Dynamic MFA Modelling of Residential Stocks

Felipe Vásquez

August 10 / 2016 – Odense, Denmark

Workshop: “Characterizing the built environment stocks: methods and case studies"

NTNU – Trondheim
Norwegian University of
Science and Technology

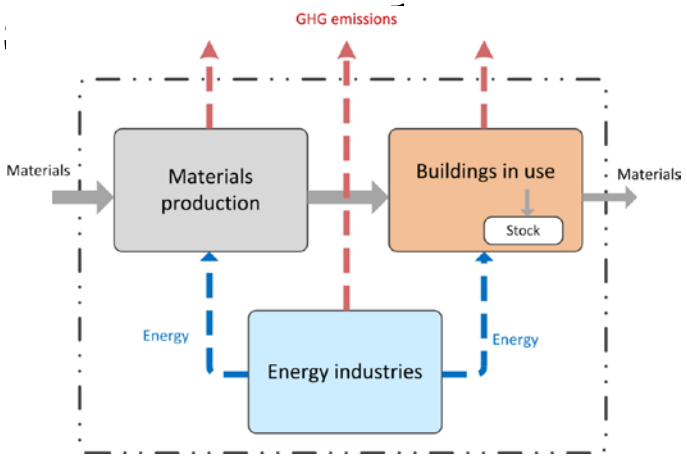
NTNU Industrial Ecology

Content

- Why Dynamic MFA Models
- Modelling Energy Demand
  - Dynamic MFA vs. Other Models
- Germany & Czech Republic Case Studies
  - On Energy
- Other Case Studies & Applications
- Conclusion

Dynamic (MFA) models

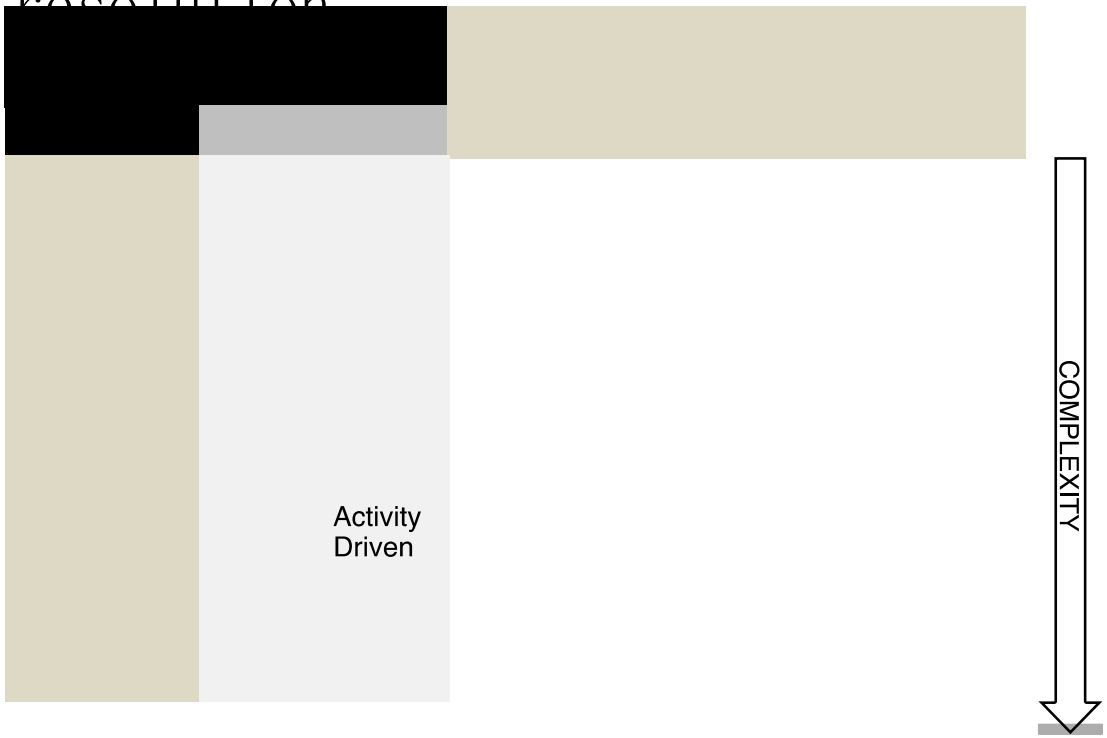
- Integrate all the aspects of the built environment system
  - Social
  - Material
  - Energy
  - Emissions



- Are suitable for the development of forecasting and backcasting scenarios that can incorporate changes in **socioeconomic** (people's needs and lifestyles) and **technological** factors in the **long term**.

Dynamic (MFA) models

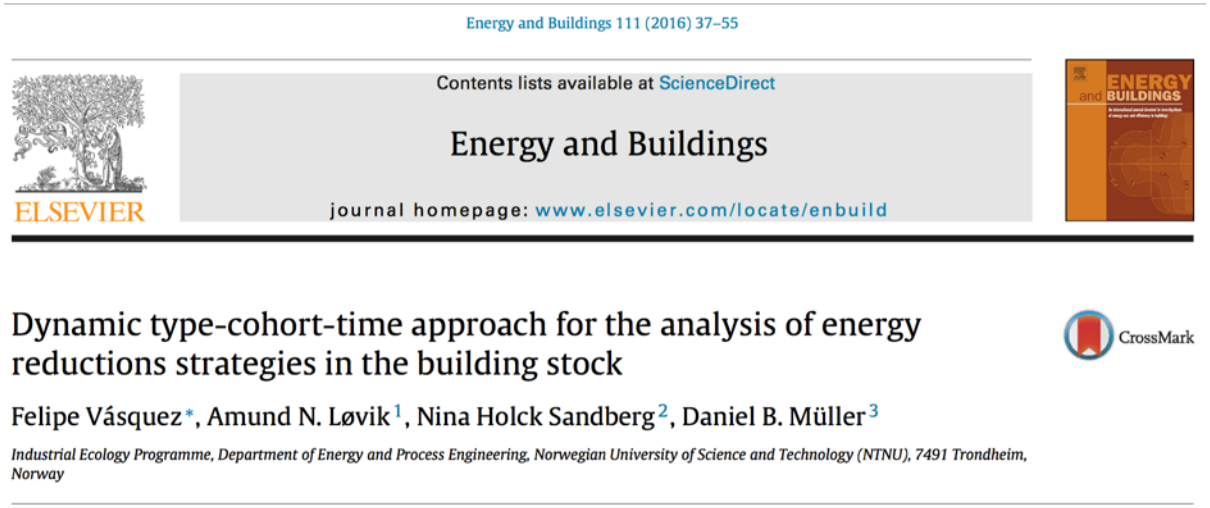
- Are ideal for modelling of construction activity and energy and material use in buildings because of their built-in **Type-Cohort-Time** (**TCT**) resolution



Literature review of models for **energy** use in the building stock from Vásquez et al. (2016)

Energy Demand in the EU Residential Sector

The cases of Germany and Czech Republic



Energy and Buildings 111 (2016) 37–55

Contents lists available at ScienceDirect

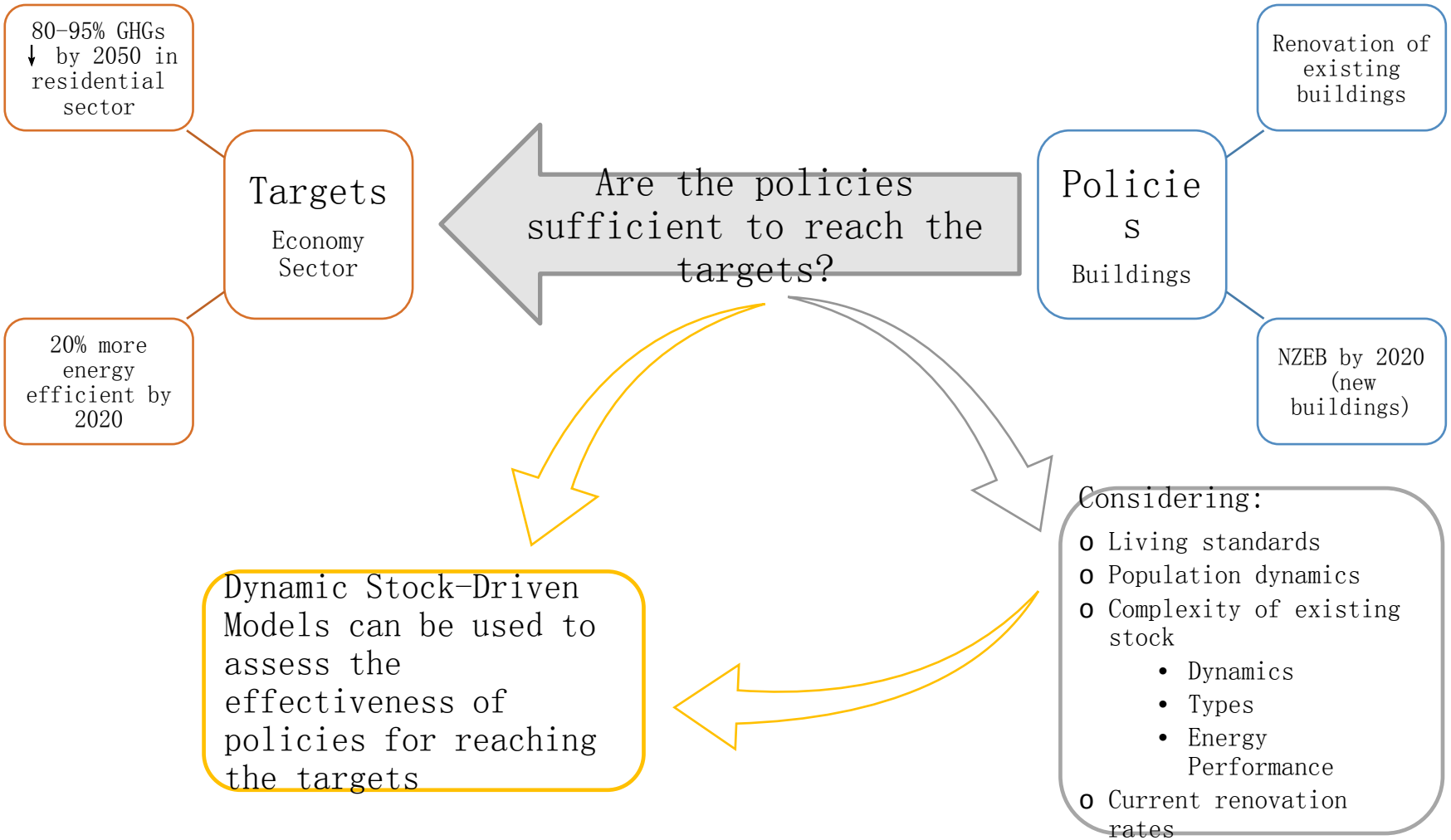
Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

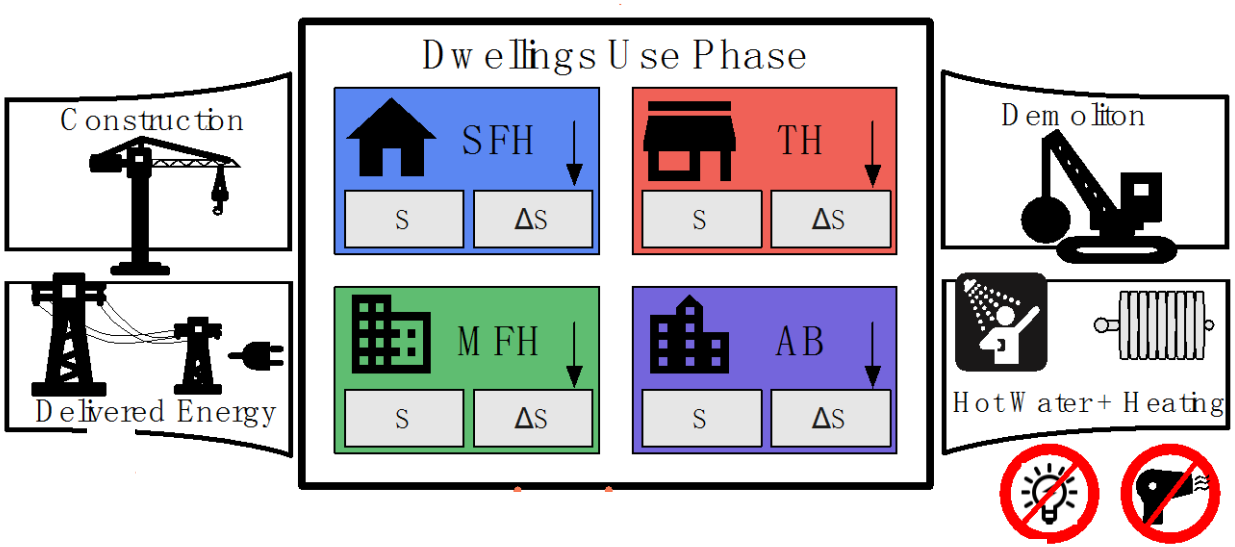
Dynamic type-cohort-time approach for the analysis of energy reductions strategies in the building stock

Felipe Vásquez*, Amund N. Løvik[1], Nina Holck Sandberg[2], Daniel B. Müller[3]

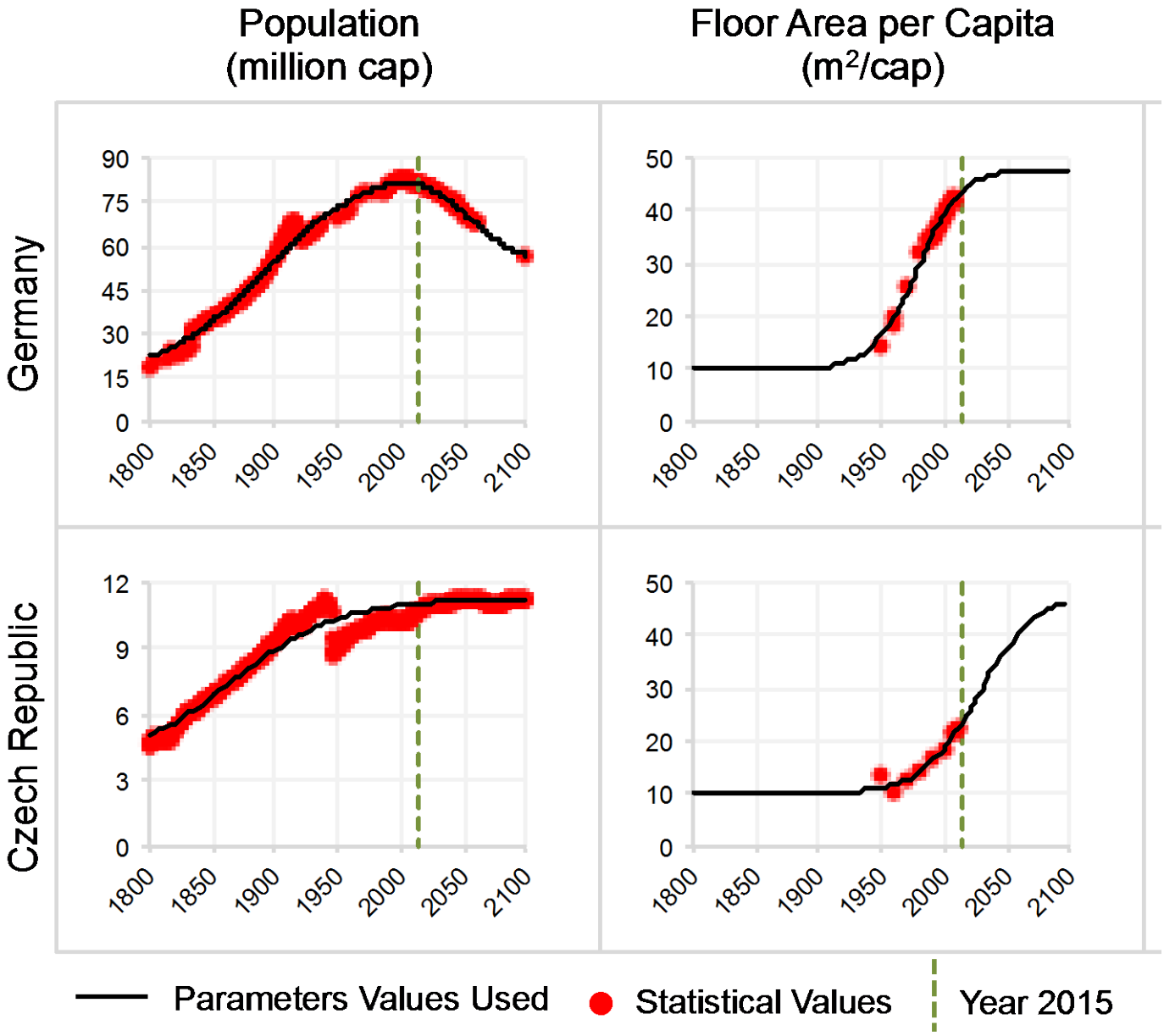
Industrial Ecology Programme, Department of Energy and Process Engineering, Norwegian University of Science and Technology (NTNU), 7491 Trondheim, Norway


80-95% GHGs ↓ by 2050 in residential sector
Targets
Economy Sector
20% more energy efficient by 2020
Are the policies sufficient to reach the targets?
Renovation of existing buildings
Policies
Buildings
NZEB by 2020 (new buildings)
Considering:
o Living standards
o Population dynamics
o Complexity of existing stock
• Dynamics
• Types
• Energy Performance
o Current renovation rates
Dynamic Stock-Driven Models can be used to assess the effectiveness of policies for reaching the targets

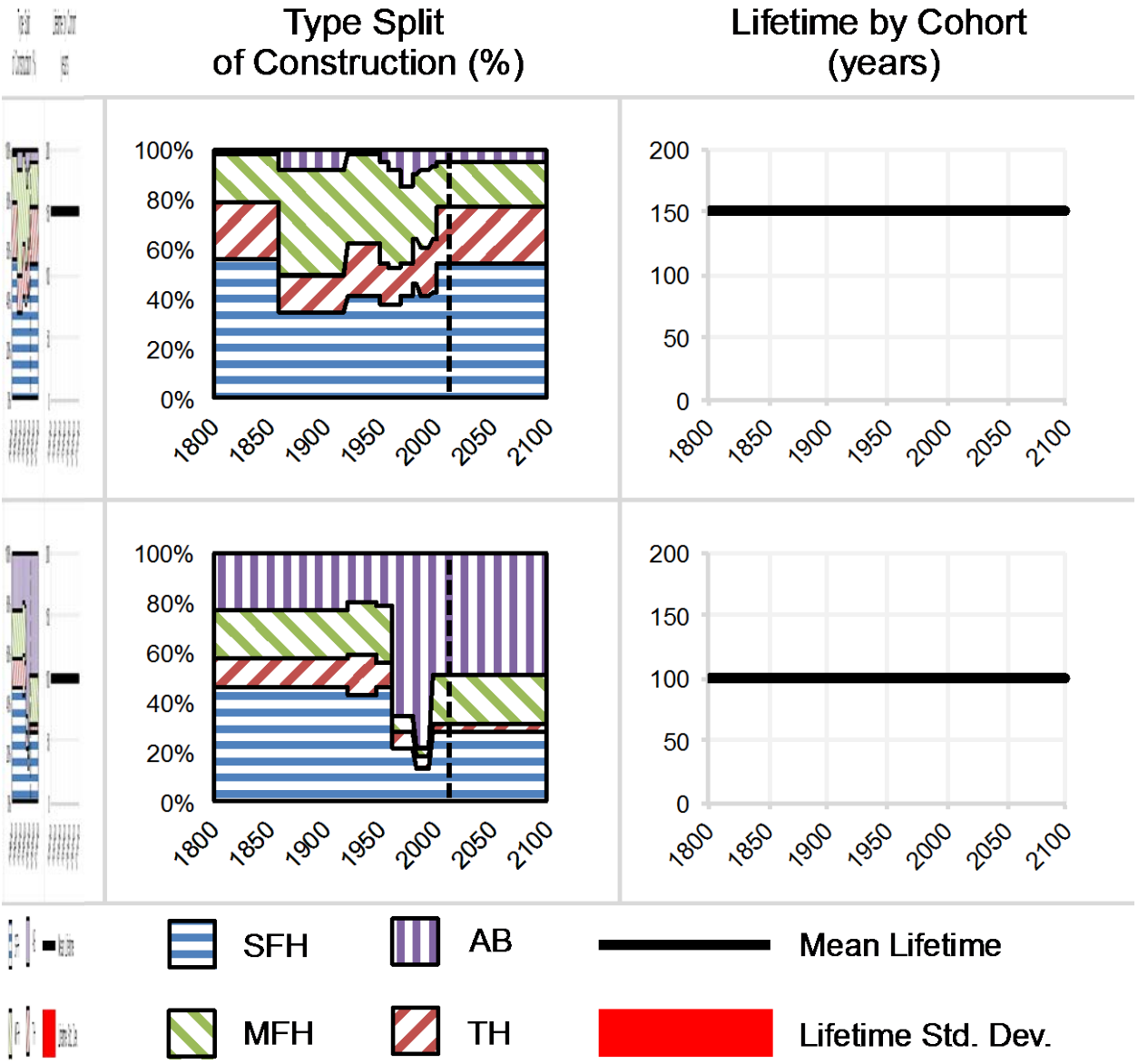
Buildings' Stock-Driven Model



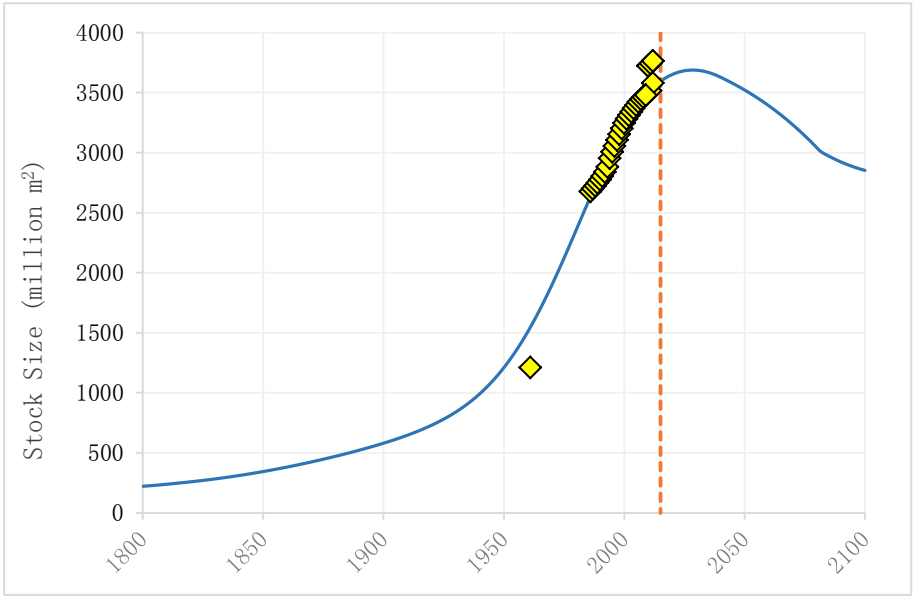
Parameters: Population and Floor Area per Capita



Parameters: Type Split of Construction and Lifetime

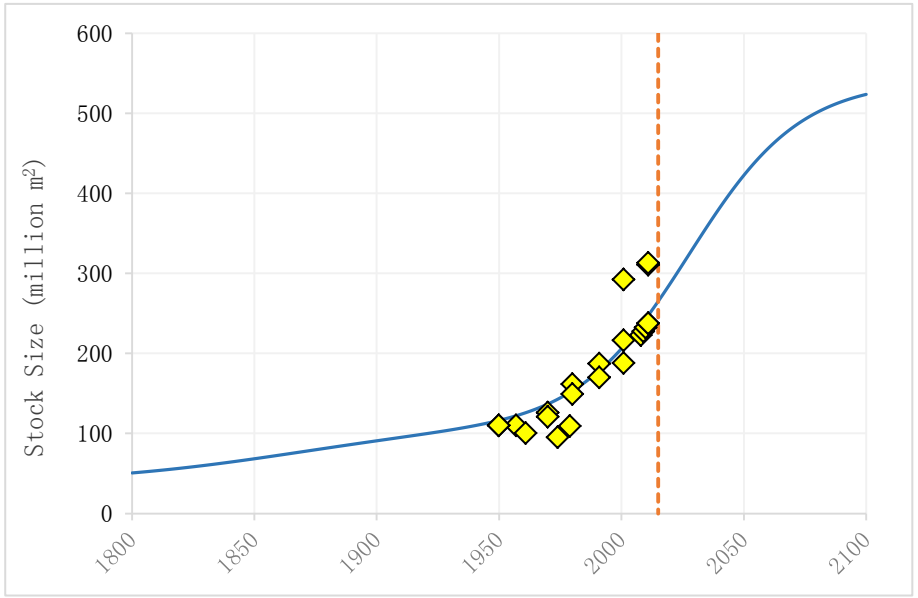


Stock
(mill. m²/yr)



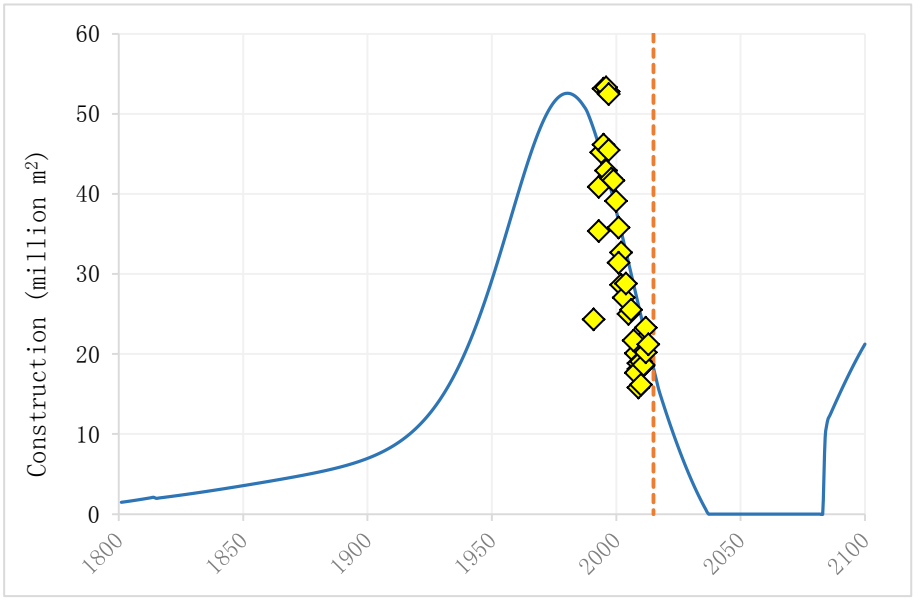
← GERMANY

CZECH REP. →



Validated Stock Historic Statistics

Construction
(mill. m^2/yr)



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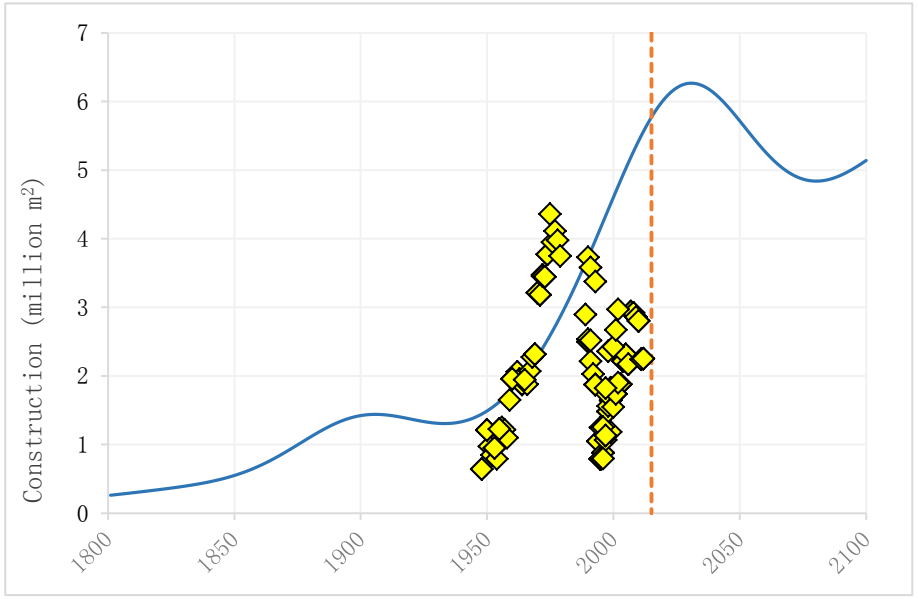
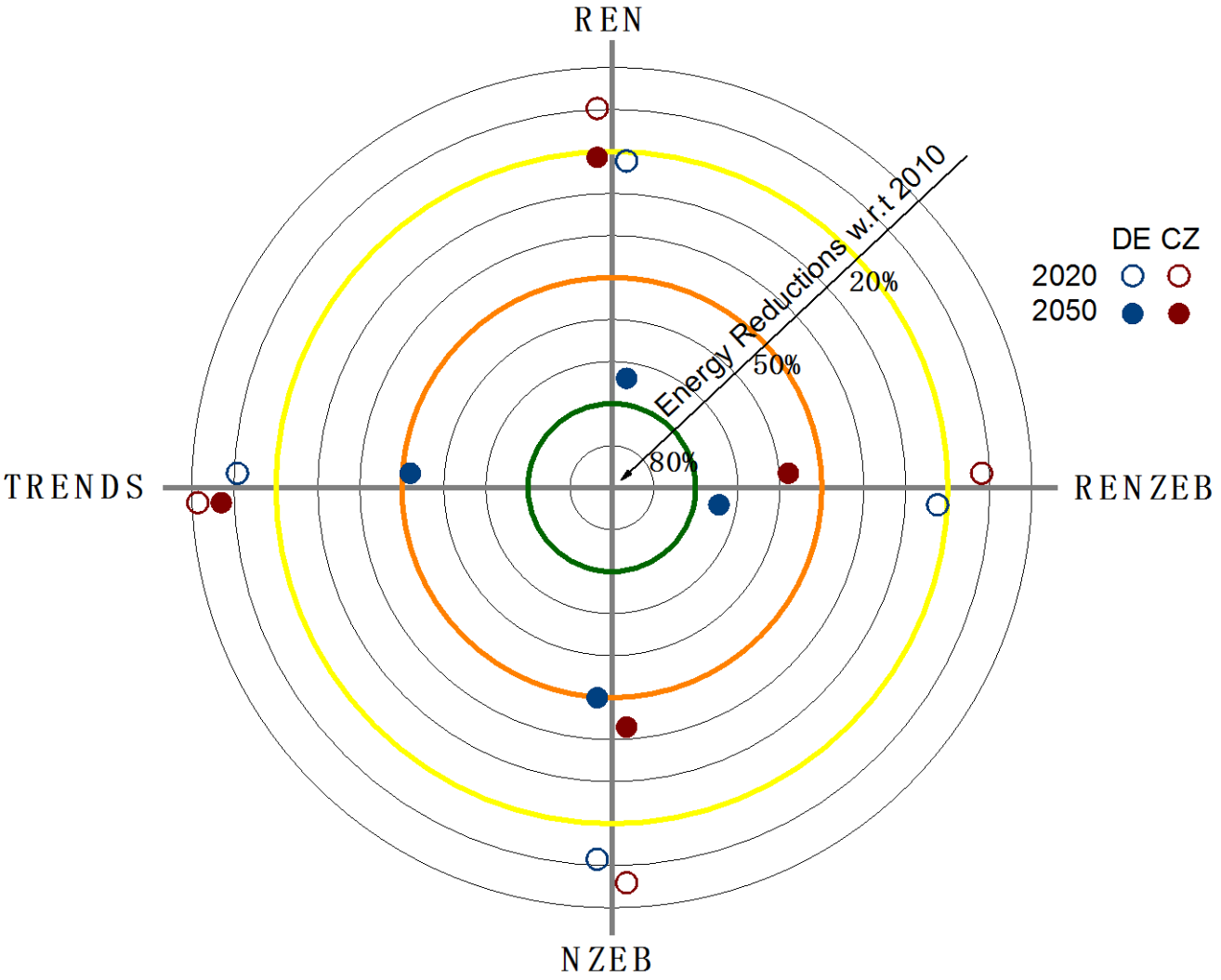
CZECH REP. →

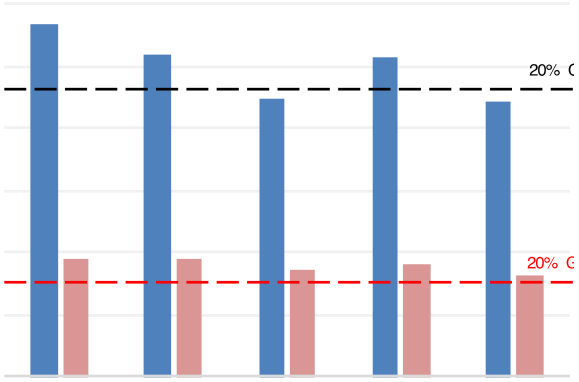


Model Results ◆ Historic Statistics

Can the EU targets be met?



Per capita and m² analysis



Conclusion

Germany

- Focus on the **renovation.**
- New NZEB are not very relevant if early demolition of old dwellings is not promoted.

Czech Republic

- Focus on future efficient buildings - NZEB.

Policy Reflexion

- Germany: less efforts for the 50% goal.
- Germany: future energy savings without doing anything (stock shrinking).
- Czech Republic: reductions required despite the increase in population and floor area per capita.
- Germany: requires smaller reductions per-m^2 and per-capita despite having a more inefficient building stock and more per-capita energy consumption.

Other Cases and Applications

NL

Floor Area & Concrete

ECOLOGICAL ECONOMICS 59 (2006) 142–156

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ELSEVIER

METHODS

Stock dynamics for forecasting material flows—Case study for housing in The Netherlands

Daniel B. Müller *

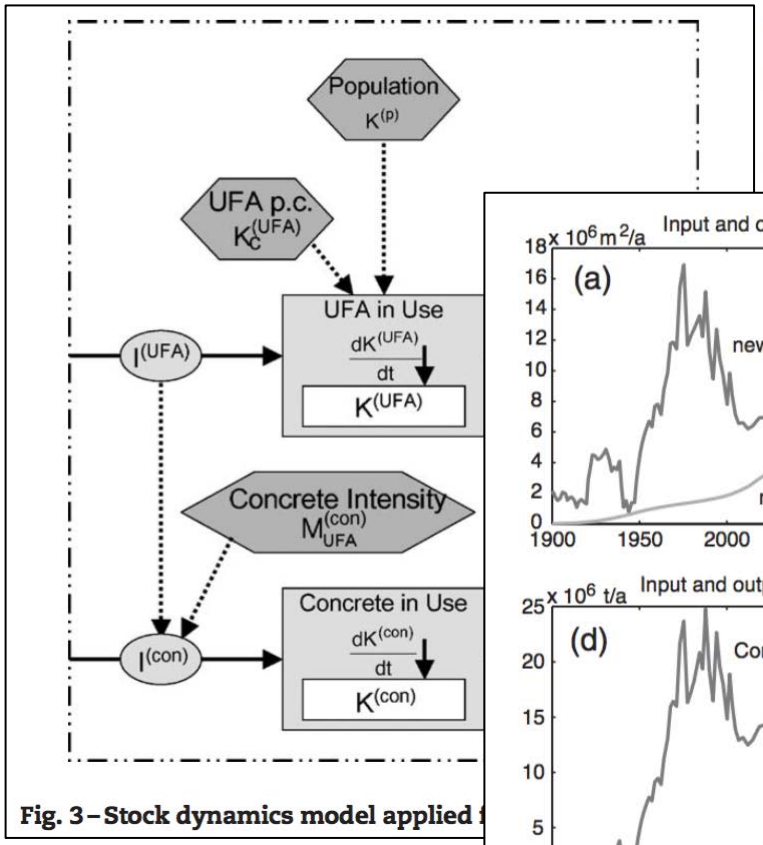


Fig. 3 – Stock dynamics model applied f

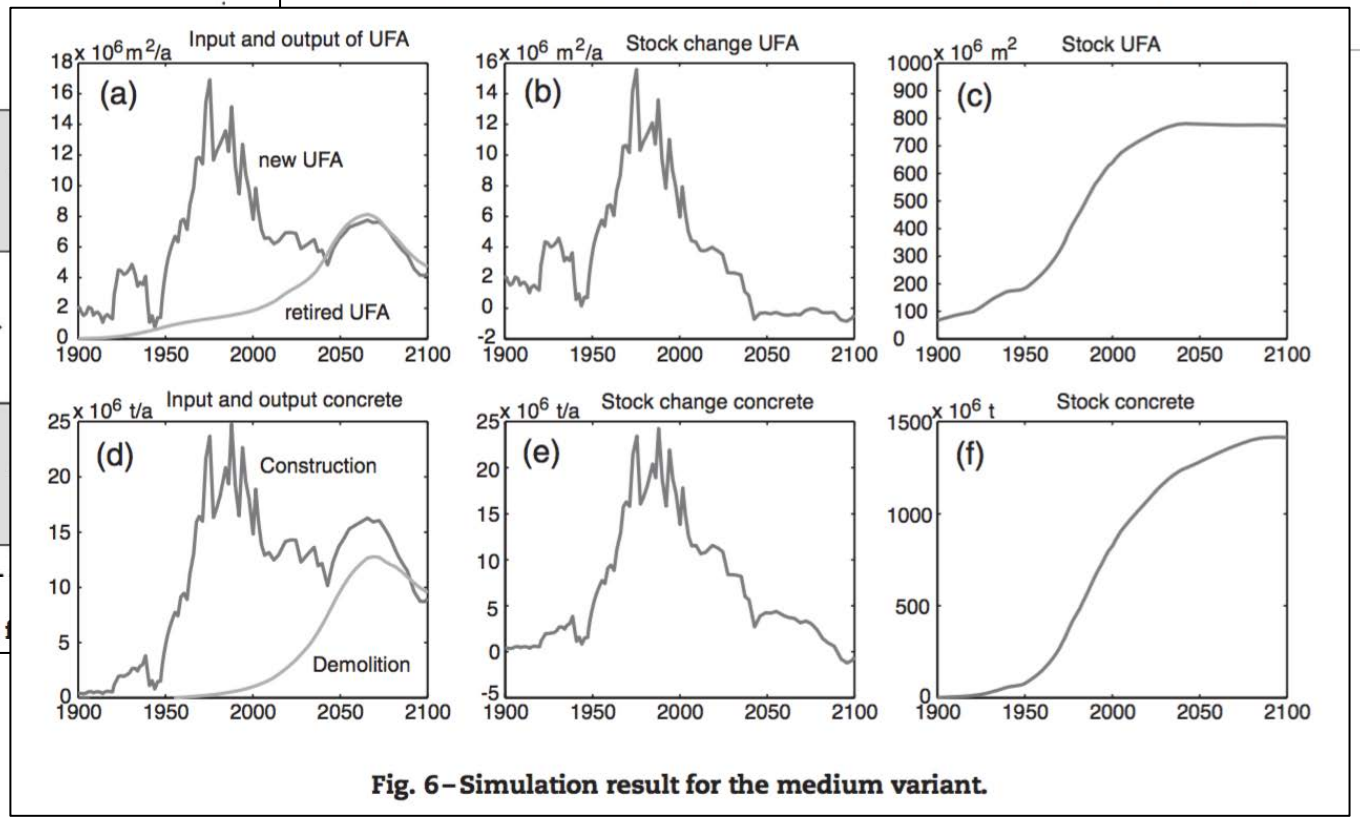


Fig. 6 – Simulation result for the medium variant.

BUILDING RESEARCH & INFORMATION (2007) 35(5), 557–570

Routledge
Taylor & Francis Group

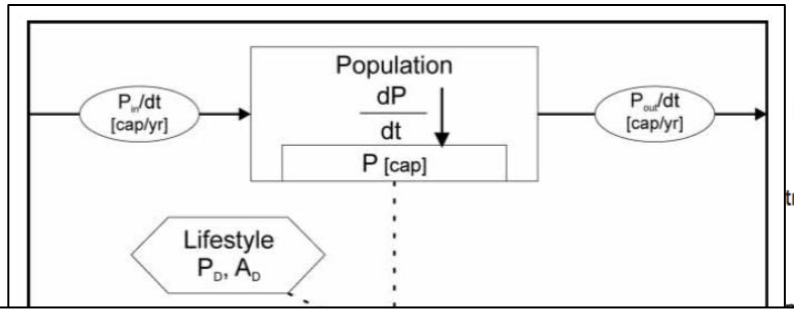
NO

Concrete & Wood

Dynamic material flow analysis for Norway's dwelling stock

Håvard Bergsdal[1], Helge Brattebø[1], Rolf A. Bohne[2] and Daniel B. Müller[3]

tment of Hydraulic and Environmental Engineering/Industrial Ecology Programme, Norwegian University of Science & Technology, N-7491 Trondheim, Norway
E-mails: havard.bergsdal@ntnu.no and helge.brattebo@ntnu.no



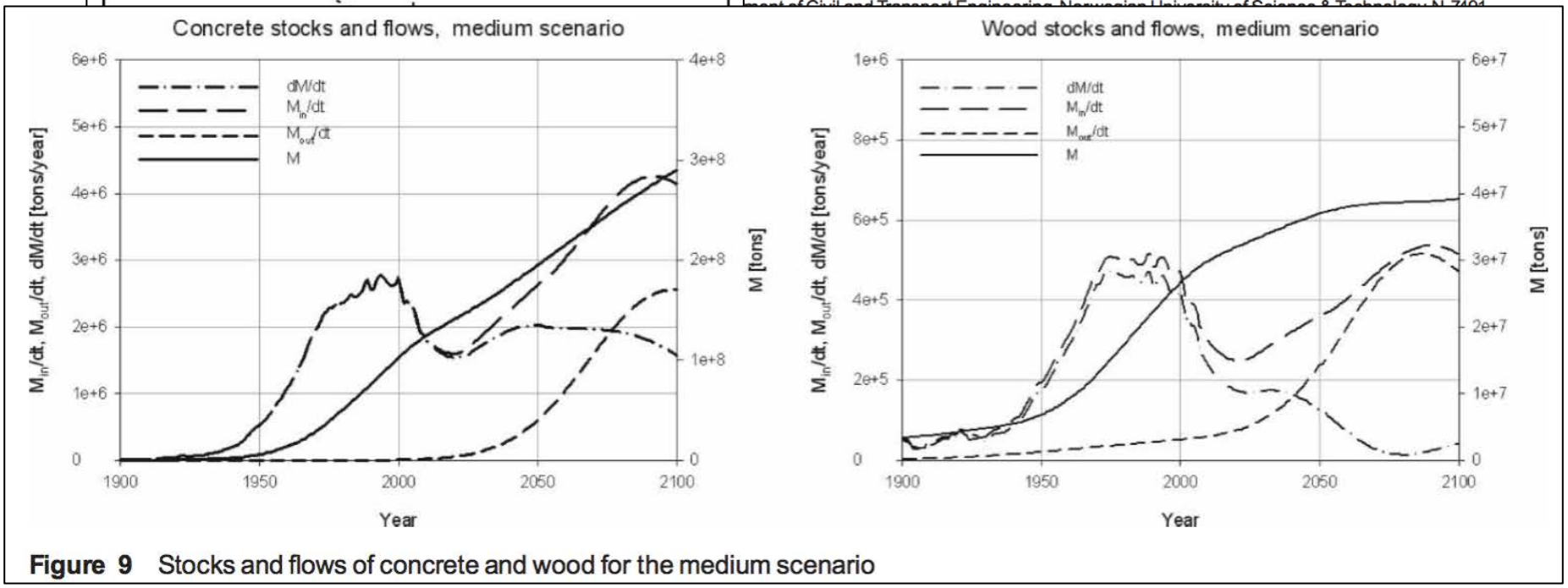


Figure 9 Stocks and flows of concrete and wood for the medium scenario

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Energy & Emissions

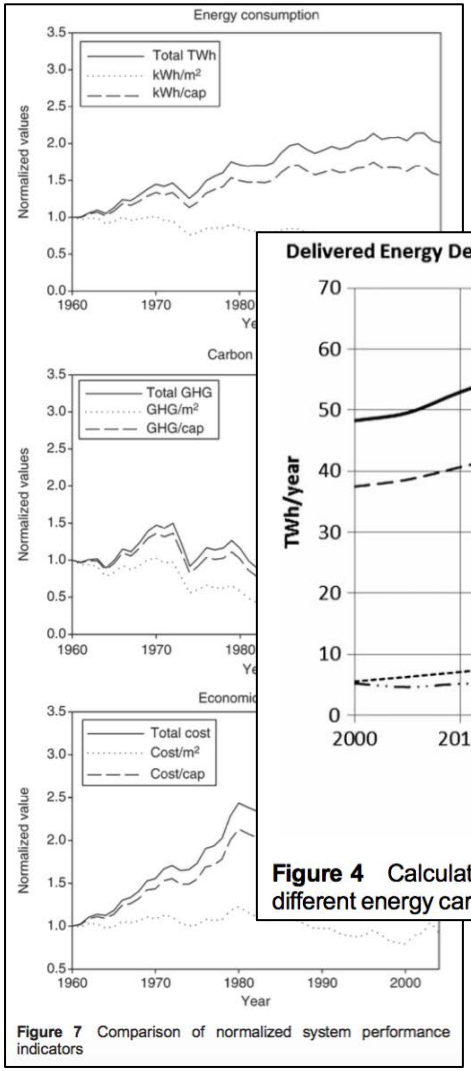


Figure 7 Comparison of normalized system performance indicators

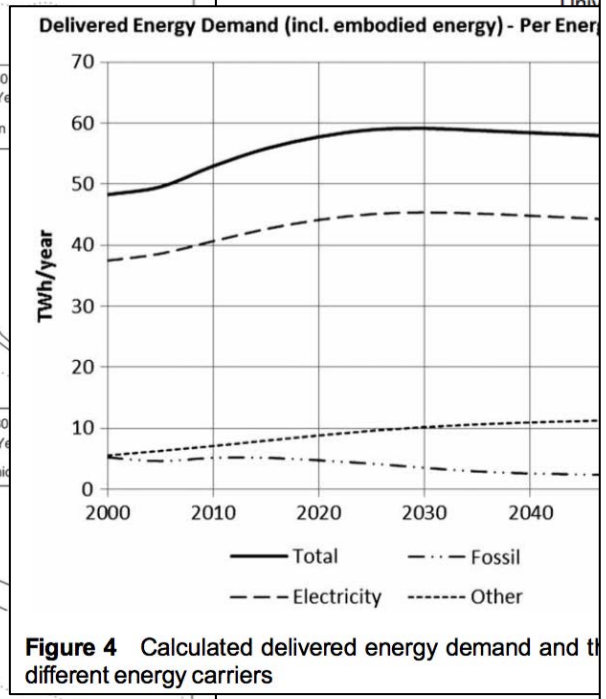


Figure 4 Calculated delivered energy demand and th different energy carriers

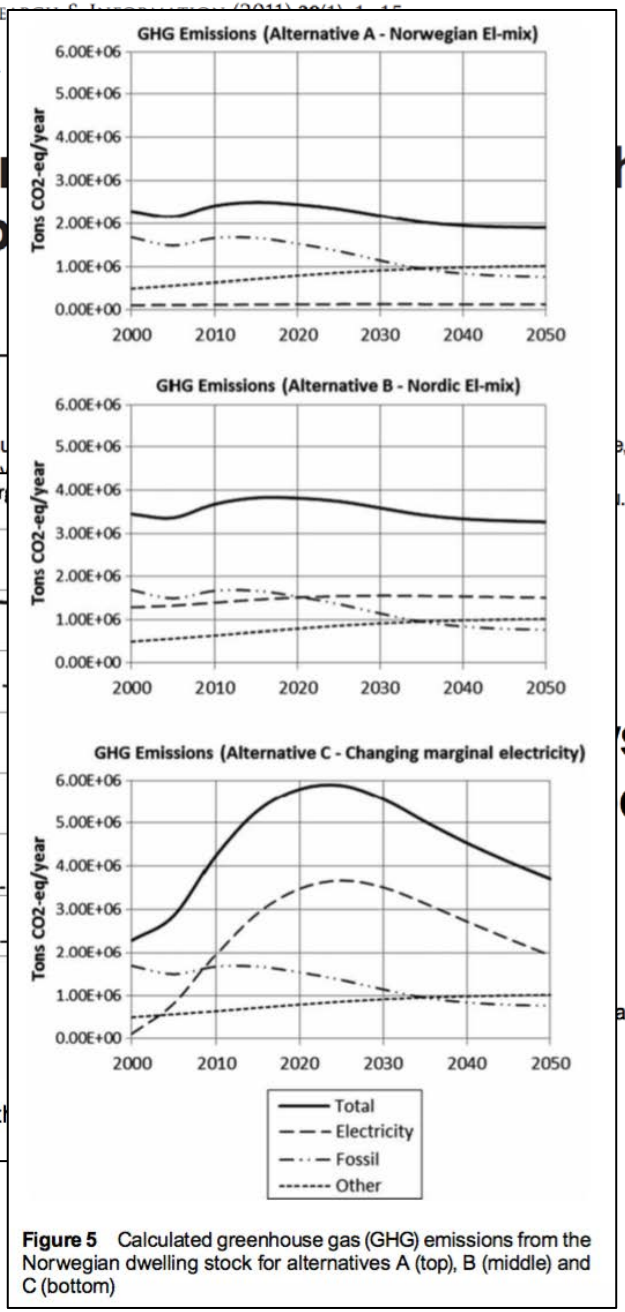


Figure 5 Calculated greenhouse gas (GHG) emissions from the Norwegian dwelling stock for alternatives A (top), B (middle) and C (bottom)

NO

Future Renovation

Energy and Buildings 82 (2014) 287–295

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Using a dynamic segmented model to examine future renovation activities in the Norwegian dwelling stock

Nina Holck Sandberg[a,*], Igor Sartori[b], Helge Brattebø[a]

[a] Industrial Ecology Programme and Department of Energy and Process Engineering, Norwegian University of Science and Technology, Trondheim, Norway
[b] SINTEF, Department of Building and Infrastructure, P.O. Box 124 Blindern, 0314 Oslo, Norway

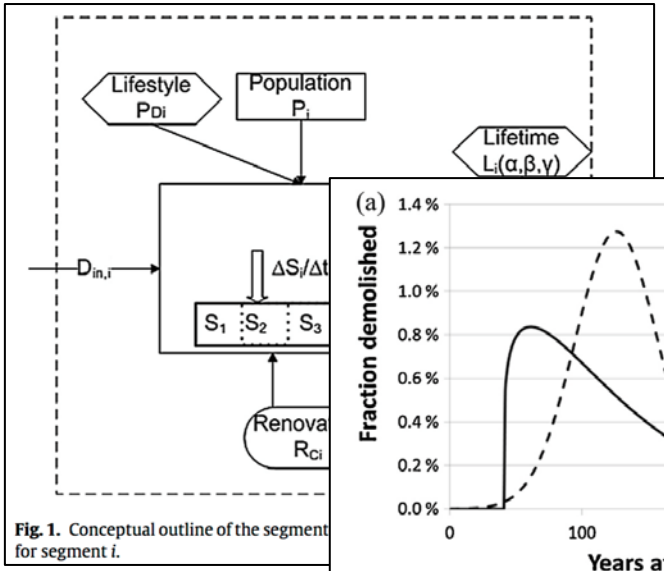


Fig. 1. Conceptual outline of the segment for segment *i*.

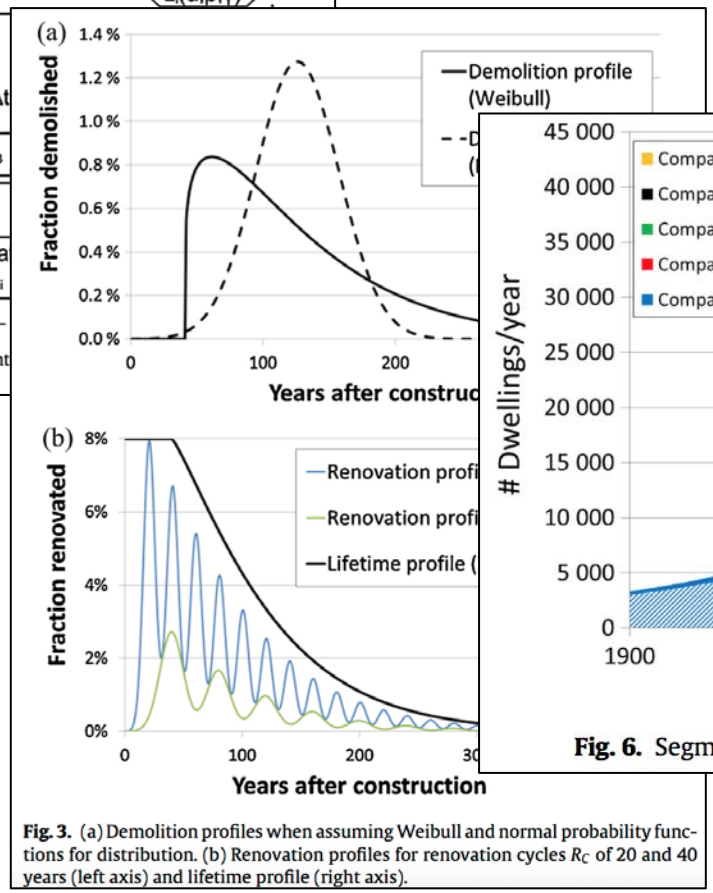


Fig. 3. (a) Demolition profiles when assuming Weibull and normal probability functions for distribution. (b) Renovation profiles for renovation cycles R_C of 20 and 40 years (left axis) and lifetime profile (right axis).

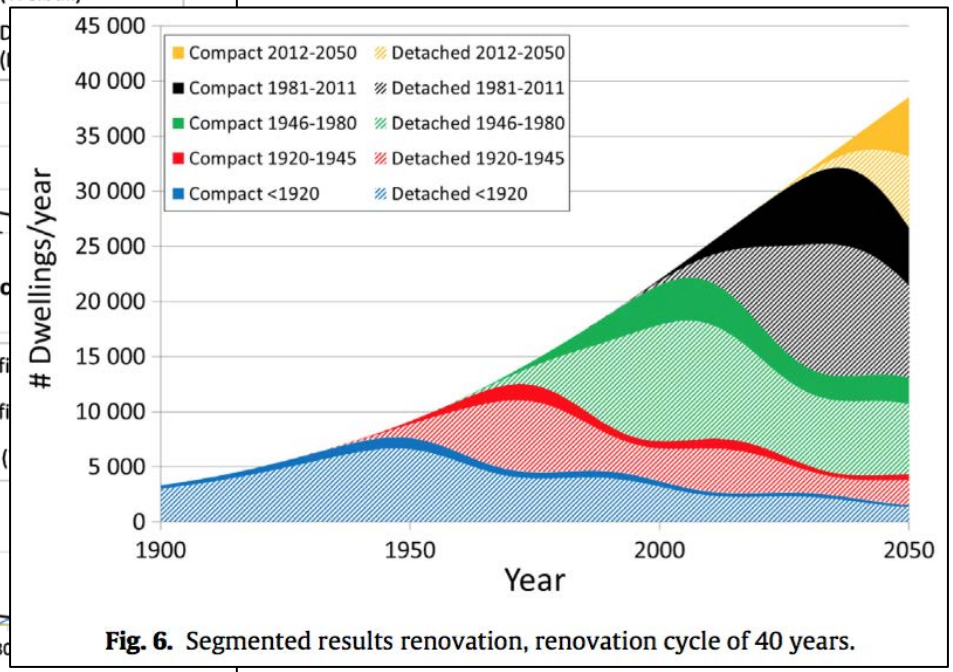


Fig. 6. Segmented results renovation, renovation cycle of 40 years.

EU

Stock Composition and Renovation

G Model
ENB-6735; No. of Pages 13
ARTICLE IN PRESS
Energy and Buildings xxx (2016) xxx–xxx

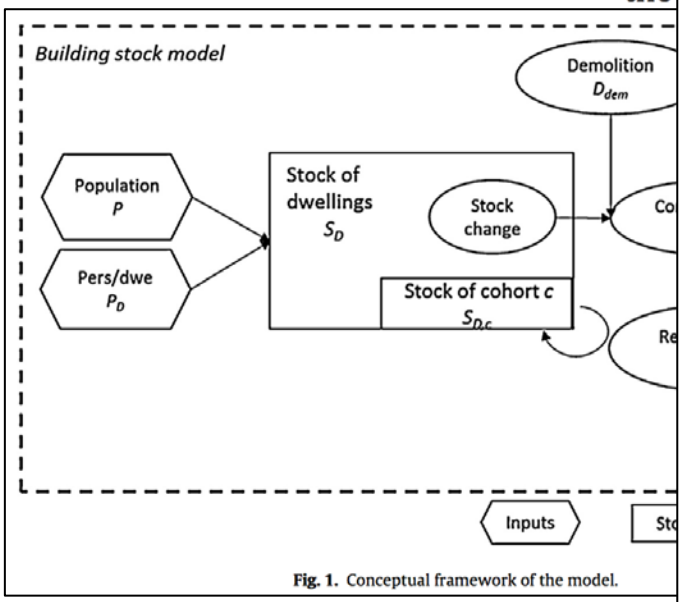
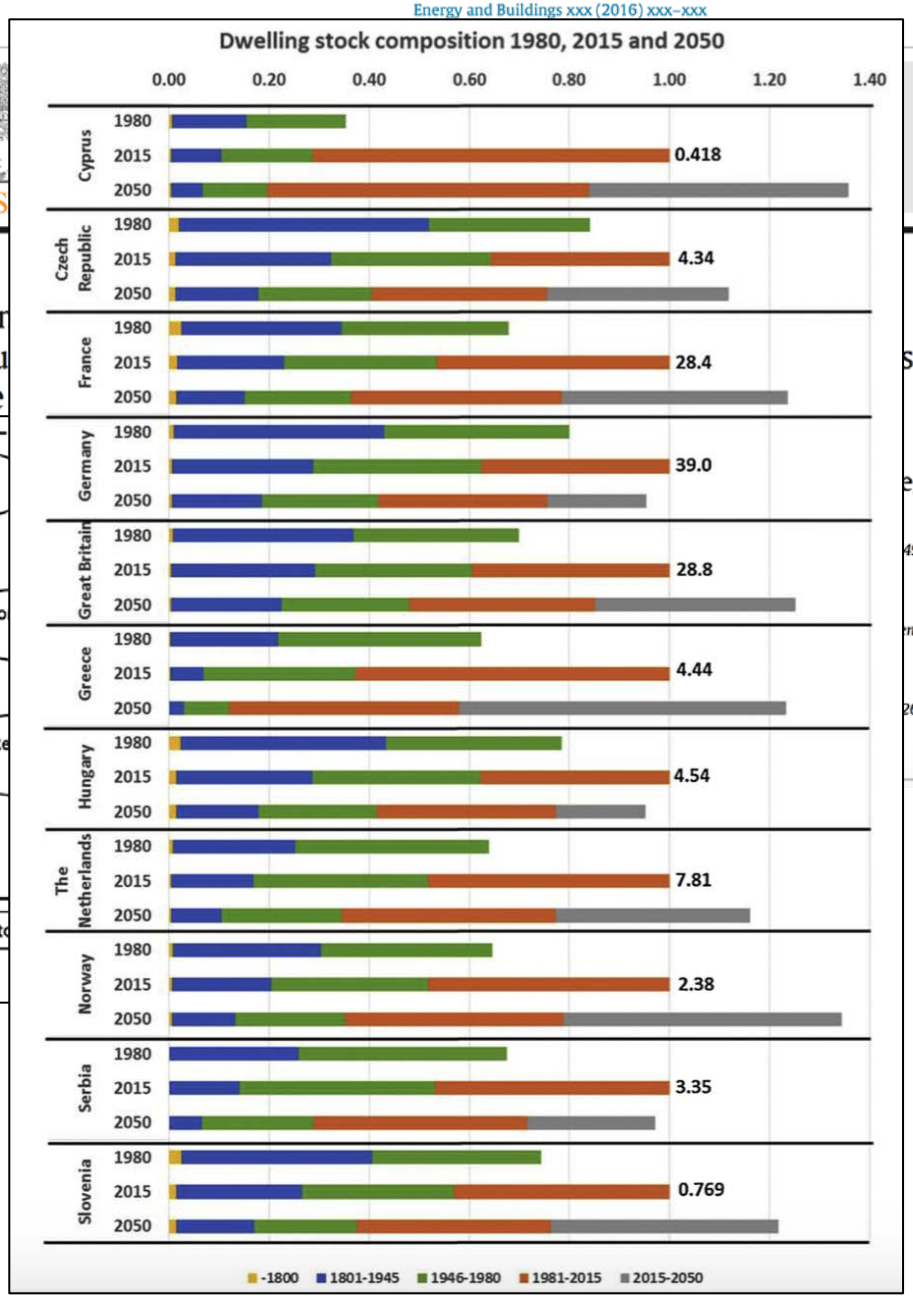


Fig. 1. Conceptual framework of the model.



CN

Urban & Rural

BUILDING RESEARCH & INFORMATION (2010) 38(3), 301–317

Routledge Taylor & Francis Group

RESEARCH PAPER

Dynamics of urban and rural housing stocks in China

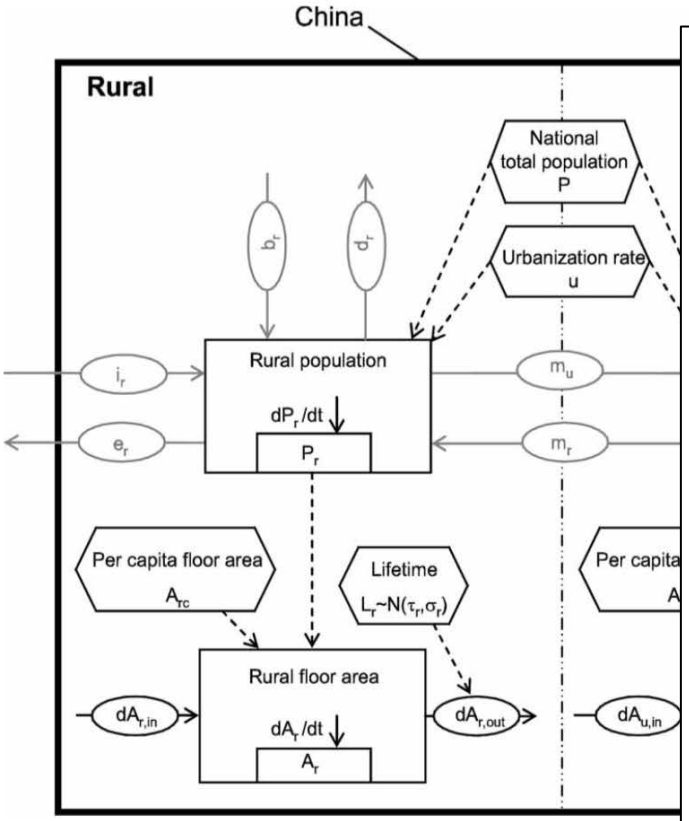


Figure 1 Conceptual outline of the stock dynamics model. Rectangles repre
determinants or drivers; and dashed lines represent influences between variabl
the modelling.

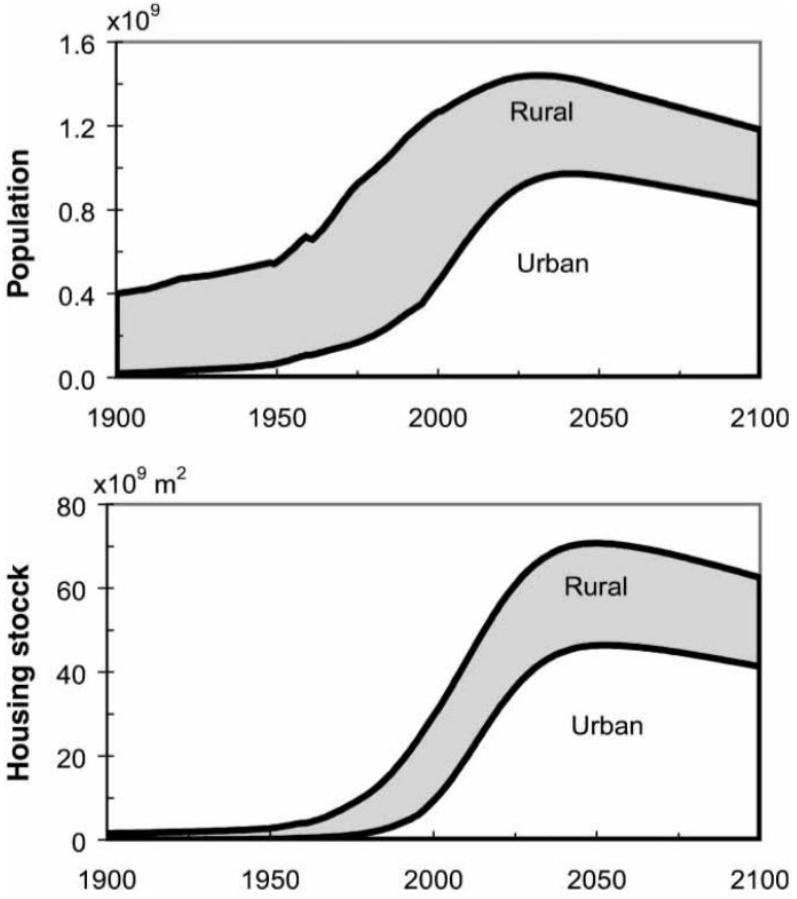


Figure 3 Population stocks and housing floor area stocks in rural (grey) and urban (white) China. All input parameters are set at medium values given in Figure 2.

CN

Iron & Steel

Resources, Conservation and Recycling 54 (2010) 591–600

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

ntial buildings: A dynamic analysis

Wang[c], Gjalt Huppes[b], Ester van der Voet[b], Daniel B. Müller[c]

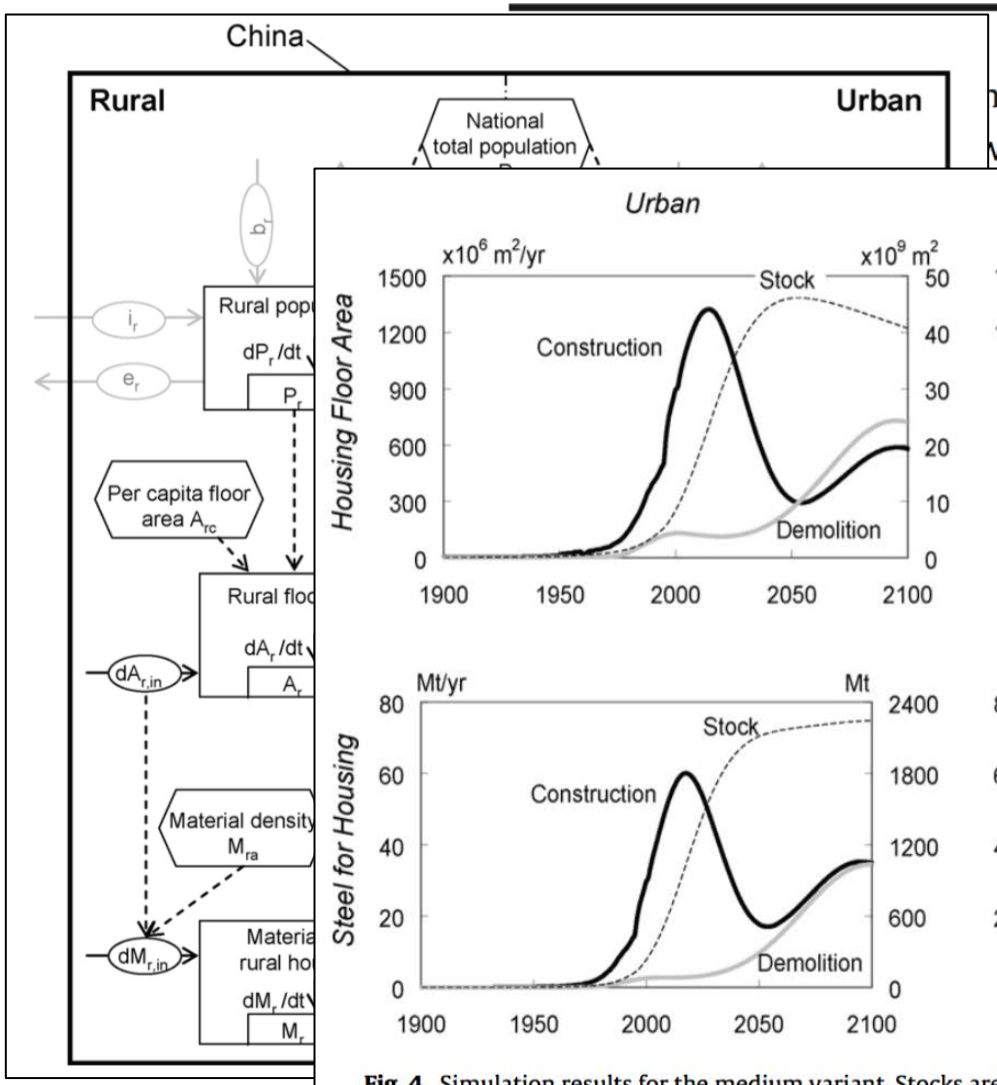


Fig. 4. Simulation results for the medium variant. Stocks are measured on the right axis and flows on the left.

BRI Building Research & Information 2014
http://dx.doi.org/10.1080/09613218.2014.872547
Routledge Taylor & Francis Group
RESEARCH PAPER

CL

Earthquake Damage

Dynamic-MFA examination of Chilean housing stock: long-term changes and earthquake damage

Carla Gallardo, Nina Holck Sandberg and Helge Brattebø

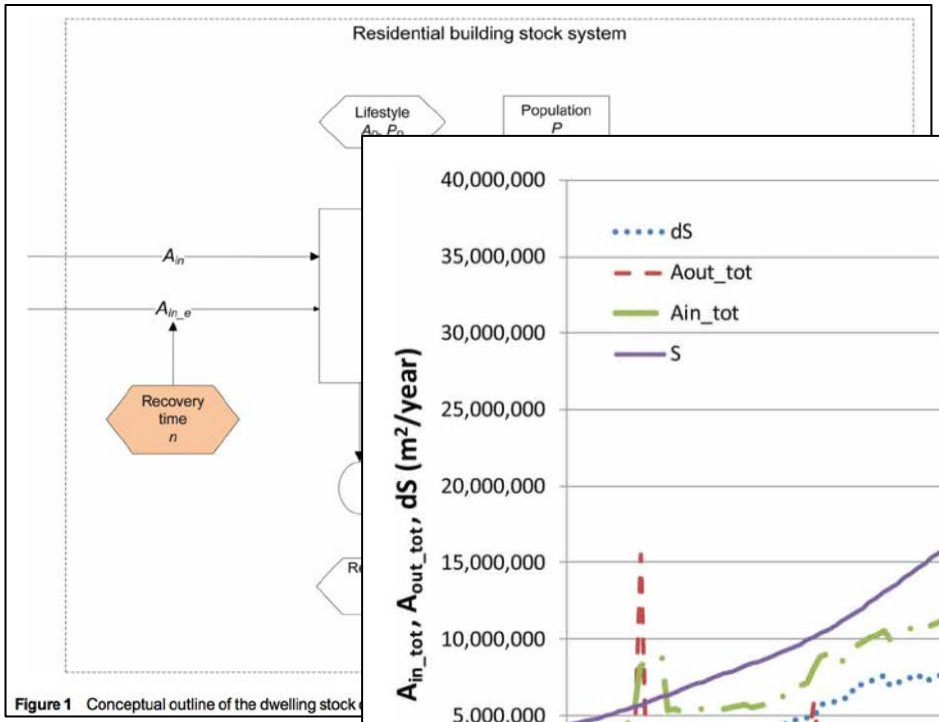
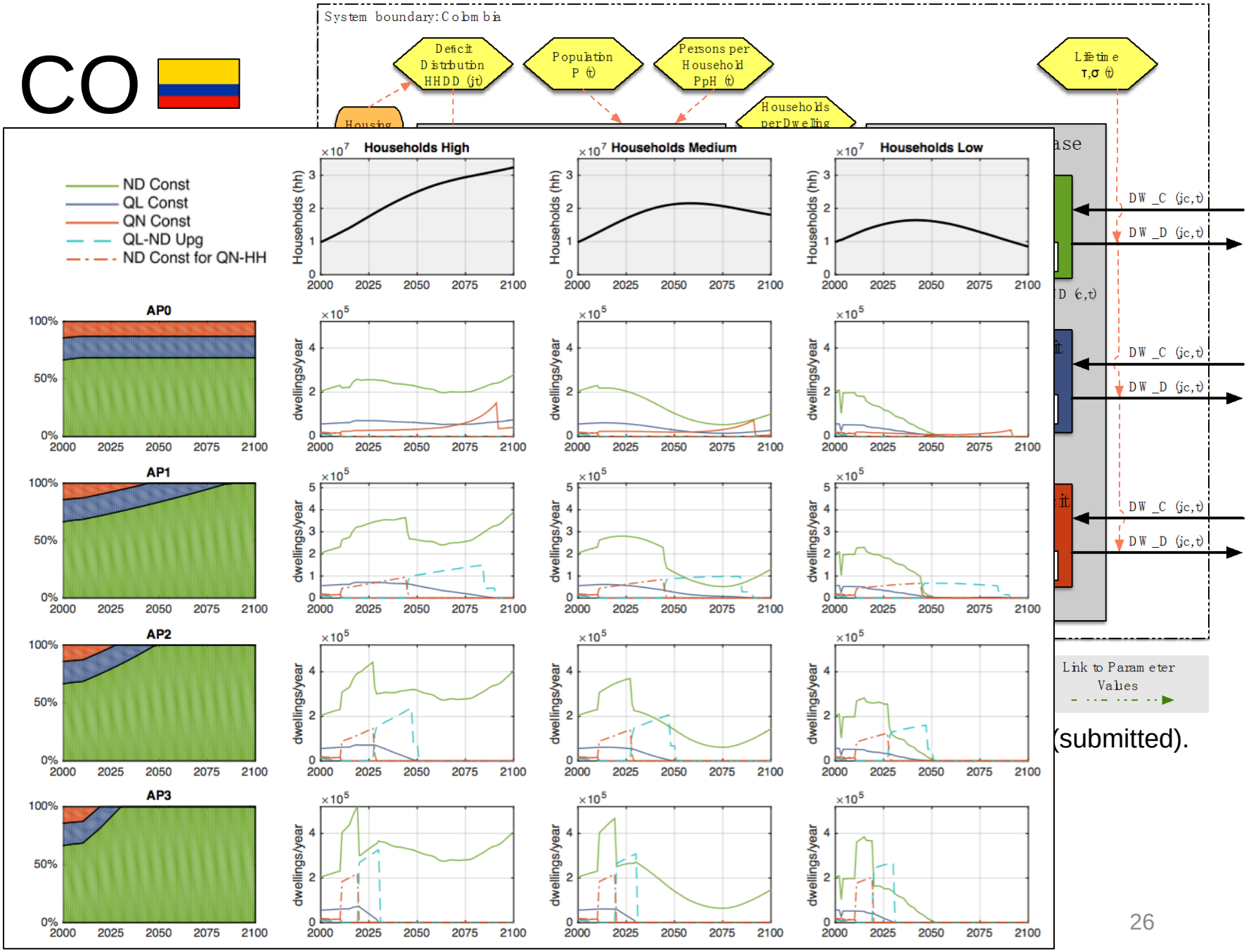


Figure 1 Conceptual outline of the dwelling stock

Figure 4 Results of the building stock model including earthquakes for the residential Chilean stock

CO

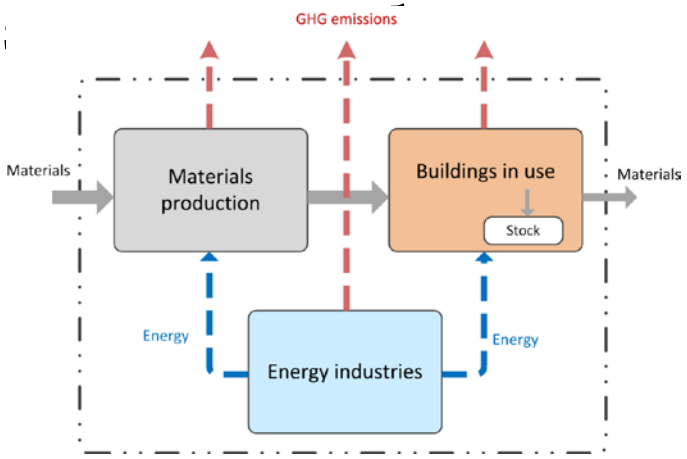


(submitted).

Conclusion

Dynamic (MFA) models

- Integrate all the aspects of the built environment system
  - Social
  - Material
  - Energy
  - Emissions



- Are suitable for the development of forecasting and backcasting scenarios that can incorporate changes in **socioeconomic** (people's needs and lifestyles) and **technological** factors in the **long term**.

Limitations / Opportunities

- Feed on statistics (usually scarce)
  - Regression techniques are used to complete time series of socio-economic indicators
- Energy modelling rest of external typologies.
- Knowledge about the lifetime of buildings is very limited.
  - Normal or Weibull distributions
  - Commonly all cohorts and types of buildings are assumed to have the same lifetime.

Thanks!

NTNU

Faculty of Engineering Science and Technology

Industrial Ecology Programme

Feel free to contact us.

Felipe

luis.v.correa@ntnu.no

http://www.ntnu.edu/employees/luis.v.correa

http://no.linkedin.com/in/lfvasco/

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