Innovative designs of building energy codes for building decarbonization and their implementation challenges

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but if you get them right, you can do some pretty cool stuff”

- Kelly Knutsen, director of technology advancement at California Solar & Storage Association

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Building Energy Codes (BEC) are **policy instruments** that **set minimum requirements for buildings** with the **aim to reduce buildings’ energy use** and **carbon emissions**

- The **Building sector** is responsible for **31%** of global final **energy demand** and **23 %** of global energy-related **CO_2 emissions** (IPCC, 2018)
- **Policy intervention** is **required** because of several market failures in the construction sector
  - Principle-agent problem
  - Strong depreciation of investment returns in later years

- **BECs** have proven to **be effective and efficient** in shaping the decarbonisation of the building sector during the last decades
- Despite their long history and success, policymakers increasingly recognize the **limitations of current BEC designs.**
  - Prescriptive requirements
  - Focus on planned values

Research shifts towards discussing individual innovative BEC designs and their potential to overcome prevalent limitations

We aim at answering three research questions

RQ 1: *How do state-of-the-art BECs address leverage points to help building decarbonization?*

RQ 2: *How do innovative BEC designs address these leverage points, and what challenges did policymakers face when implementing them?*

RQ 3: *What general design principles for future BECs can we draw from these innovative designs?*

Literature Review

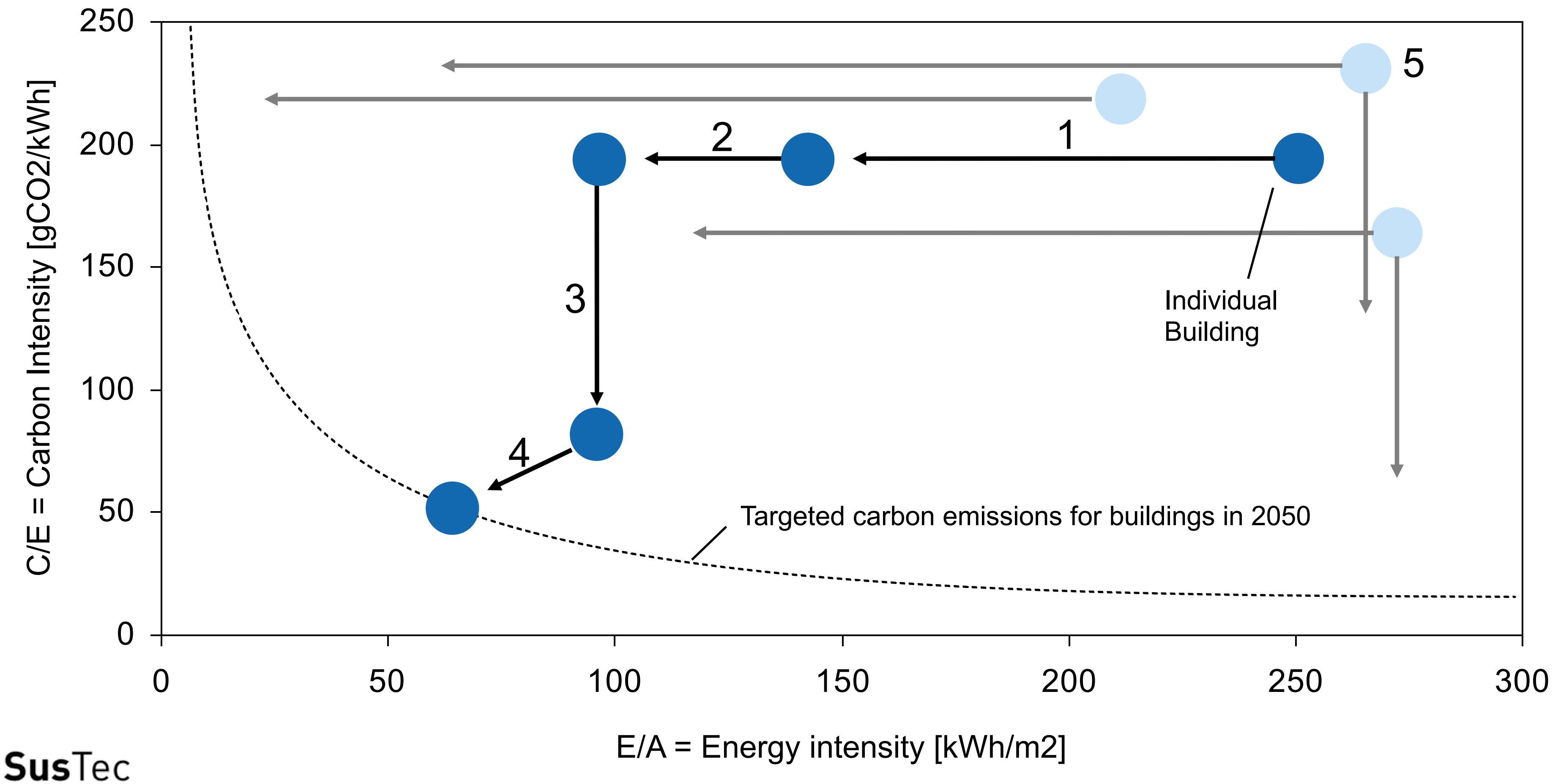
- Identifying leverage points for building decarbonization

Multi-case study analysis

- Step 1 – **Case Selection**: Selection of BECs that are already in the phase of implementation and have similar climatic condition
- Step 2 – **Document Analysis**: In-depth analysis of building regulations of selected countries (707 pages), validation with secondary literature
- Step 3 – **Semi-structured Interviews**: 18 semi-structured expert interviews with researchers, practitioners and regulators

We identified 5 key leverage points for the future decarbonisation of the building sector

$$C = \frac{C}{E} * \frac{E}{A} * A$$



- Energy Efficiency
- Embodied Energy
- Renewable Energies
- Performance Gap
- Renovations

Insights from selected international cases

Increase Energy Efficiency

State-of-the-art

- General trend towards **performance based regulation** (kWh/m^2)
- But complemented with **prescriptive boundary conditions** (e.g., U-values)

Innovative

- *Denmark*: Increasing energy efficiency by **preannouncing upcoming BECs**

Reduce Embodied Energy

State-of-the-art

- **Hardly considered in current regulations**

Innovative

- *France*: Reducing embodied energy by **taking a lifecycle perspective** and **adopting requirements for the construction phase**

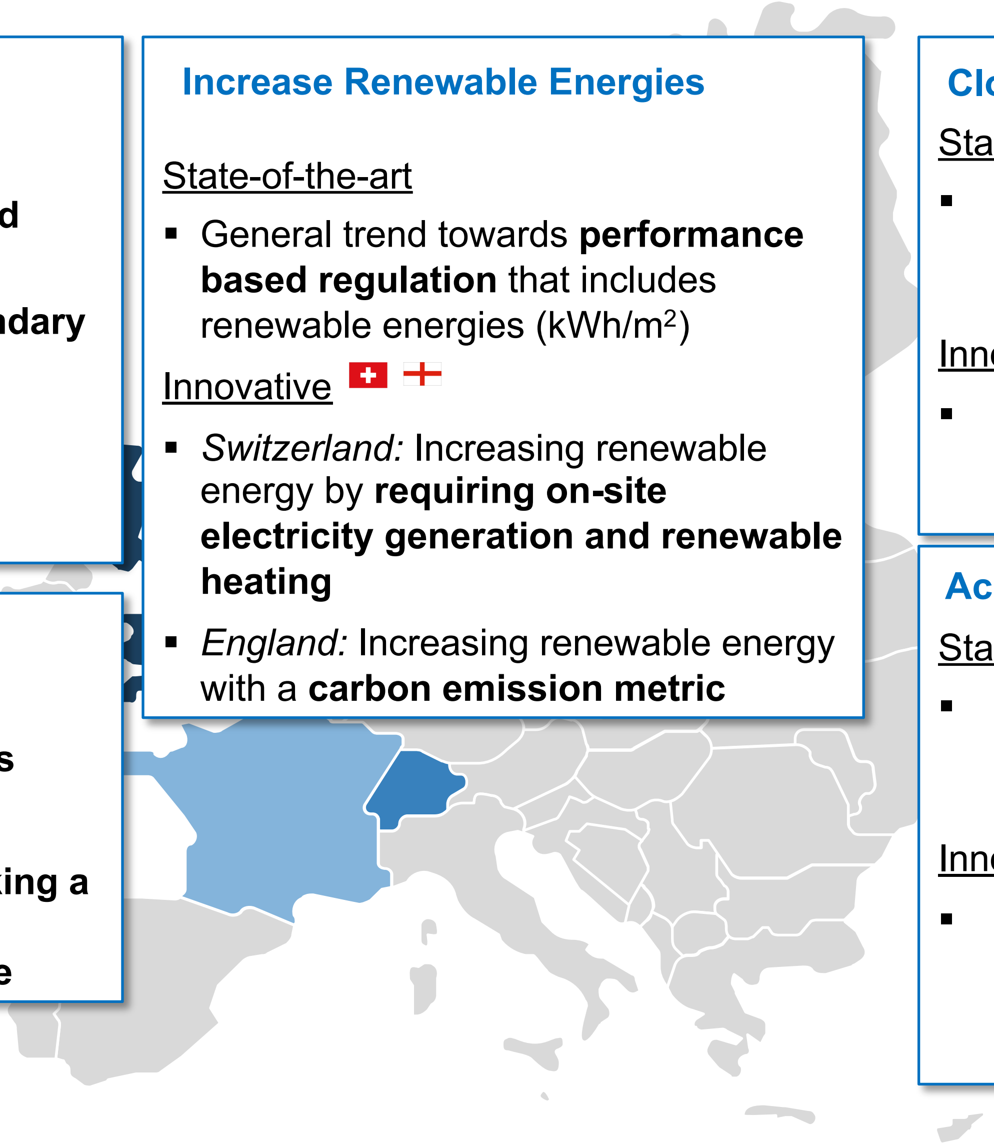
Increase Renewable Energies

State-of-the-art

- General trend towards **performance based regulation** that includes renewable energies (kWh/m^2)

Innovative

- *Switzerland:* Increasing renewable energy by **requiring on-site electricity generation and renewable heating**
- *England:* Increasing renewable energy with a **carbon emission metric**



Close the Performance Gap

State-of-the-art

- **Evaluation of building performance bases** almost exclusively **on predicted values**

Innovative

- *Sweden:* Closing the performance gap by **complying with measured energy demand** two years after occupancy

Accelerate Renovation

State-of-the-art

- Renovations are regulated, but there is **no specific measures to increase the rate**

Innovative

- *France:* Accelerating retrofits through **retrofit obligations for existing buildings** and **preannouncing them years in advance**

Implementation challenges of innovative BEC designs

Leverage point	Innovative Design	Implementation Challenge
Energy Efficiency	*Increasing energy efficiency by preannouncing upcoming BECs*	+ Strong endorsement for innovation – Increases concerns about higher investment costs
Embodied Energy	*Reducing embodied energy by taking a lifecycle perspective and adopting requirements for the construction phase*	+ Encourages construction industry to use and development low-energy building materials – Requires extensive prior testing and continuous learning
Renewable Energies	*Increasing renewable energy by requiring on-site electricity generation and renewable heating*	+ Very effective in increasing renewable energy – Seen as technology specific
	Increasing renewable energy with a carbon emission metric	+ Aligns BEC requirements with energy & climate targets – Can results in less energy-efficient buildings
Performance Gap	*Closing the performance gap by complying with measured energy demand two years after occupancy*	+ Increases matching between calculated and measured requirements – Requires increased effort for enforcing authority
Renovations	*Accelerating retrofits through retrofit obligations for existing buildings and preannouncing them years in advance*	+ Provides a fair planning horizon for building owners for retrofitting – Increases upfront investment costs – Could result in more but less deep retrofits

By synthesizing the implementation challenges across our five case studies, we derive six policy design principles for BECs

Keep additional burdens for building owners light	*Create long-term regulatory certainty*	*Beware technology-specific requirements*
Anticipate the impact of new regulations on smaller actors	*Promote knowledge of innovative design*	*Integrate BECs in the local context*

Conclusion

- Building Energy Codes that historically set minimum requirements for the energy use of buildings have proven effective and efficient for building decarbonization
- However, researchers increasingly recognize the design limitations of prevalent BECs.

➡ This study, therefore, aimed to evaluate innovative BEC designs that address leverage points for building decarbonization.

We identify 5 leverage points for building decarbonization

- Energy Efficiency
- Embodied Energy
- Renewable Energies
- Performance Gap
- Renovations

State-of-the-art BEC designs increase energy efficiency and renewable energies

Frontrunner countries have already begun to address the remaining leverage points by implementing innovative BEC designs

Synthesizing challenges that policymakers face when implementing innovative BEC designs, **we derived six design principles**

Keep additional burdens for building owners light	*Create long-term regulatory certainty*	*Beware technology-specific requirements*
Anticipate the impact of new regulations on smaller actors	*Promote knowledge of innovative design*	*Integrate BECs in the local context*

Thanks for your attention!

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