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How to Integrate the Gender Dimension into the Research of Simulation Tools and Sustainable Insulation Materials to Achieve Zero-Emission Buildings

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A dual opportunity for zero-emission buildings

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1

Persistent disparities

Construction is a major contributor to energy use and emissions, and is marked by gender disparities in both its workforce and its built outcomes.

2

Two sides of the problem

Women are underrepresented in site-based and technical roles, and are also disproportionately affected by indoor environmental quality as occupants.

3

The gap

Studies address workforce inclusion or occupant comfort in isolation. SNUG's potential for gender equity has not been systematically examined, and no framework exists for it.

Two research questions and one framework

RQ1 Workforce

Which building component and material characteristics promote equitable participation of all genders in construction work by reducing physical barriers and improving working conditions?

RQ2 Occupants

Which indoor environment attributes are disproportionately prioritised by women as occupants, owing to physiological, metabolic and time-use differences?

Outcome

A comprehensive, actionable framework for integrating the gender dimension into SNUG's research, development and communication activities

Method: literature review, then analytical review

1 Narrative literature review

- Scopus, ScienceDirect and Google Scholar
- 28 peer-reviewed publications referenced
- Covers ergonomics, gender in construction and indoor environmental quality
- Not exhaustive; not a systematic review or meta-analysis

2 Analytical review of SNUG

- Deliverables, technical reports and work package documents
- Density, thermal conductivity, VOC class and installation data checked against gender-relevant criteria
- Items reviewed: Data Management Plan, Digital Tool Assistant, Digital Building Logbook, stakeholder engagement, communication and exploitation
- Gaps identified, recommendations formulated, three-tier framework derived inductively

What the evidence says

Results

Workforce: physical demands and workplace culture

Physical demands and design

- Women often do physically demanding tasks such as digging and lifting, with no division of work by ability
- Result: undue physical stress and higher injury risk
- Many sites lack adequate sanitary and welfare facilities for women
- Lightweight materials cut dead load and strain, and reduce musculoskeletal disorder risk

Culture and organisation

- Masculine culture shows up as exclusion, discrimination and harassment
- Long, inflexible hours hit carers hardest; flexible scheduling needs industry-wide collaboration
- Tailored safety training, mentorship and supervisor support go with higher job satisfaction and less harassment

Occupants: women prefer warmer indoor temperatures

Documented optimal temperature range (°C)

Women

18.5 – 24.2

Men

17.3 – 23.4



Women show more dissatisfaction, especially in cooler conditions: lower metabolic rates, body composition and hormonal influences are cited.

- Women spend more time indoors, which raises exposure to lighting, air quality and thermal conditions
- They use air conditioning and cooling devices more often
- They give greater weight to security, cleanliness and maintenance
- Dust, poor ventilation and indoor air pollution are respiratory risk factors, so low-emission materials matter

Twelve gender-relevant material traits

Workforce inclusion facilitators

- Lower weight and density (bio-panels at 290 kg/m³)
- Installation speed and simplicity
- On-site adaptability and cuttability
- Mechanical robustness reduces unit handling
- Dimensional stability limits corrective work
- Easy maintenance, fewer demanding repairs

Occupant health benefits

- Insulation meets women's higher comfort temperature (24.2 vs 23.4 °C)
- Improved indoor air quality
- Low VOC emissions: A+ class, 21–31 ppb formaldehyde
- Fungal resistance
- Sound insulation for acoustic sensitivity
- Low dangerous substance release in fire

A three-tier framework for gender integration

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1

Tier 1

Structural

Embed gender in the foundational research structure: data models, metadata standards and monitoring systems.

2

Tier 2

Analytical

Add gender-differentiated parameters to methods: material selection criteria, thermal comfort algorithms, user requirements.

3

Tier 3

Translational

Communicate gender dimensions: sex-disaggregated analyses, business cases and policy briefs.

Goes beyond binary sex categories to examine intersections with age, disability, socioeconomic status and cultural background.

Recommendations: data and digital tools

SNUG item	Recommendation
Data Management Plan	Mandatory metadata for gender identity (with non-binary options), age, socioeconomic indicators and occupant demographics; gender keywords for FAIR; ISO/IEC 5218 extended taxonomies
Gender Dimension Monitoring Dataset	Quarterly KPIs: women in project roles, PhD graduates, researchers, management, publications, patents, outreach
Material specifications	Gender-responsive criteria; selection matrices weighting social impact alongside environmental and economic performance
Digital Tool Assistant	Gender-differentiated comfort models (50 % female occupancy raises optimal temperature by 0.4 °C); demographic UI fields; comfort equity as an optimisation criterion
Digital Building Logbook	Occupant demographic fields, gender-disaggregated energy tracking and social equity indicators, aligned with EU Gender Equality Strategy and ISO 26000

Recommendations: demonstration, outreach

Demonstration projects

- Deliberately recruit diverse installation teams
- Use ergonomic feedback from workers with varied physical capabilities to refine material design, packaging and training protocols

Communication and exploitation

- A "Women in Sustainable Construction" series
- Social impact briefs for each exploitable result
- Gender-balance monitoring for conferences and social media
- At least 7 % of publications on gender dimensions; toolkits for future research programmes

Limitations: analytical, not empirical

No primary data

No data on workforce composition, ergonomic outcomes or occupant satisfaction were collected for SNUG materials.

Retrospective evidence

Gender-relevant properties come from technical performance data, not field studies with gender-disaggregated outcomes.

Bigger barriers elsewhere

Harassment, discrimination, inflexible scheduling and pay inequity are often cited as more significant, and materials alone cannot address them.

Validation needed

Gender-disaggregated field trials, worker surveys and occupant studies are required.

Conclusions

1

Genuine, unvalidated potential

Lightweight materials, low VOC emissions and strong thermal performance are technical advances with significant, if as yet unvalidated, potential for gender-responsive impact.

2

An actionable pathway

The three-tier framework and recommendations translate technical achievement into social intentionality, with minimal additional resources.

3

A reference for Horizon Europe

With targeted action in demonstration, digital tools, data management and communication, SNUG can become a reference for gender-responsive construction innovation.



Thank you

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