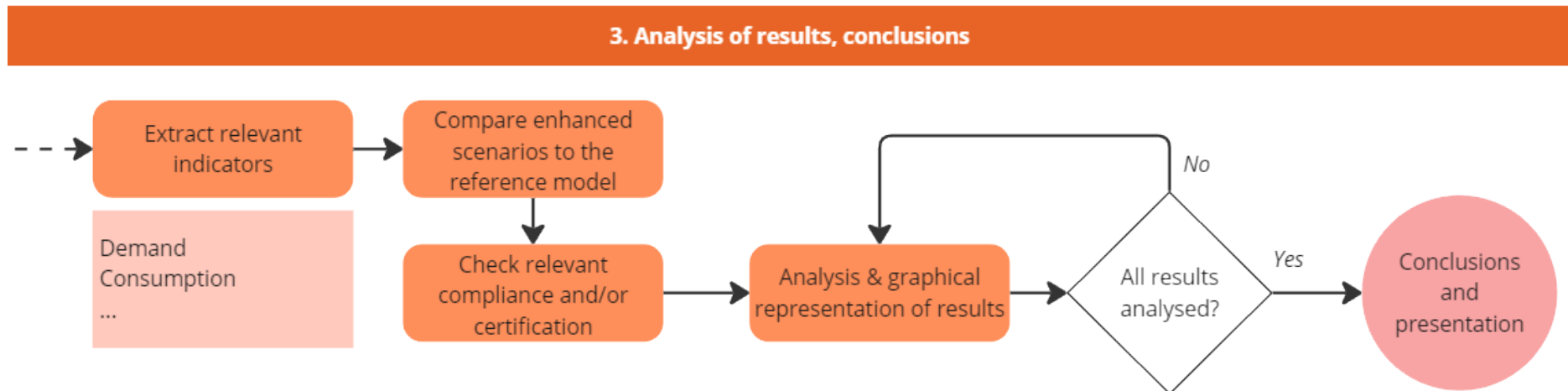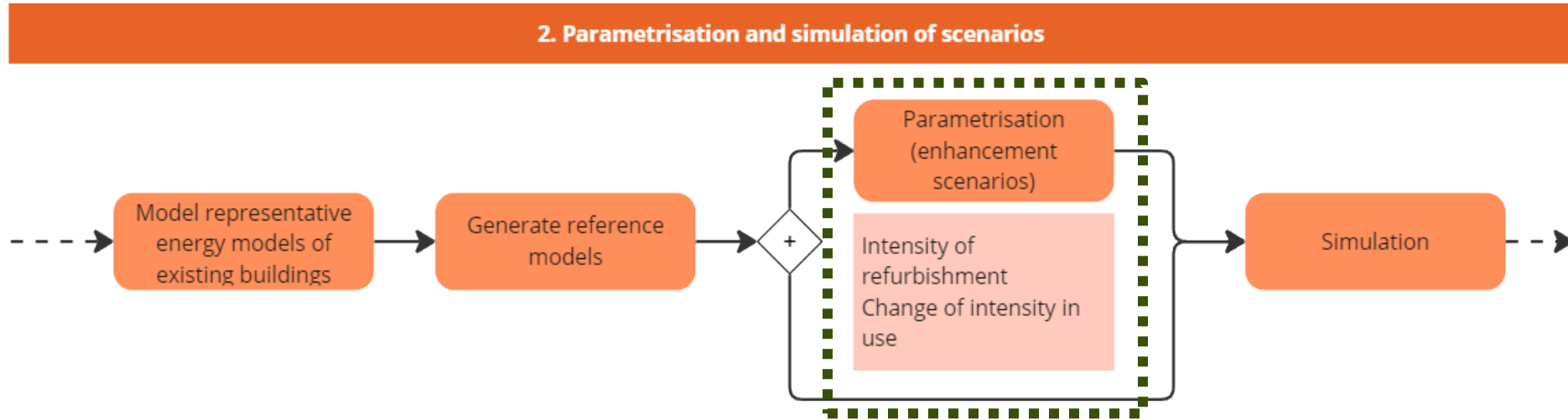# Future application: Existing buildings and renovations

If you would like further information, please contact us at

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