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

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SBE Graz 2019
“Building Energy Codes are a sleeper, but if you get them right, you can do some pretty cool stuff”

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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 CO₂ 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

\[ C = \frac{C}{E} \times \frac{E}{A} \times A \]

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/m²)
  - But complemented with prescriptive boundary conditions (e.g., U-values)
- **Innovative**
  - Denmark: Increasing energy efficiency by preannouncing upcoming BECs

Increase Renewable Energies
- **State-of-the-art**
  - General trend towards performance-based regulation that includes renewable energies (kWh/m²)
- **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

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

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

<table>
<thead>
<tr>
<th>Leverage point</th>
<th>Innovative Design</th>
<th>Implementation Challenge</th>
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<tbody>
<tr>
<td>Energy Efficiency</td>
<td><strong>Increasing energy efficiency by preannouncing upcoming BECs</strong></td>
<td>+ Strong endorsement for innovation</td>
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<td></td>
<td>- Increases concerns about higher investment costs</td>
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<tr>
<td>Embodied Energy</td>
<td><strong>Increasing renewable energy by requiring on-site electricity generation and renewable heating</strong></td>
<td>+ Encourages construction industry to use and development low-energy building materials</td>
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<td>- Requires extensive prior testing and continuous learning</td>
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<tr>
<td>Renewable Energies</td>
<td><strong>Increasing renewable energy by taking a lifecycle perspective and adopting requirements for the construction phase</strong></td>
<td>+ Very effective in increasing renewable energy</td>
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<td>- Seen as technology specific</td>
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<td><strong>Increasing renewable energy with a carbon emission metric</strong></td>
<td>+ Aligns BEC requirements with energy &amp; climate targets</td>
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<td>- Can results in less energy-efficient buildings</td>
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<tr>
<td>Performance Gap</td>
<td><strong>Closing the performance gap by complying with measured energy demand two years after occupancy</strong></td>
<td>+ Increases matching between calculated and measured requirements</td>
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<td>- Requires increased effort for enforcing authority</td>
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<td>Renovations</td>
<td><strong>Accelerating retrofits through retrofit obligations for existing buildings and preannouncing them years in advance</strong></td>
<td>+ Provides a fair planning horizon for building owners for retrofitting</td>
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<td>- Increases upfront investment costs</td>
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<td>- Could result in more but less deep retrofits</td>
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By synthesizing the implementation challenges across our five case studies, we derive six policy design principles for BECs:

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

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Thanks for your attention!

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