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2017 – 2019 Research Assistant

2015 – 2017 MSc Energy Science and Technology

2011 – 2015 BSc Civil Engineering

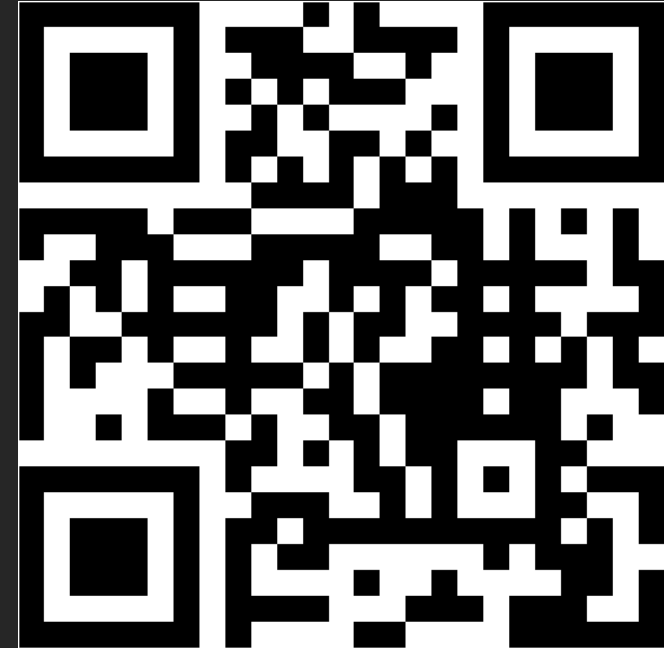


Buildings are built for the future

Why robust building systems are necessary for climate change mitigation and how robustness can be assessed.

Before we start with buildings,

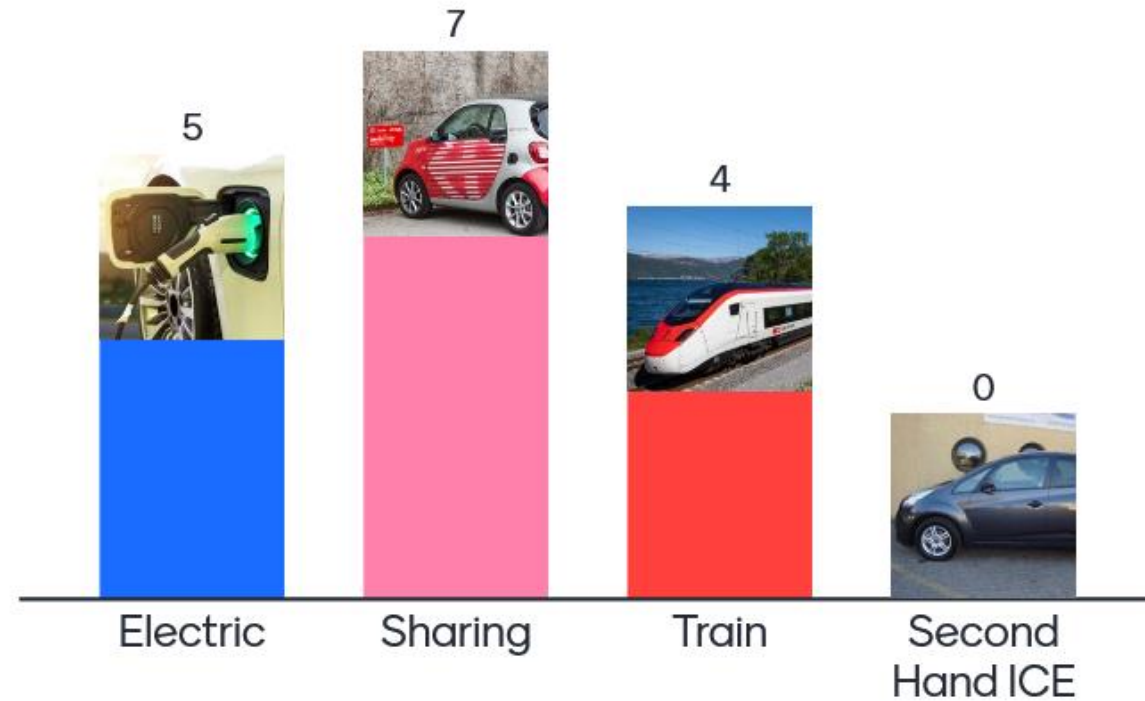
let's look at a more relatable problem from our daily life.



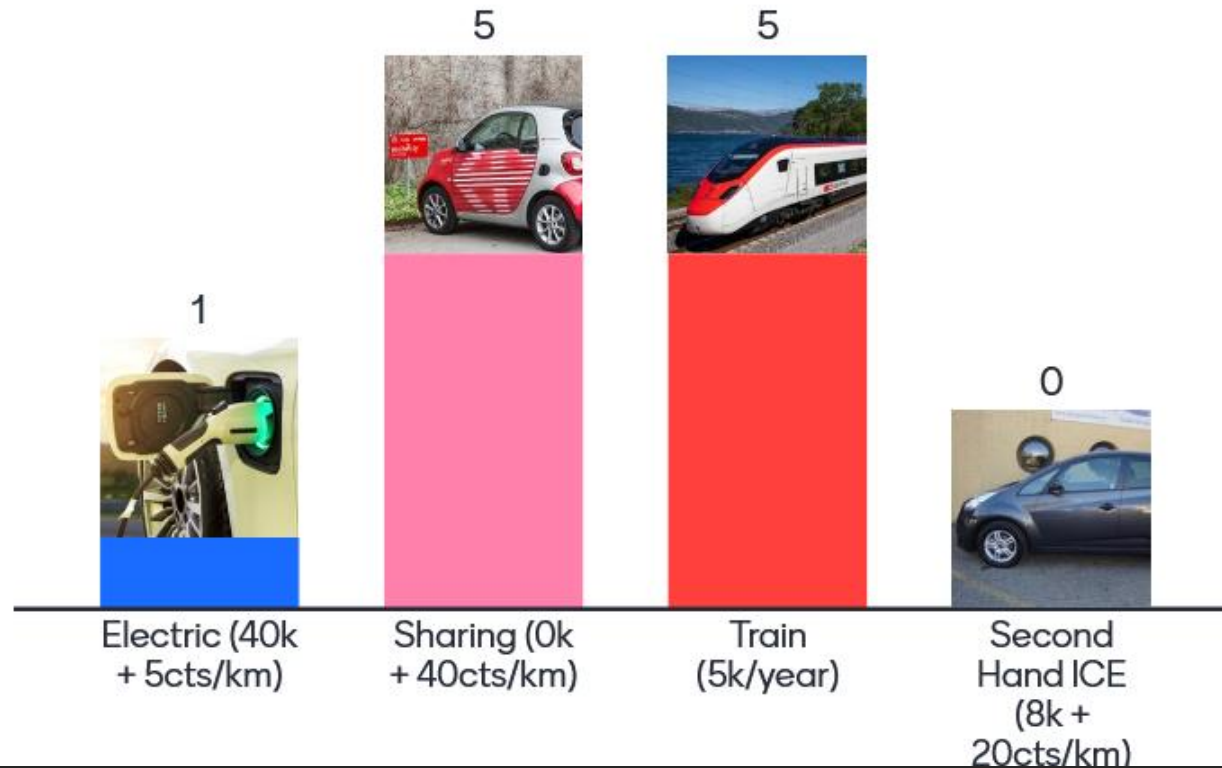
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Choose your mobility concept for the next 10 years.

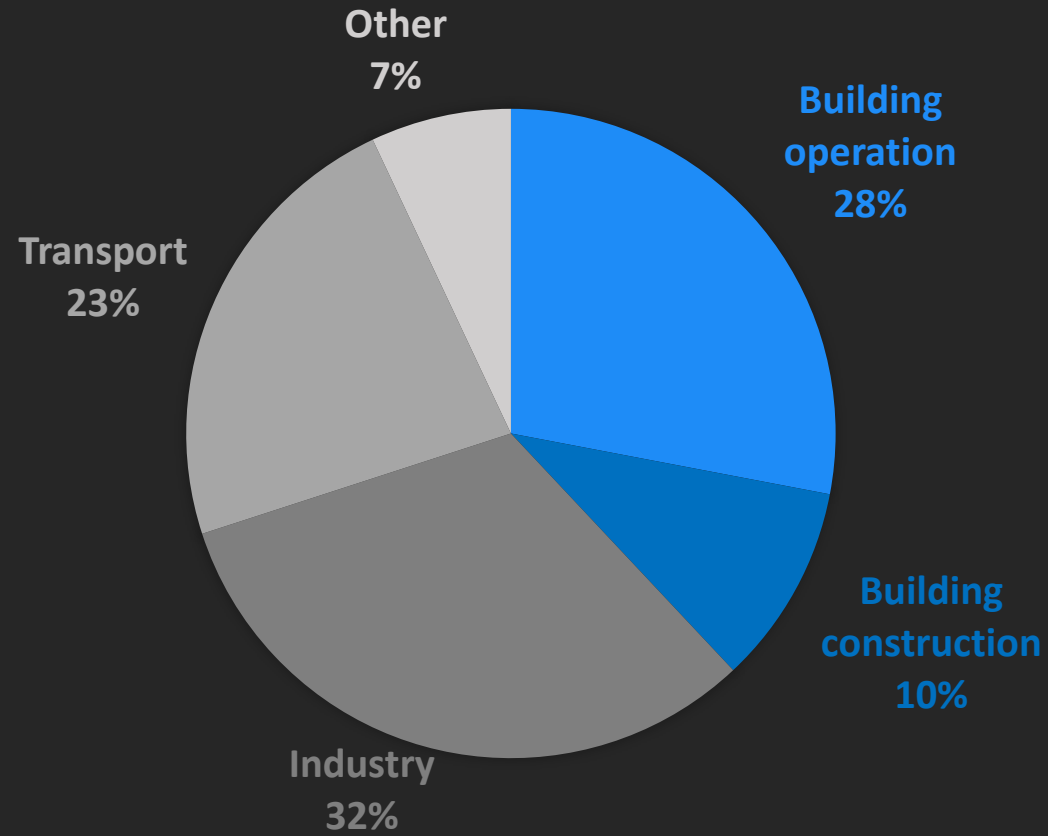


Choose your mobility concept for the next 10 years. (You expect to drive 18'000km per year)

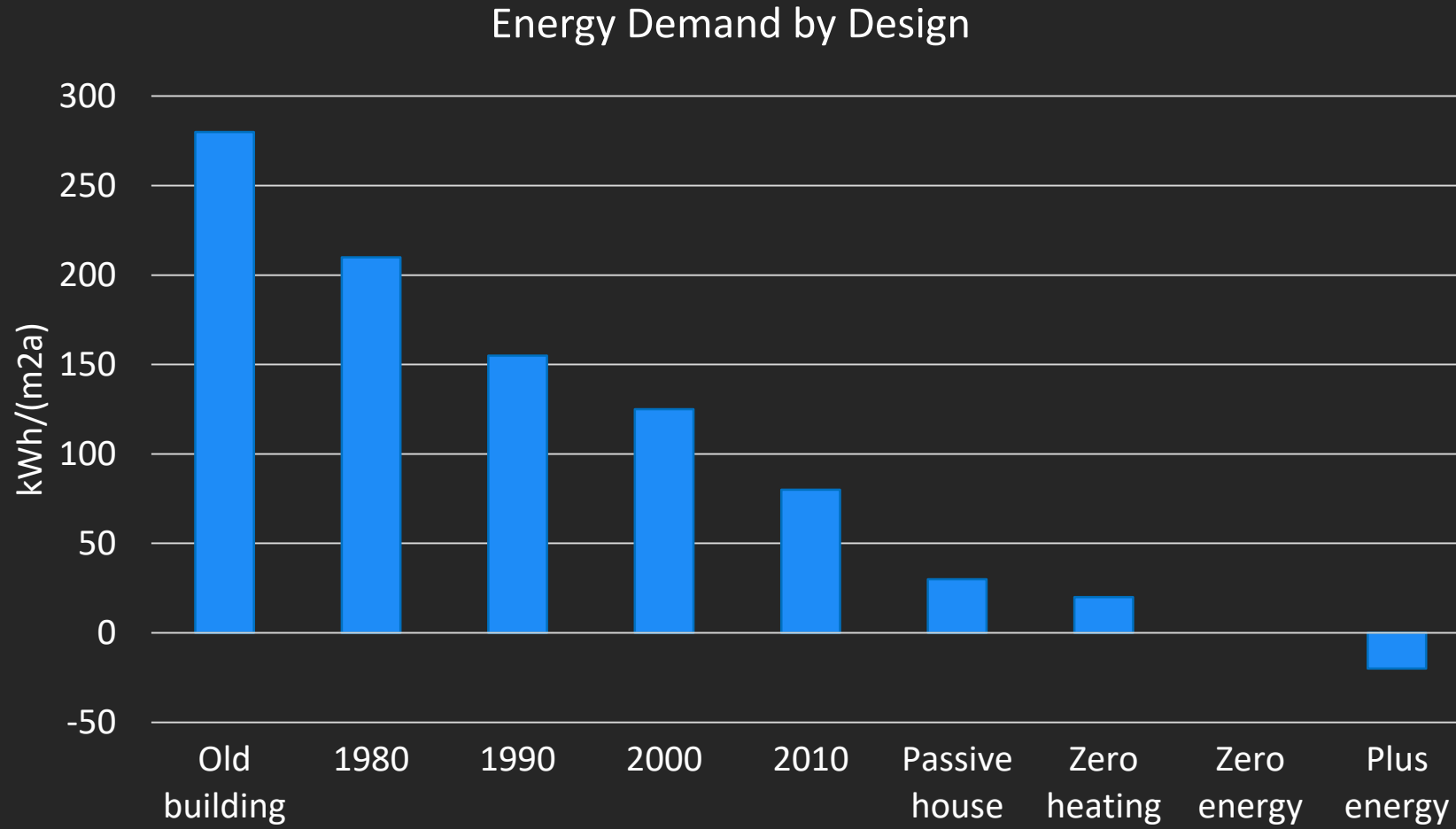


Motivation

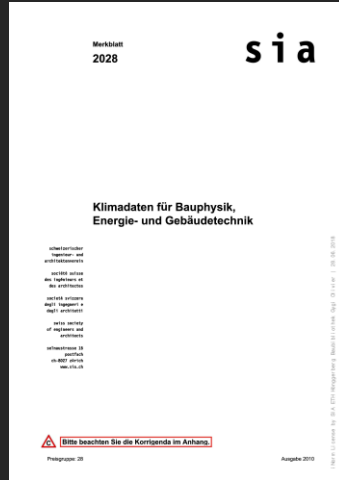
GLOBAL EMISSIONS



What has been done

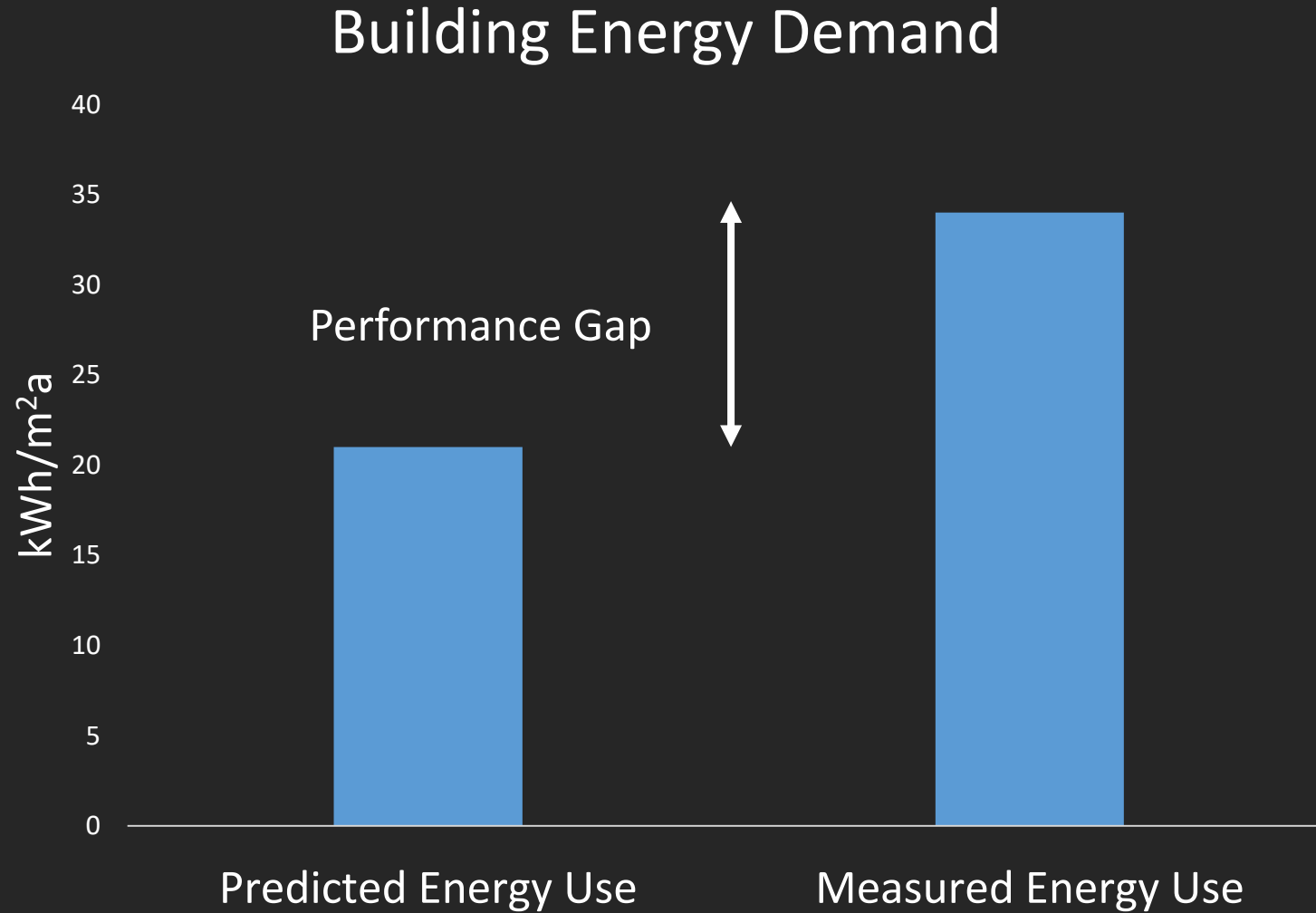


Current Way of Building Energy Assessment



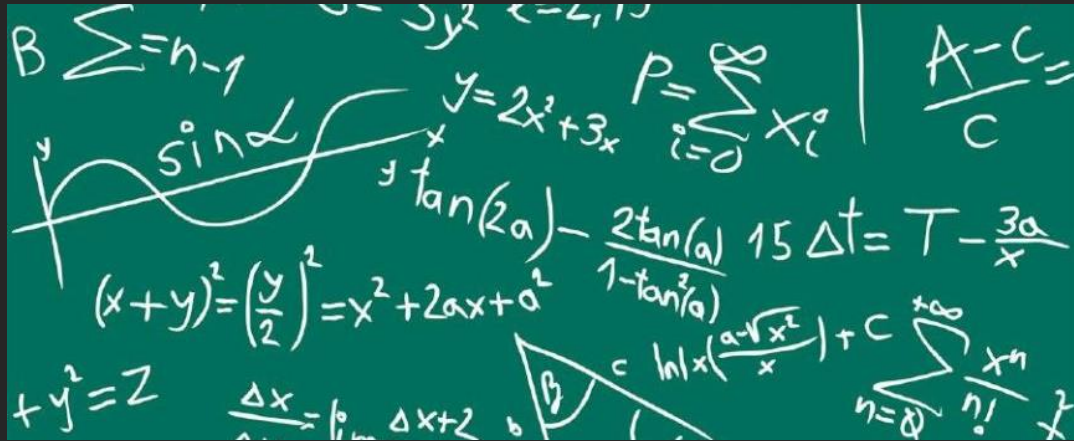
A+++

Performance Gap



Performance Gap

Modelling Gap



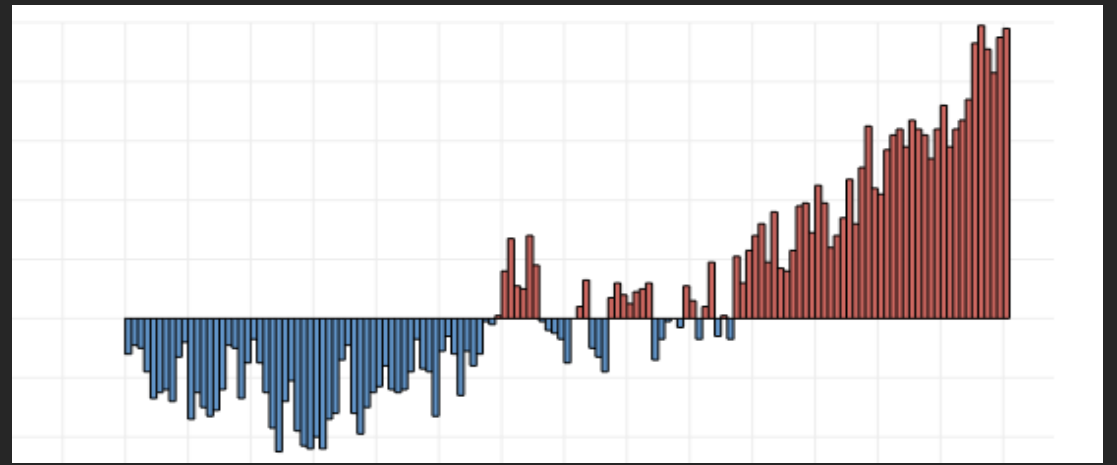
Behavioral Gap



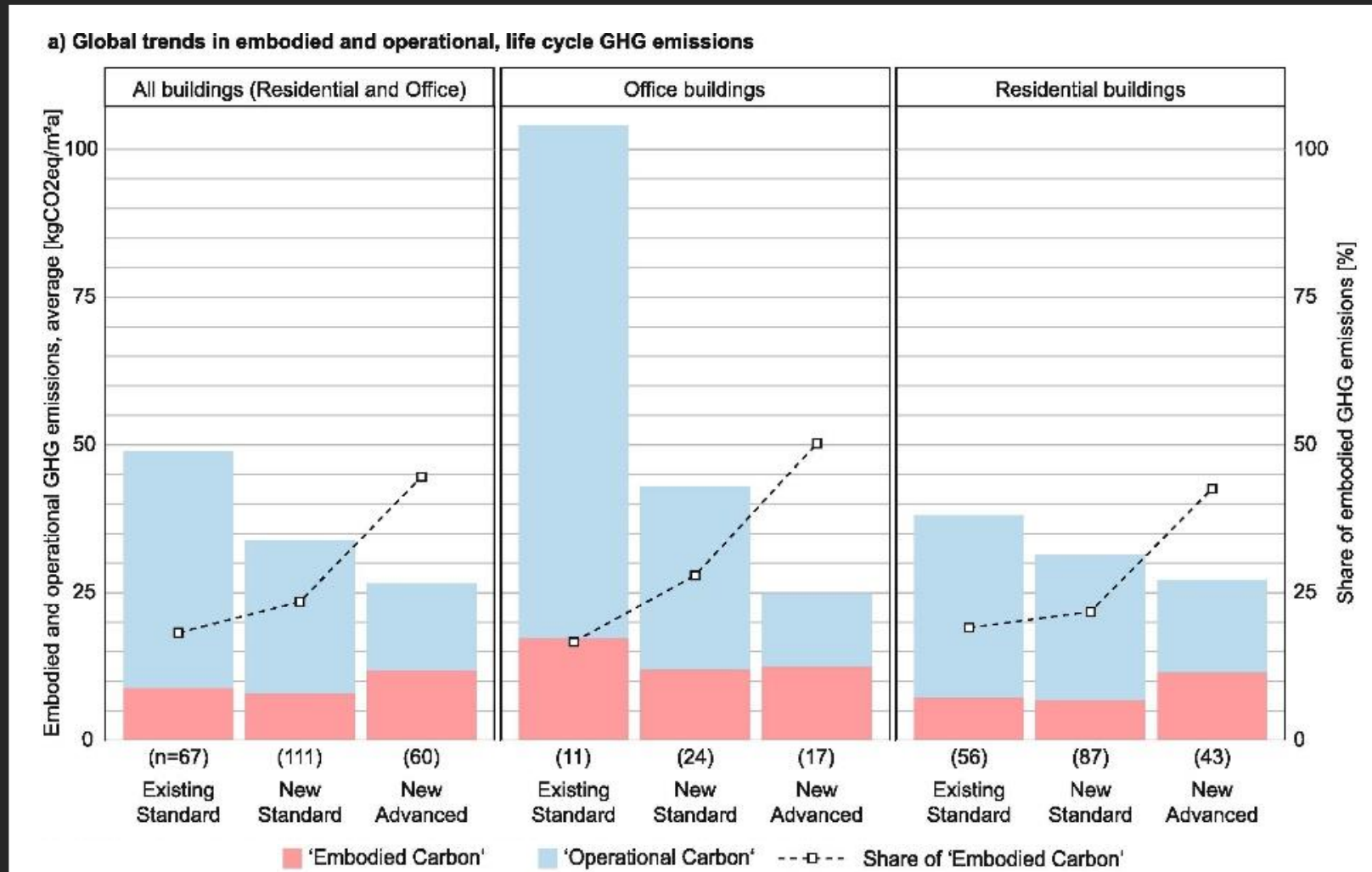
Technical Gap



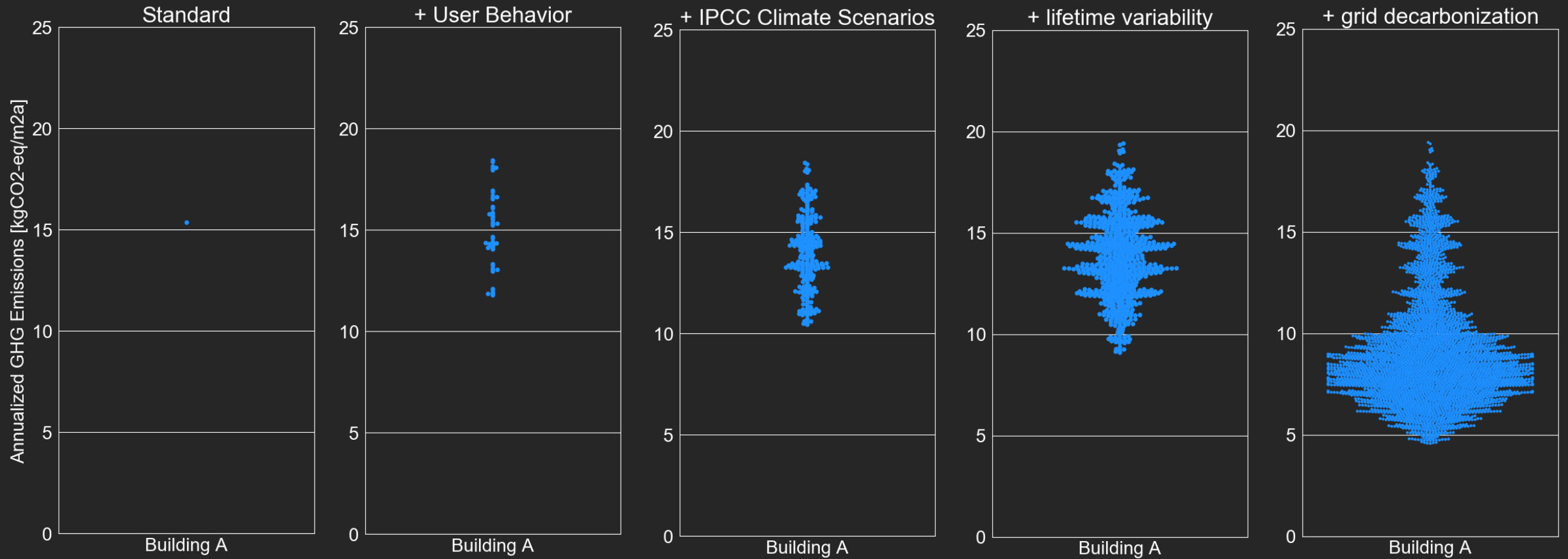
Climate Gap / Future Gap



From Energy to Emissions



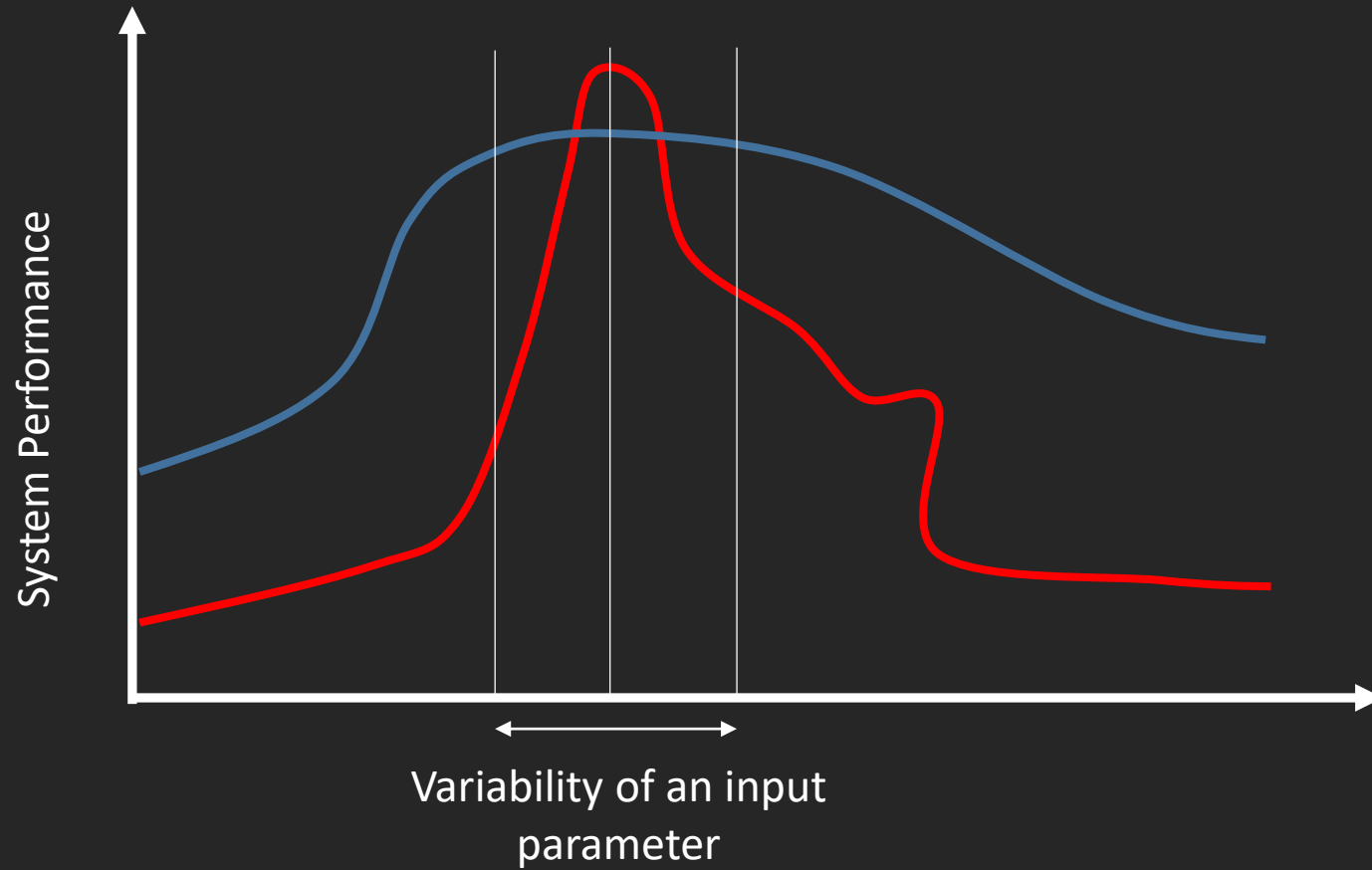
Emissions under variable conditions (operational + embodied)



Main Question

How can **robust building configurations** be identified that perform well from a life cycle perspective considering possible **future boundary conditions**?

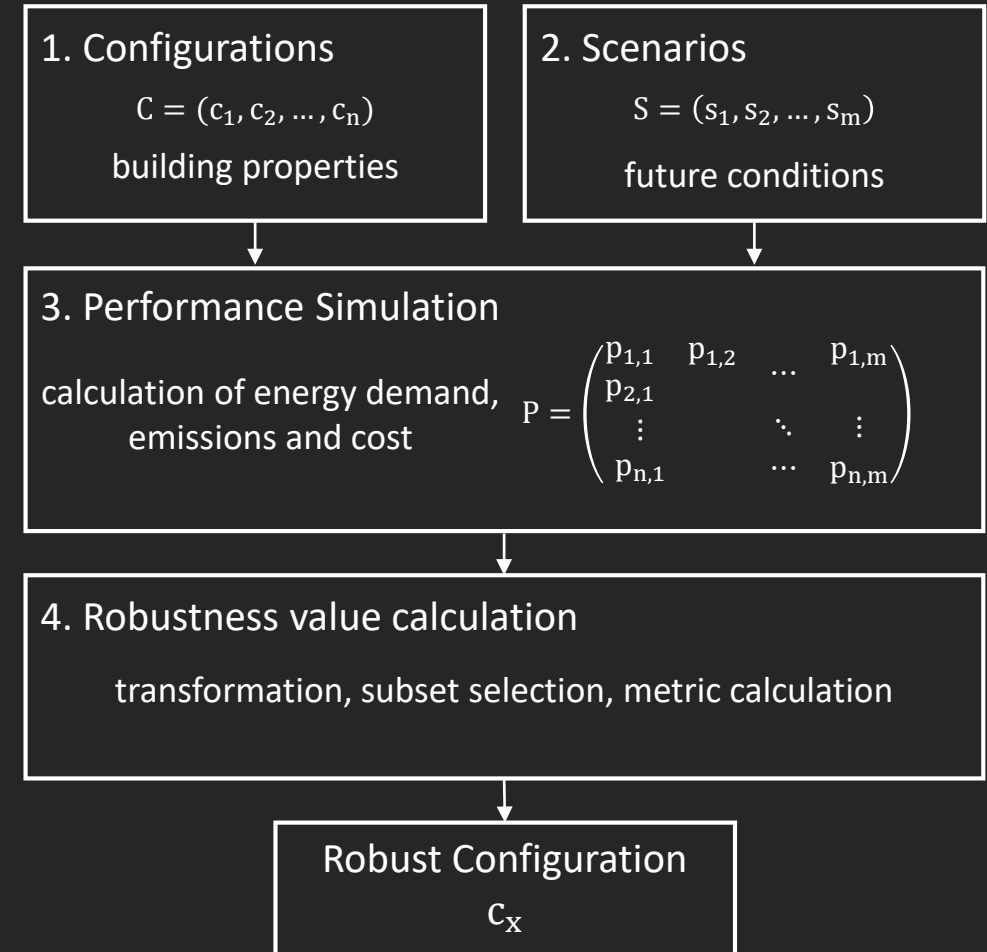
Robustness



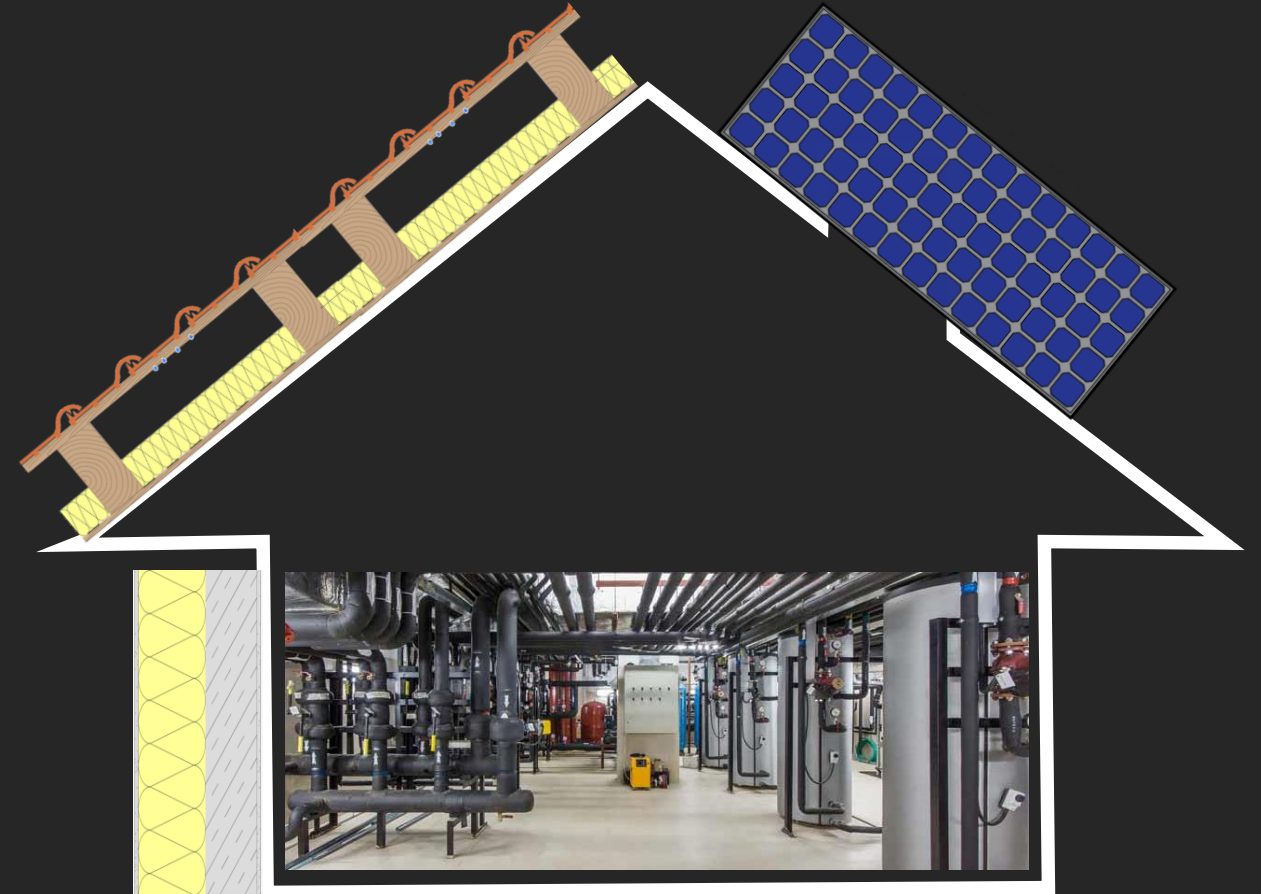
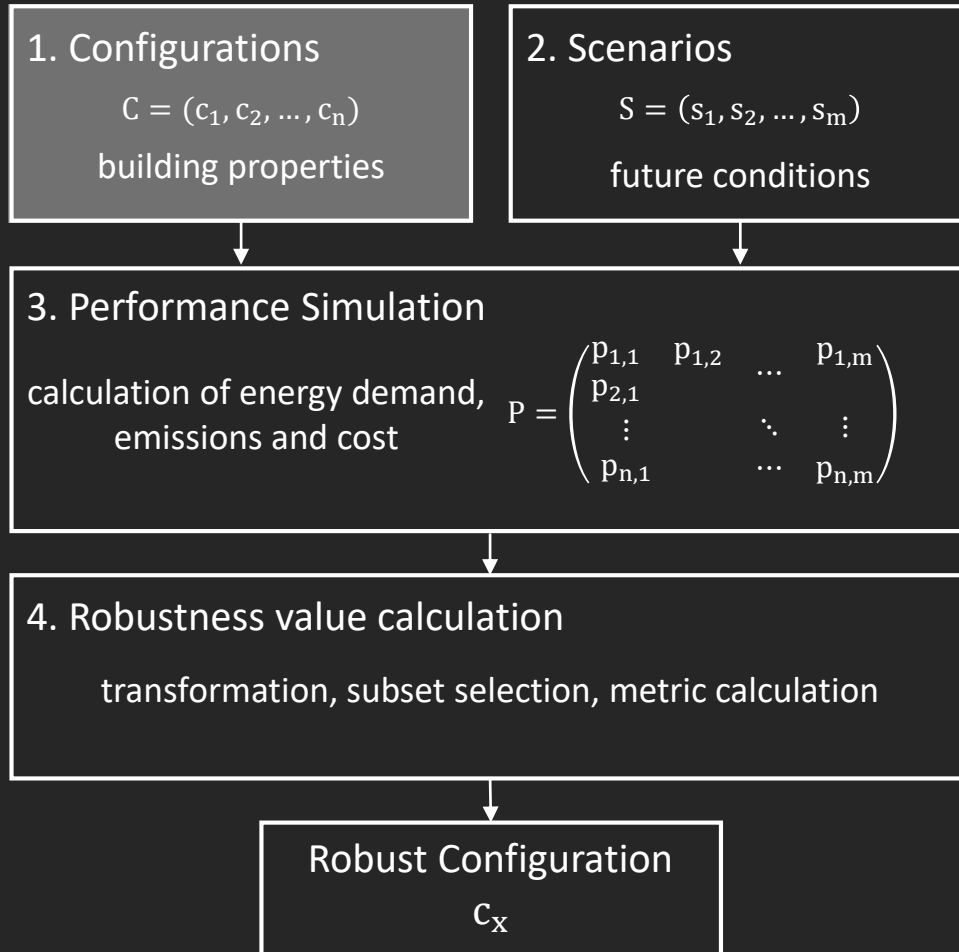
Scenario-based robustness assessment

Scenario-based robustness assessment means:

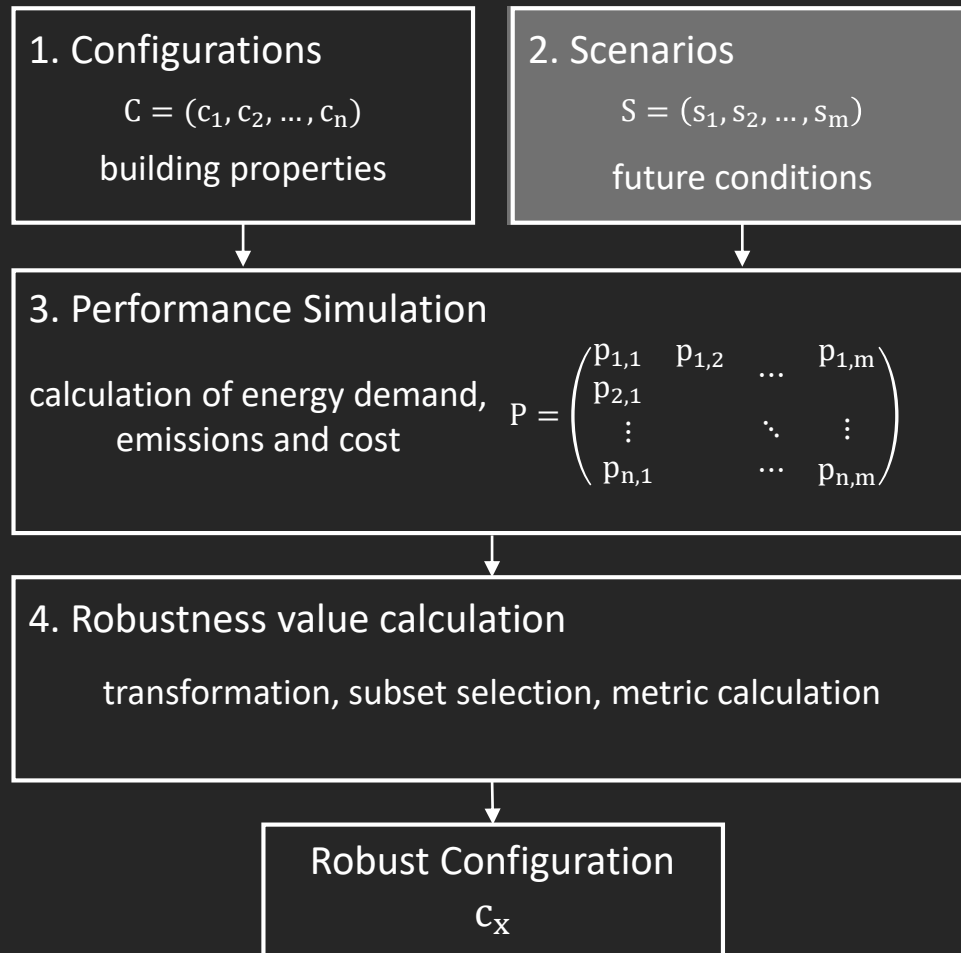
- No probabilities for the future required (deep uncertainty)
- More tangible for decision maker
- Taking concepts from economics and infrastructure decision making to building design



1. Configurations

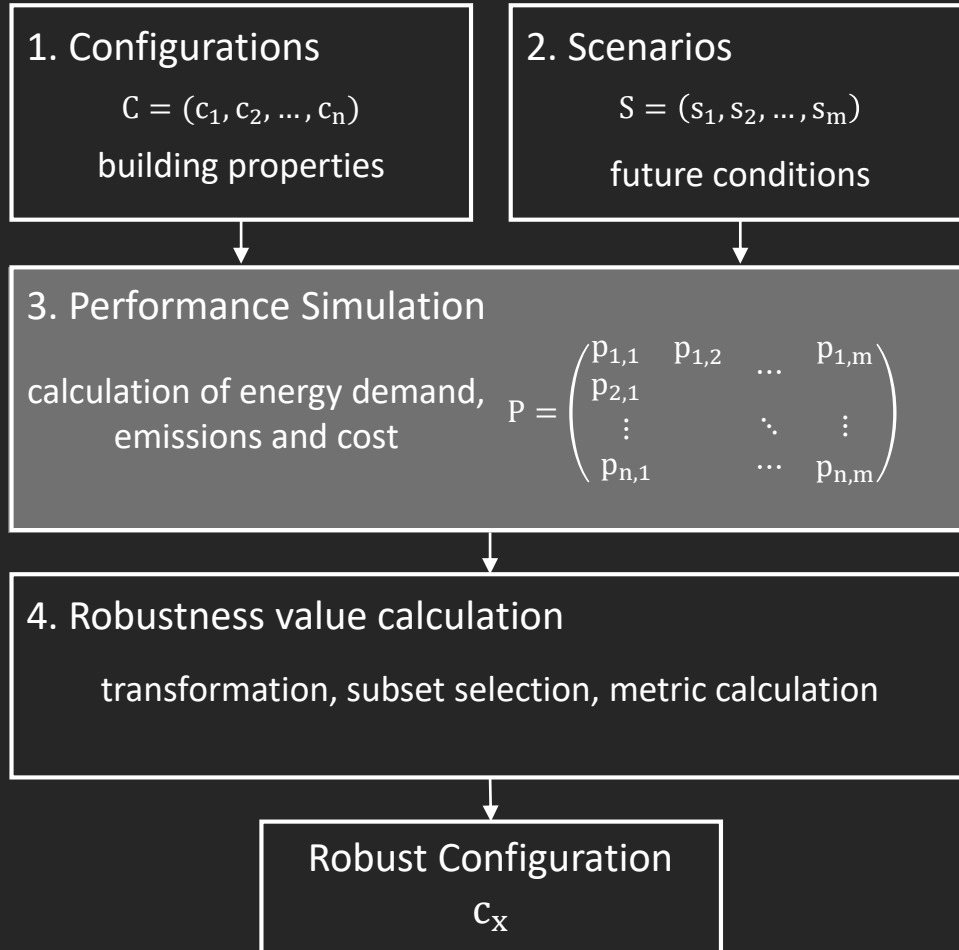


2. Scenarios



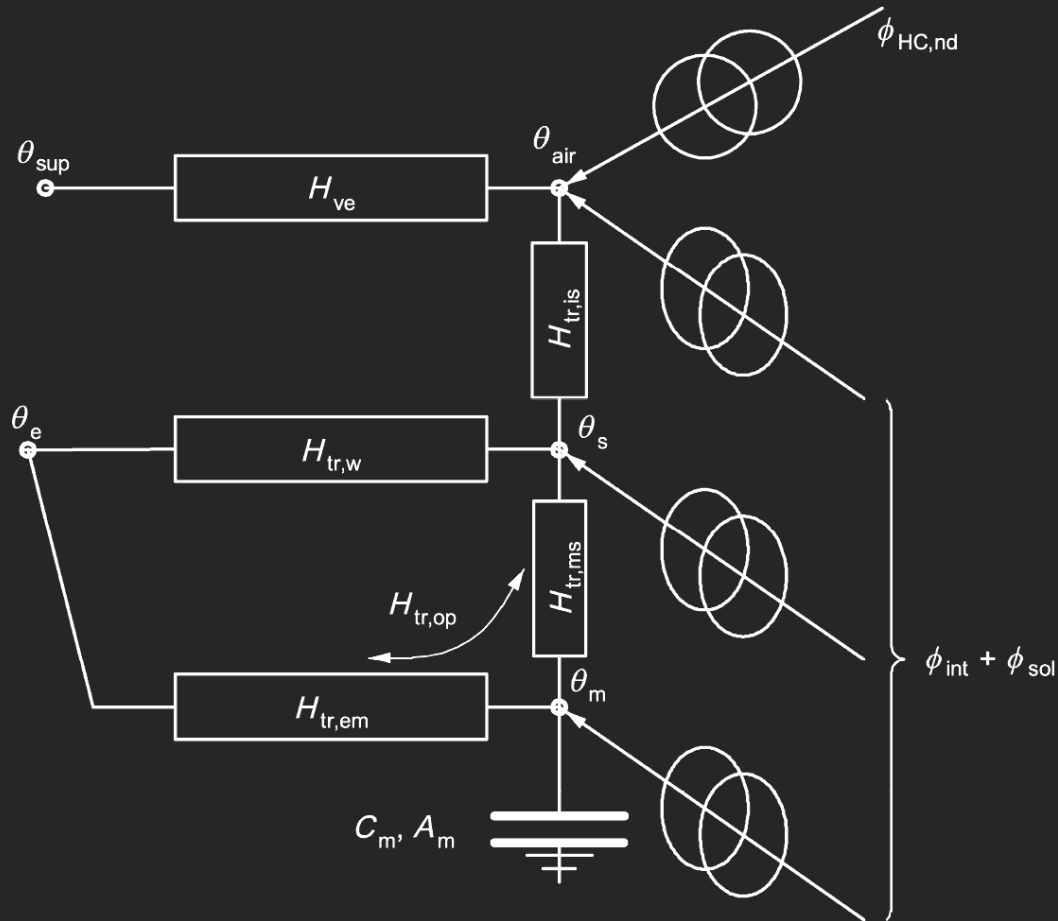
- Climate change
 - RCP scenarios
- Simplified occupant preferences
 - Temperature set points
 - Ventilation set points
 - Various occupancy schedules
- Decarbonization
 - Electricity grid decarbonization
- Component lifetime
 - Lifetime factors

3. Performance Simulation



3. Performance Simulation

Resistance-Capacitance Model



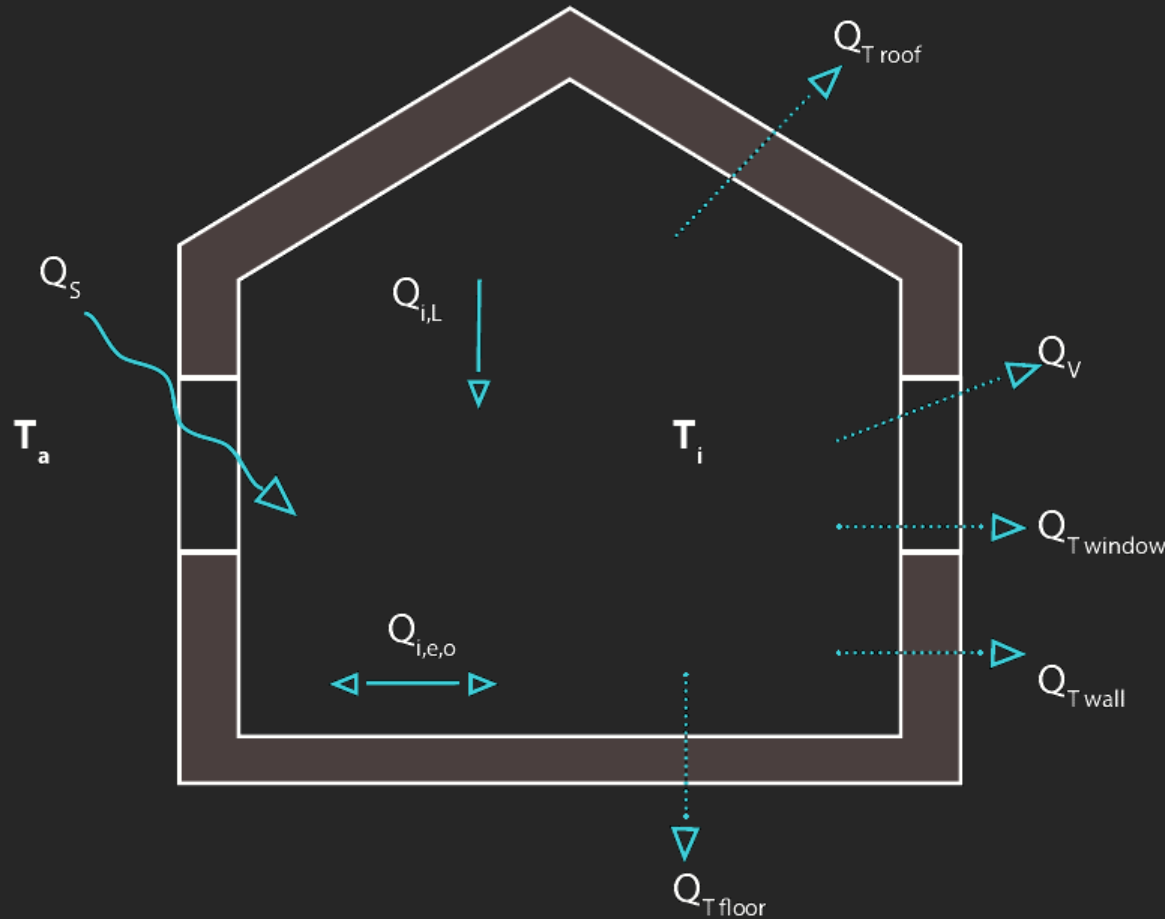
Grey box model

Hourly time resolution

Capable of capturing dynamic effects

3. Performance Simulation

Energy balance model



Quasi static calculation

Monthly time resolution

Extended by surrogate model for electricity allocation

3. Performance Simulation

Materials



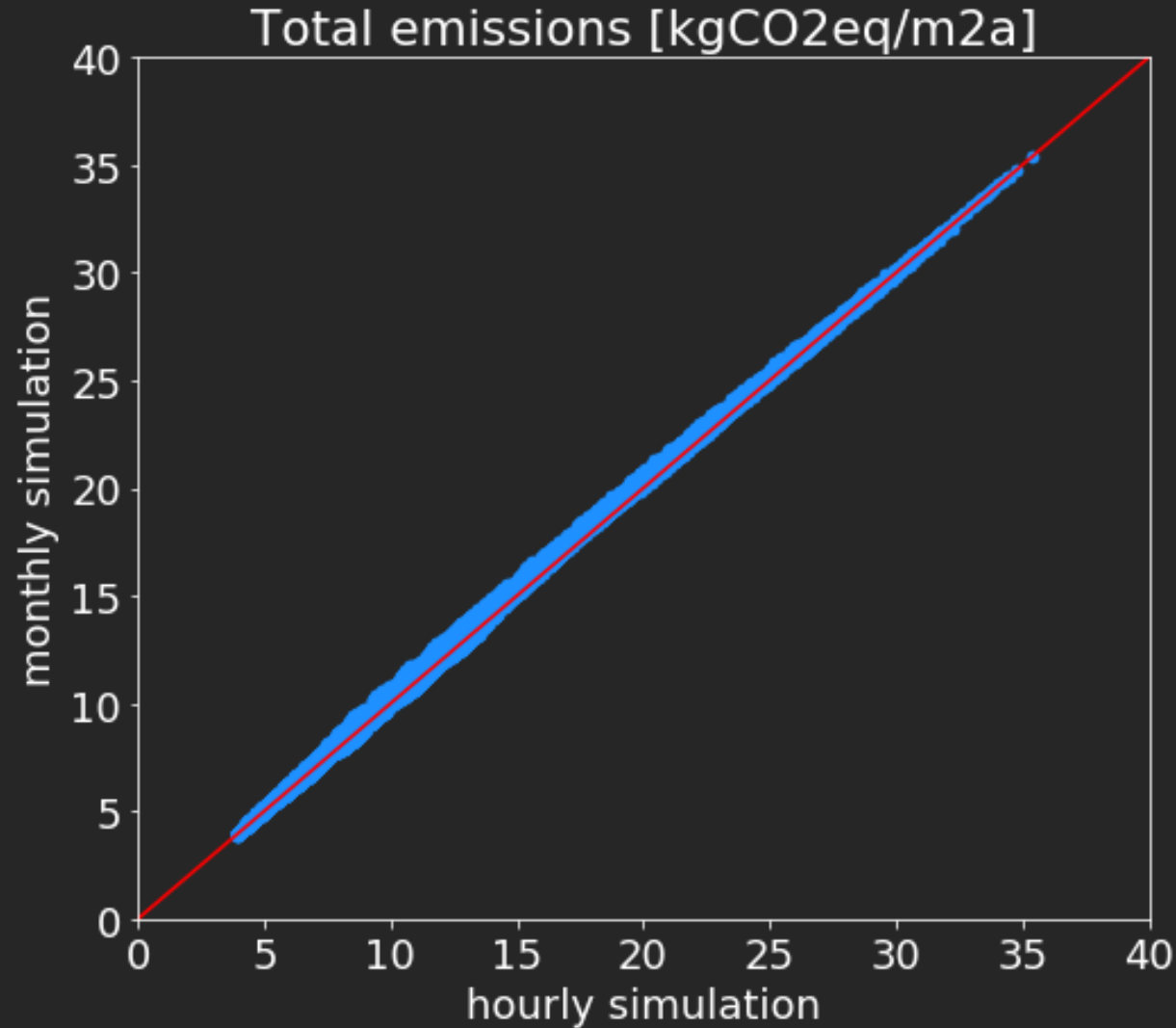
Energy use



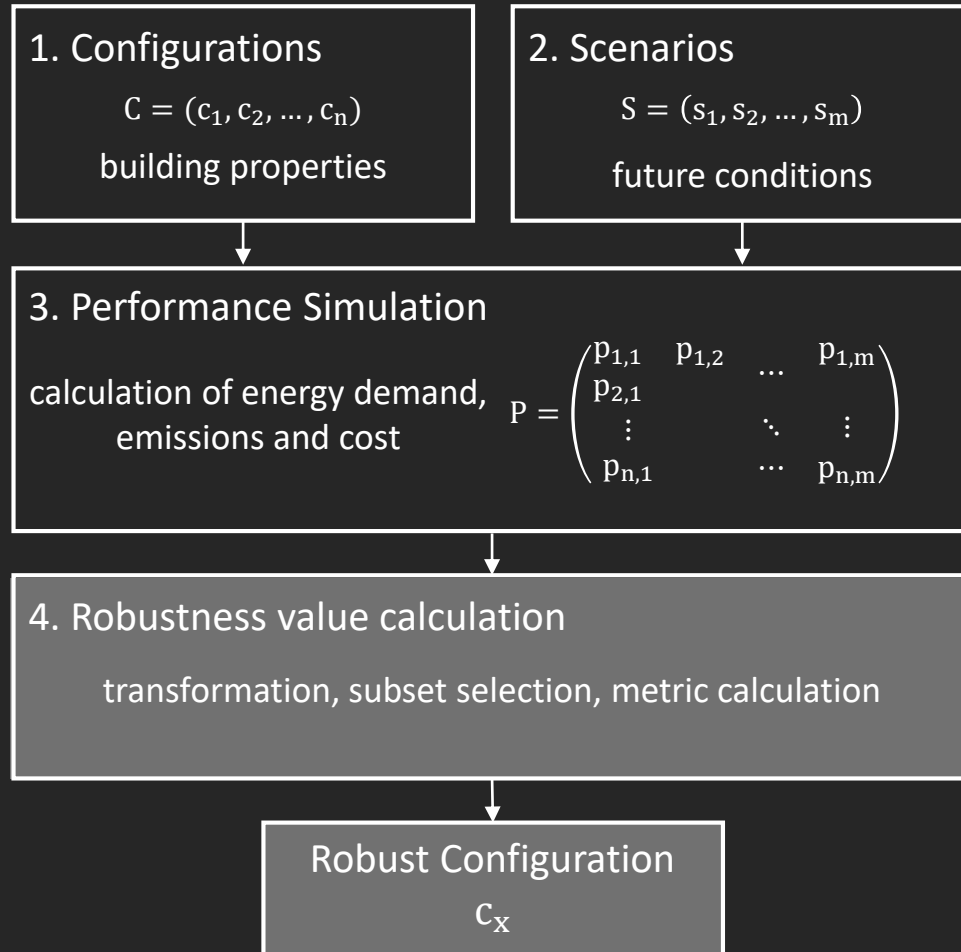
LCA
database

kg-CO₂eq/m²a

3. Performance Simulation (Model Comparison)



4. Robustness value calculation



Various metrics with different inherent weightings and risk aversion exist

Let's go through some of them in our mobility example

Recap



You think about the next 10 years

What could happen?




- Policies
- Market forces
- Change of use

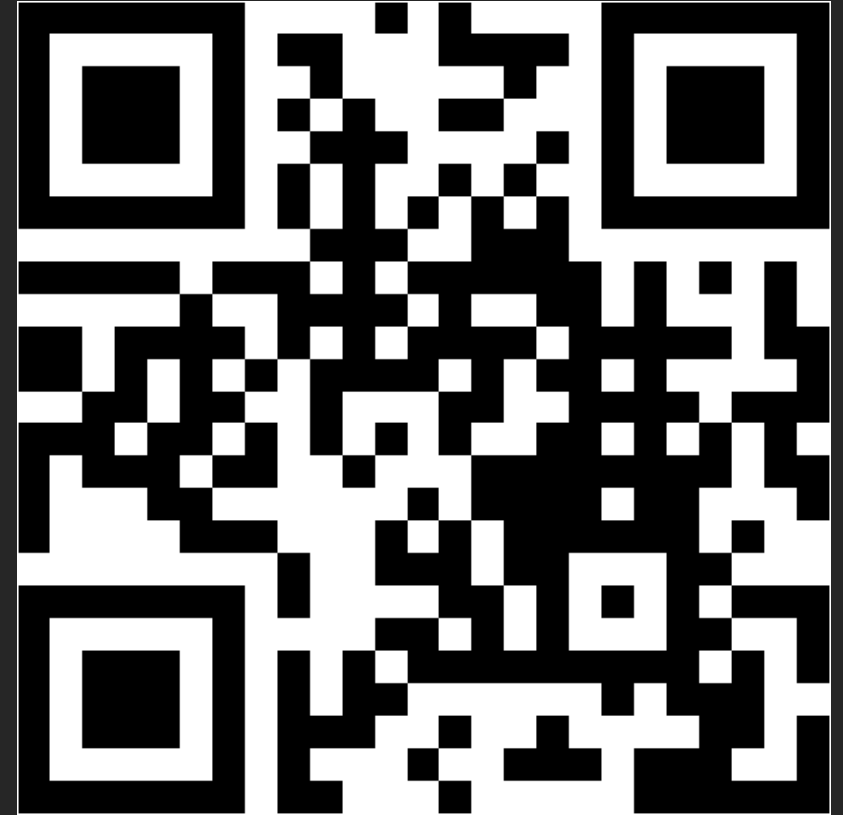
Example

- Road pricing for all cars (10cts per km)
- Carbon tax (5cts per km)
- Your boyfriend lives in Basel,+ 190km every week
- Train price increase +2k per year

S0	S1	S2	S3	S4
	x			
		x		x
			x	x
			x	

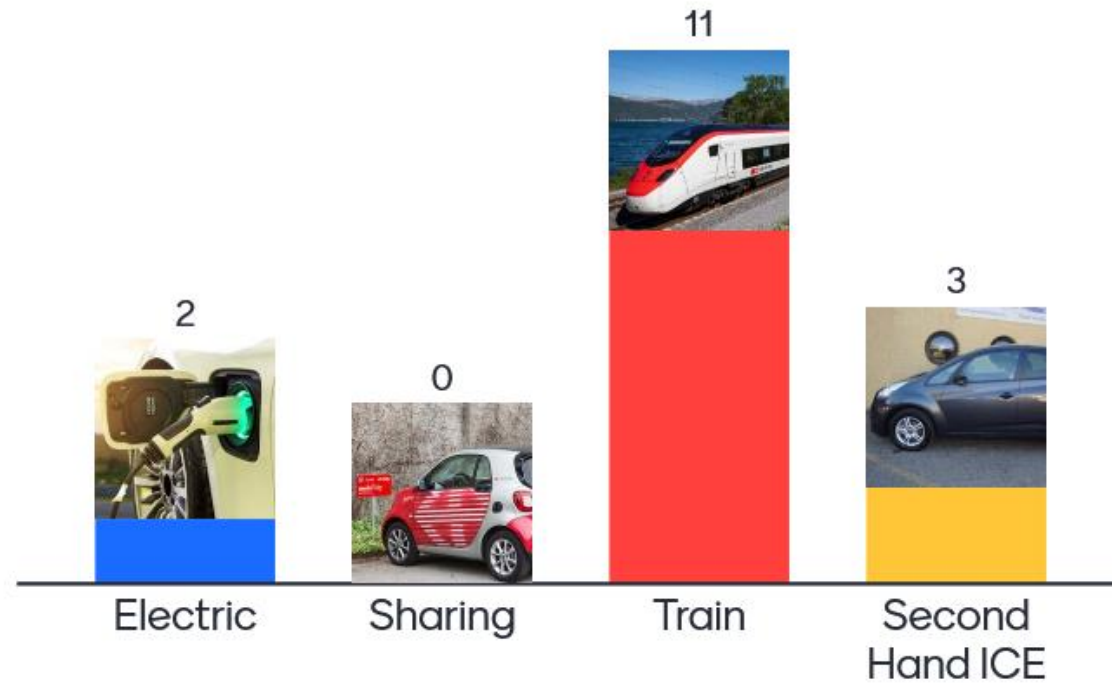
What is your choice now?

Cost for 10y	S0	S1	S2	S3	S4
	49	67	49	54	54
	72	90	72	112	112
	50	50	50	70	50
	44	62	53	64	92







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Choose your mobility concept for the next 10 years.



Optimist & Pessimist

Cost for 10y	S0	S1	S2	S3	S4	Best Case	Worst Case	Minimax
	49	67	49	54	54	49	67 →	67
	72	90	72	112	112	72	112	
	50	50	50	70	50	50	70	Maximax
	44	62	53	64	92	44 →	92 →	44





Fixed Budget 50k (Starr's domain criterion)

Cost for 10y	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4	AVG Pass
	49	67	49	54	54	1	0	1	0	0	0.4
	72	90	72	112	112	0	0	0	0	0	0.0
	50	50	50	70	50	1	1	1	0	1	0.8
	44	62	53	64	92	1	0	0	0	0	0.2

Most passes

0.8

Minimax Regret

Cost for 10y	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4	Max regret
	49	67	49	54	54	5	17	0	0	4	17
	72	90	72	112	112	28	40	23	58	62	62
	50	50	50	70	50	6	0	1	16	0	16
	44	62	53	64	92	0	12	4	10	42	42
											Minimax regret
											16

What is your choice now?

Optimist

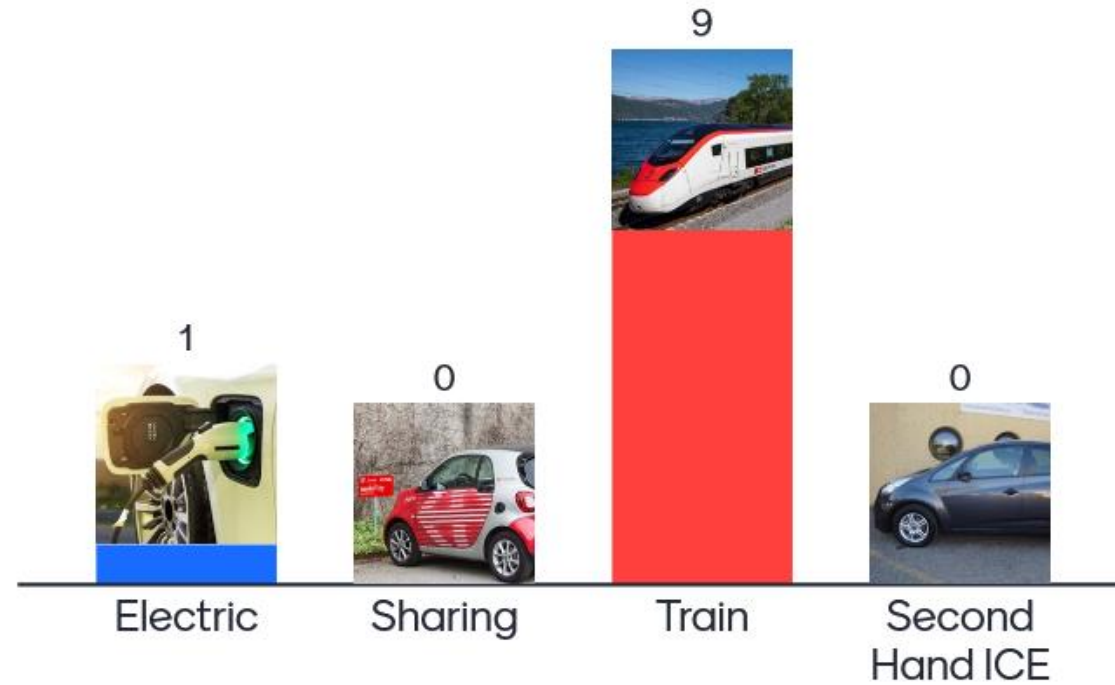
Pessimist

**Fixed
Budget**

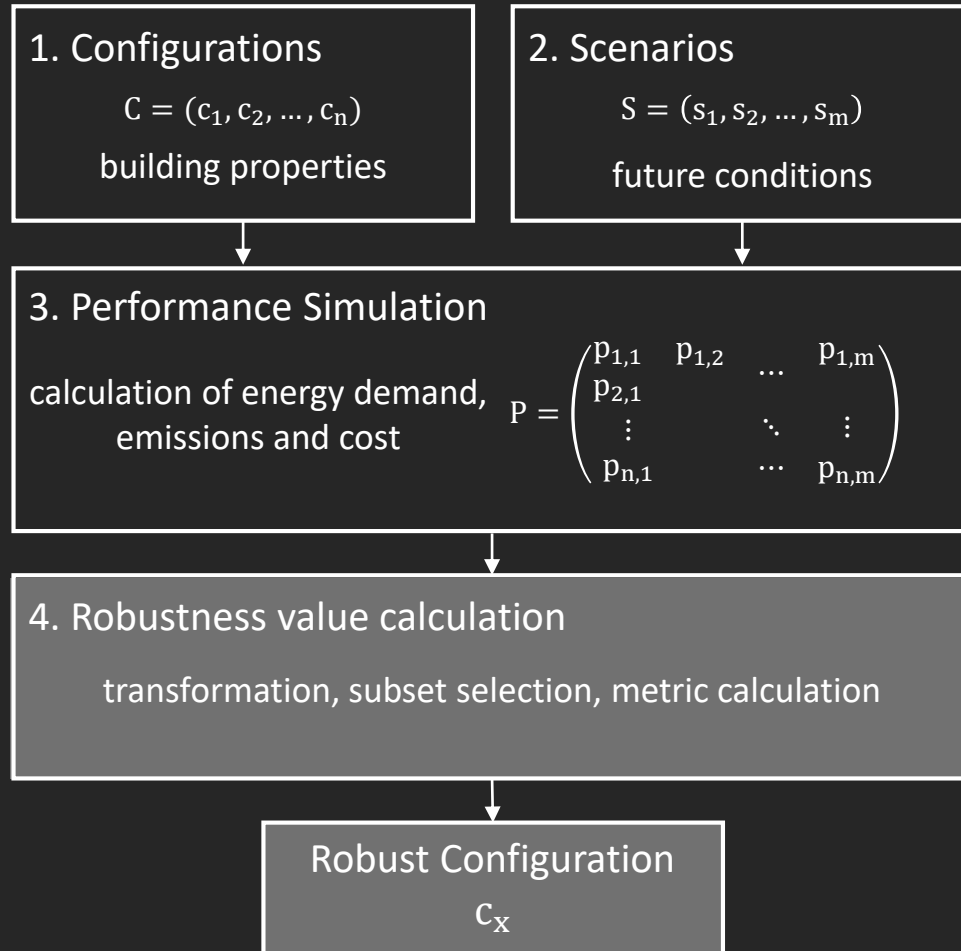
**Minimax
regret**



Choose your mobility concept for the next 10 years.



4. Robustness value calculation



Similar to the example but in a larger scale and with more metrics

Case Study

- Not available in public slides

Limitations

Scalability not considered

Results are case study- and scenario-specific

Building integrated battery storage not yet considered

Emission databases have methodological assumptions

Conclusion

Building performance assessment with standard values does not make sense for low-energy buildings

Future conditions heavily influence the actual GHG building performance

A monthly simulation resolution can be suitable for GHG emission assessment

Assuming grid decarbonization, reducing embodied emissions now, can be a viable option (envelope choice)

Heating system electrification should be continued

Outlook- Where am I going?

Investigate in more depth when and why metrics agree/disagree

Investigate building retrofit decisions

Cost and comfort modeling

Run the analysis on multiple, typical buildings/retrofit measures for Switzerland

Thank you for your attention

Q&A

Figure References

Introduction Example:

- Electric car: <https://www.iberdrola.com/innovation/electric-car-batteries>
- Sharing: https://de.m.wikipedia.org/wiki/Datei:Mobility_car_sharing_SMART_in_St._Gallen.jpg
- Train: <https://www.sbb.ch/de/bahnhof-services/waehrend-der-reise/unsere-zuege.html>
- Second hand car: <https://www.autolina.ch/auto/kia-venga/2943206>

Performance Gap:

- Technical Gap: Tom Huber, <https://www.ubs.com/ch/de/private/mortgages/information/magazine/2016/shoddy-workmanship-your-rights.html>
- Behavioral Gap: <https://www.co2online.de/energie-sparen/heizenergie-sparen/thermostate/>
- Modeling Gap: <https://www.snopes.com/fact-check/the-unsolvable-math-problem/>