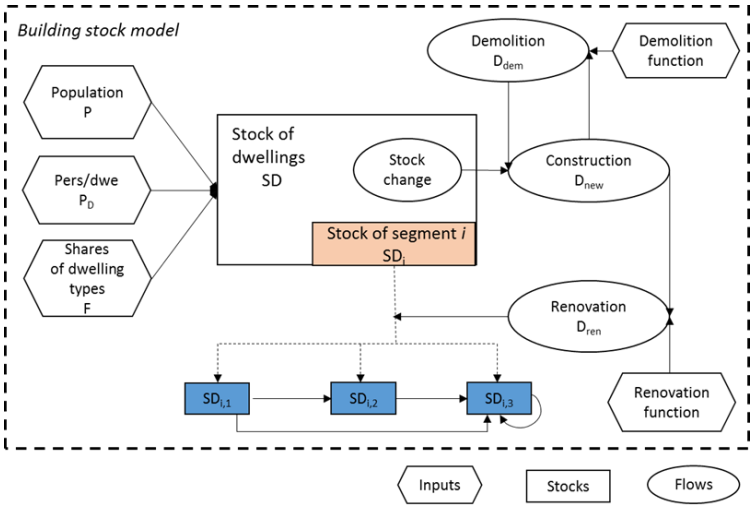
Using a dynamic segmented model to examine future renovation activities in the Norwegian dwelling stock - Basis for energy and carbon analyses



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Energy demand in dwelling stocks

Historical development

$$I(t) = \frac{E(t)}{A(t)}$$

E = Total energy demand
A = Total floor area
I = Average energy intensity
t = Year t

Future development

$$E(t) = A(t) * I(t)$$

Potential studies: potential for energy savings in existing stocks

- $I(t)$ changes over time depending on renovation rates and energy efficiency measures
- Changes in dwelling stock size or composition not considered

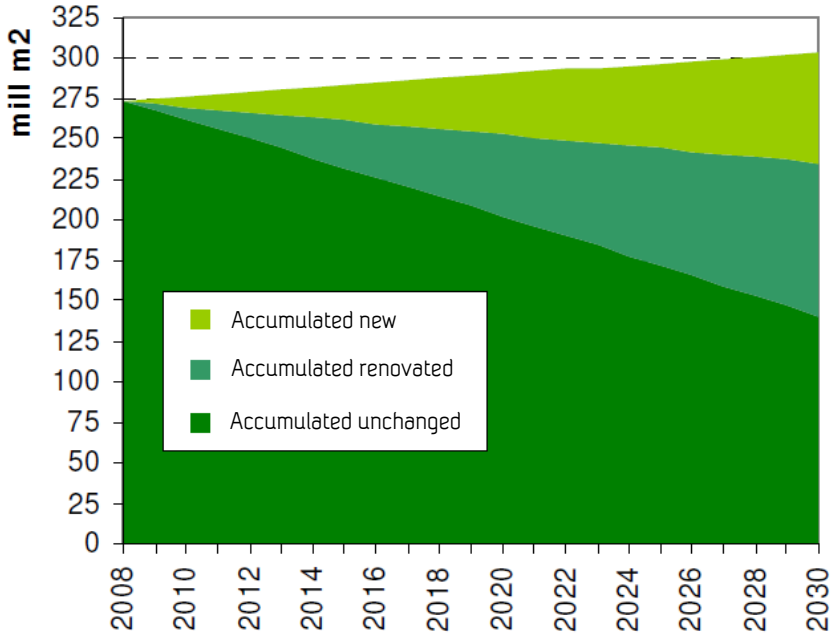
Forecasts and scenario analyses: possible future development paths of the stock

- Both $I(t)$ and $A(t)$ change over time
- Standard models:
  - Development in $I(t)$ modeled using detailed analyses
  - Development in $A(t)$ based on recent trends and assumptions
- The resulting total energy demand is the product of $I(t)$ and $A(t)$. Good models are needed for both!

Future development in building stocks:

Just percentages and straight lines?

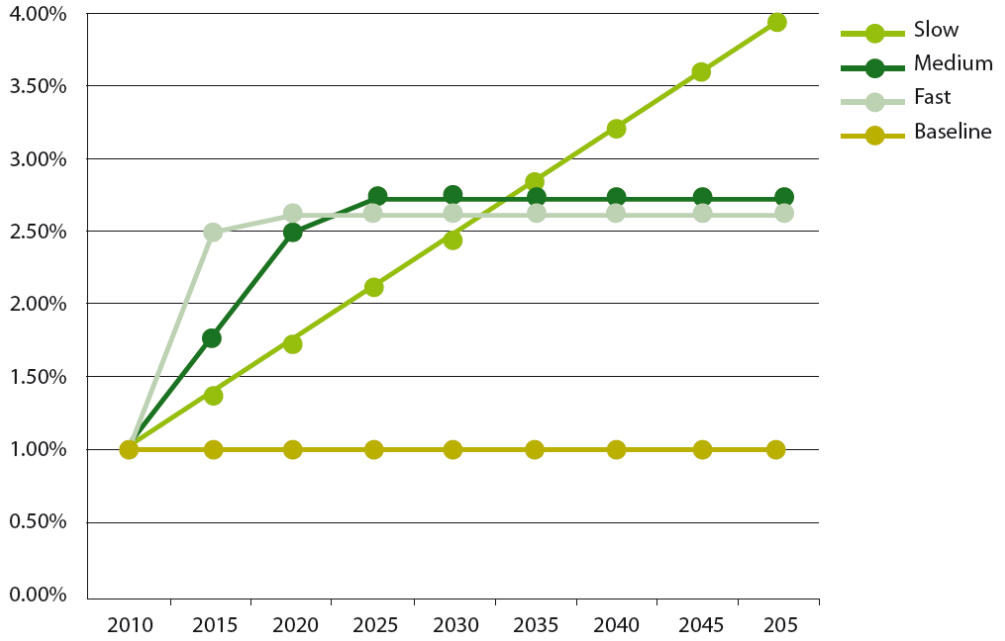
Examples from a Norwegian and a European study



Forecasted gross floor area in Norwegian dwellings, including holiday homes. (Source: NVE 2011)

Figure 3B2 – Profiles of renovation rates considered herein

Source: BPIE model



Renovation profiles in different scenarios for the EU residential stock (Source: BPIE 2011)

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Dynamic segmented building stock model

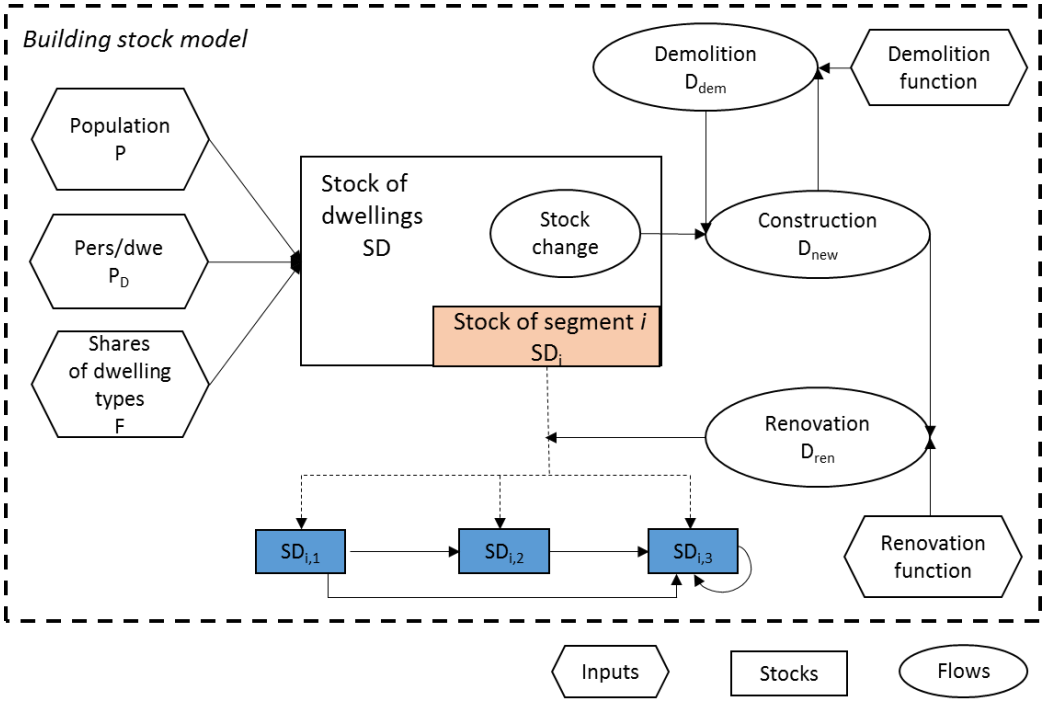
Stock and flows of dwellings

Model based on mass balance equations and probability functions

Segments defined by dwelling type and construction period (cohort)

Archetypes defined by segment and renovation state

Dwellings can move between archetypes within the same segment when renovated



Renovation activity is an output from the model, estimated as the need for maintenance of previous construction

Basis for applications

Building Stock Dynamics as the basis for policy making and market strategy support on:

- Energy efficiency and GHG emissions: national plans and roadmaps (for 2030 and 2050)
- Climate change: vulnerability, mitigation and adaptation strategies (towards 2050 and 2100)
- Demographic changes: adaptation to ageing society
- Material and waste projections: material flows in construction, renovation and demolition activities
- Building and installations Industry: anticipate market opportunities

Building stock model – Inputs (Norwegian dwelling stock)

Past and future trends in the main driving forces:

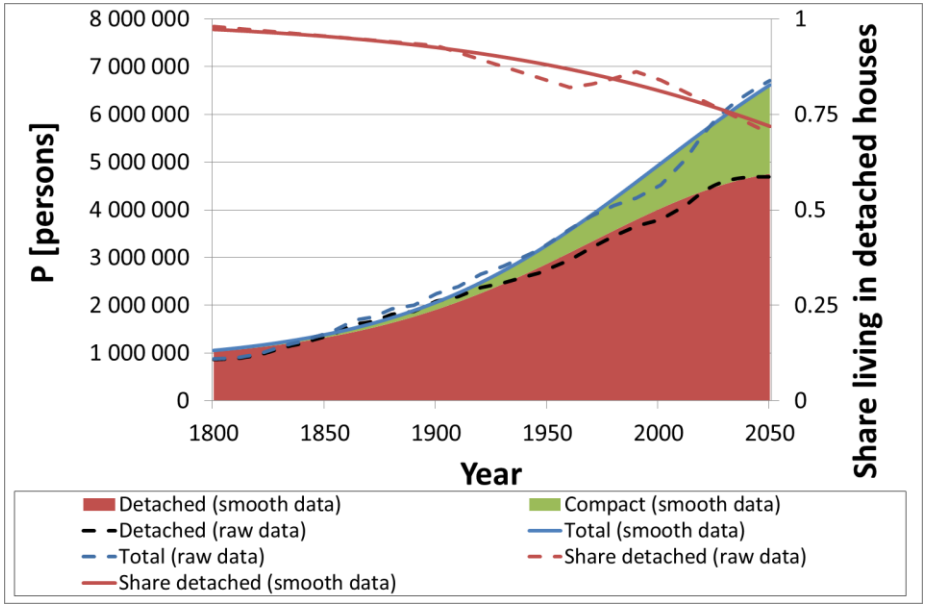
- Population
- Lifestyle parameters:
  - Persons per dwelling
  - Share of stock being of different types

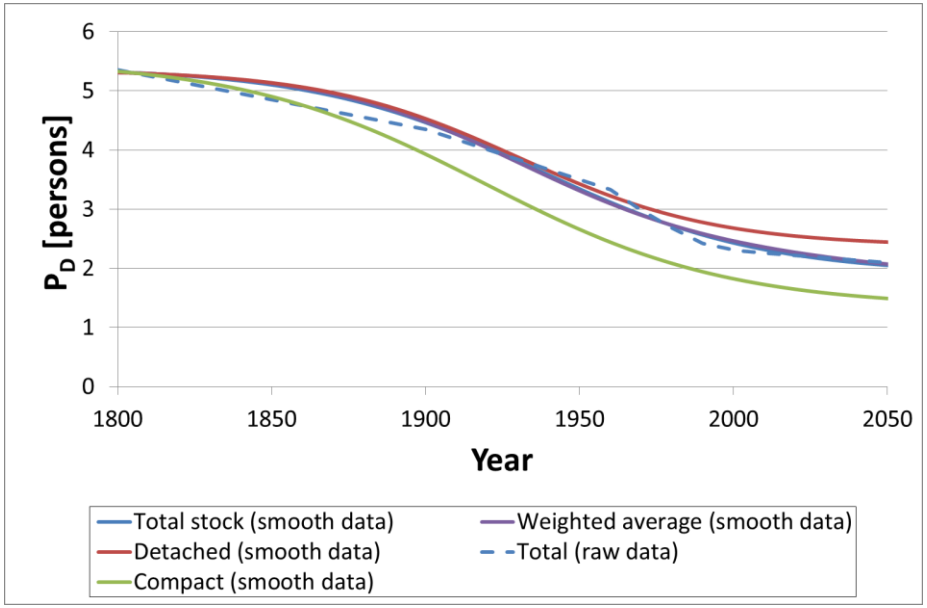
Technical indicators ← Good input data required

- Buildings technical lifetime
- Renovation intervals ← "Natural" need for maintenance

Segmentation

- Cohort definition
- Dwelling type definition





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Demolition and renovation

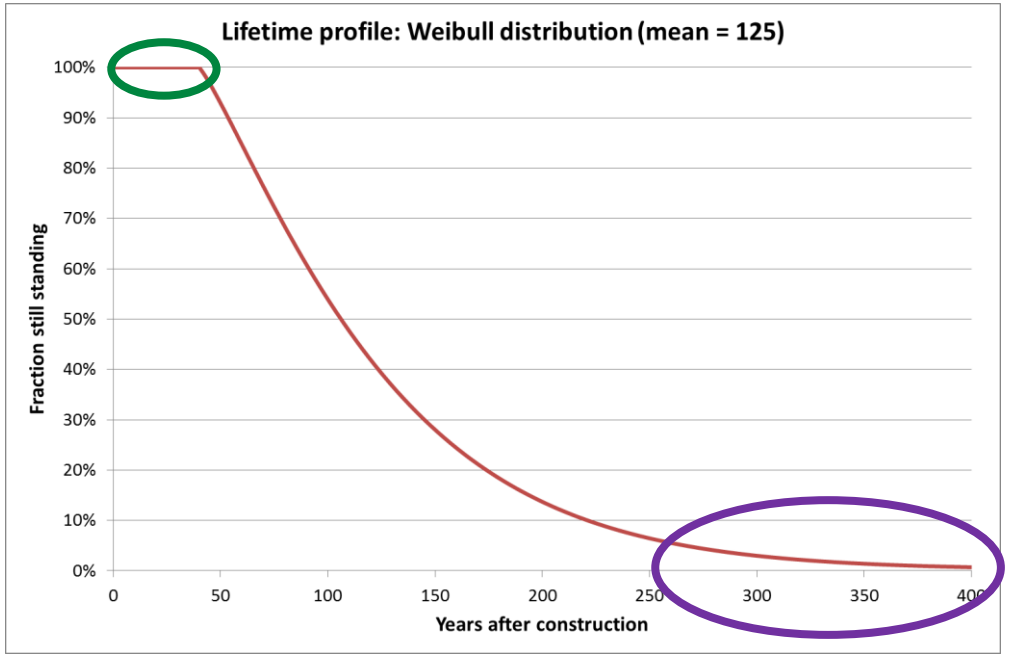
Building lifetime profile:

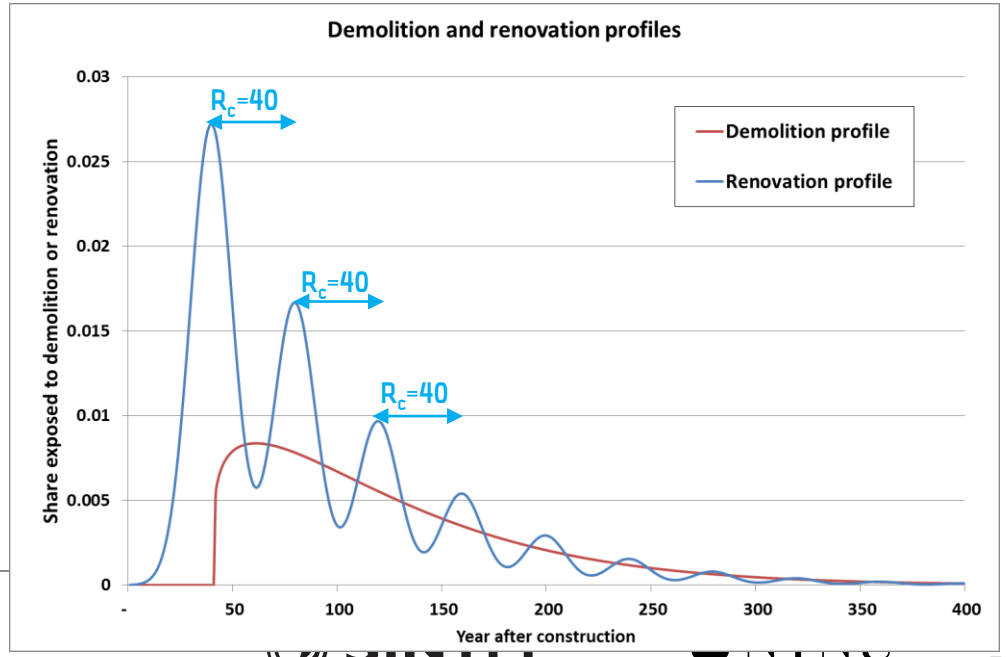
- Modeled using demolition probability function
- Weibull distribution suitable
  - Initial period with no demolition activity
  - A long «tail» covering the stock of old preserved buildings

Renovation activity:

- Modeled using probability function with multiple renovation cycles
- R_c is average time between renovations of a building
- For example R_c=40 years represents deep renovation of facades
- Renovation activity linked to the lifetime profile
- Assumed normal distribution

Demolition and renovation profiles are applied to construction from all previous years.





Segmentation

Cohorts

- 1920

1921 – 1945

1946 – 1980

1981 – 2011

2012 – 2050

Dwelling types

Detached houses

Compact houses

	Region	Construction Year Class	Additional Classification	SFH Single-Family House	TH Terraced House	MFH Multi-Family House	AB Apartment Block
1	National (not region specific)	… 1955	generic	 NO.N.SFH.01.Gen	 NO.N.TH.01.Gen		 NO.N.AB.01.Gen
2	National (not region specific)	1956 … 1970	generic	 NO.N.SFH.02.Gen	 NO.N.TH.02.Gen		 NO.N.AB.02.Gen
3	National (not region specific)	1971 … 1980	generic	 NO.N.SFH.03.Gen	 NO.N.TH.03.Gen		 NO.N.AB.03.Gen
4	National (not region specific)	1981 … 1990	generic	 NO.N.SFH.04.Gen	 NO.N.TH.04.Gen		 NO.N.AB.04.Gen
5	National (not region specific)	1991 … 2000	generic	 NO.N.SFH.05.Gen	 NO.N.TH.05.Gen		 NO.N.AB.05.Gen
6	National (not region specific)	2001 … 2010	generic	 NO.N.SFH.06.Gen	 NO.N.TH.06.Gen		 NO.N.AB.06.Gen
7	National (not region specific)	2011 …	generic	 NO.N.SFH.07.Gen	 NO.N.TH.07.Gen		 NO.N.AB.07.Gen

Results: Stock dynamics

Dwelling stock is growing strongly

The share of compact houses is increasing

Increasing number of dwellings constructed, renovated and demolished

Examples of renovation cycles:

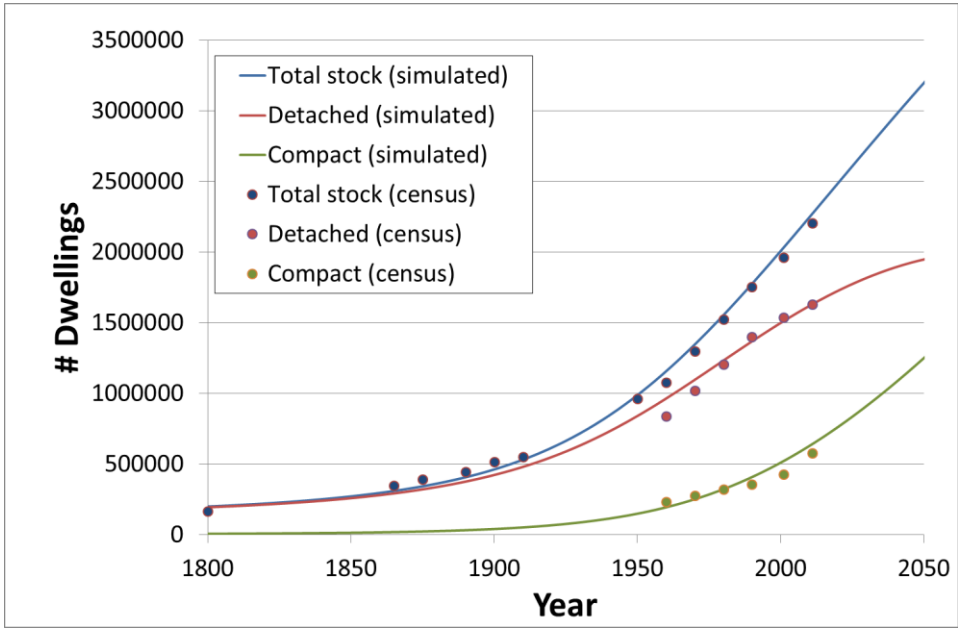
40 years (e.g. facade/deep renovation)

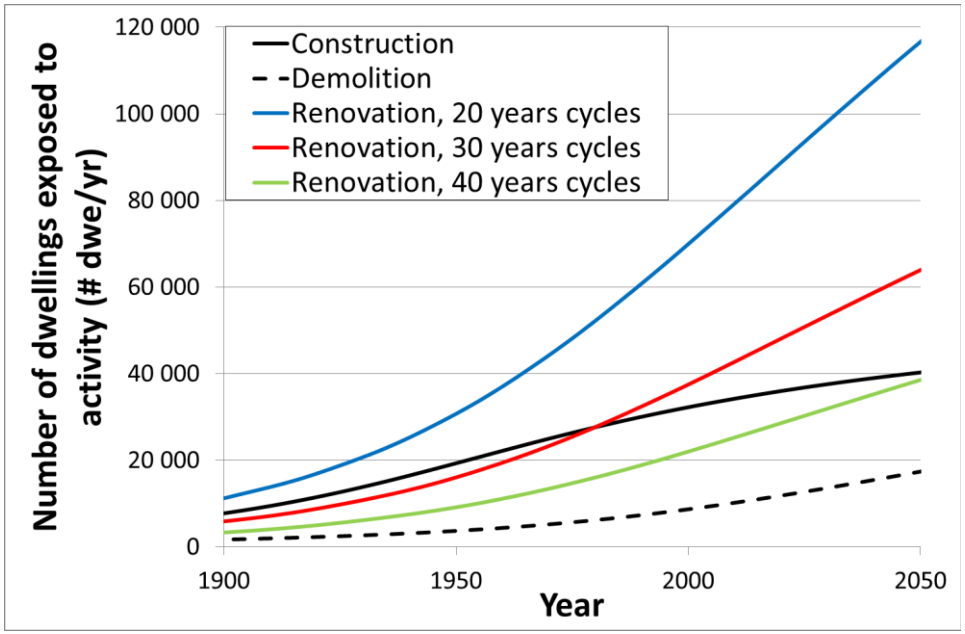
30 years (e.g. windows/roofs)

20 years (e.g. boiler replacement)

Renovation activities (#dwellings per year) increase rapidly due to growing and ageing stock

- Potential for large accumulated effect of energy-efficient renovation





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Results: Future annual renovation rates

Examples of renovation cycles:

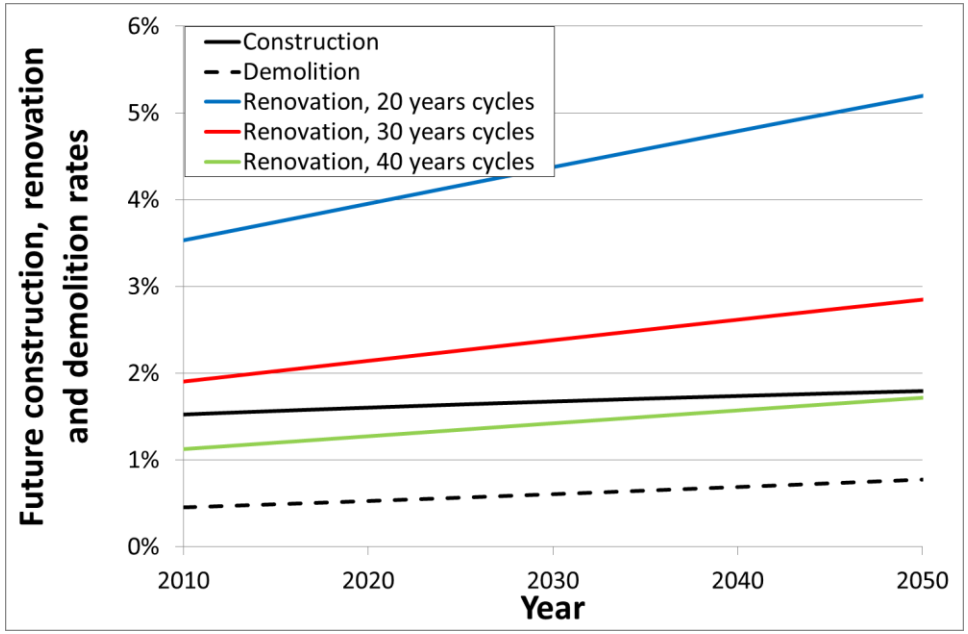
40 years (e.g. facade/deep renovation)

30 years (e.g. windows/roofs)

20 years (e.g. boiler replacement)

Renovation rates (% of 2010 stock) are increasing, but not to levels commonly assumed in scenario analyses and action plans

When a building is going through renovation in any case, energy-efficiency measures should be included



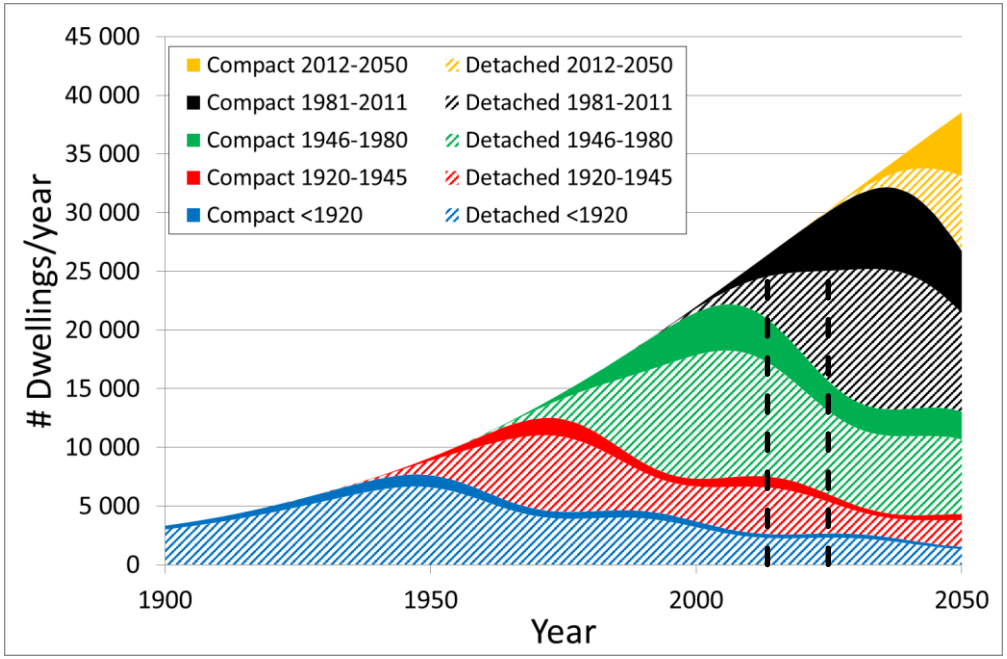
Segmented results: Renovation

Renovation activity for different stock segments

Shows what segments are exposed to renovation at different times

Solutions for improving the energy efficiency of dwellings vary between segments

- Model results can be used for tailoring energy policies towards cost-efficient energy saving measures in the most important segments
- Solutions should be prepared for the expected shift towards renovation of other recent cohorts and increase in renovation of compact houses



Conclusions

The segmented dynamic dwelling stock model estimates future activities as a consequence of historical activities

- Gives detailed insight in the changing composition of the growing and aging Norwegian dwelling stock

Renovation activity is increasing in the growing and aging Norwegian dwelling stock

- Large potential for accumulated effects of energy-efficient renovation

However, the annual renovation rate resulting from the need for maintenance will not increase much in the future

- Limited potential for rapid increase of the renovation rate

Understanding the cause-effect dynamics in the building stock can help effectively influencing the causes (e.g. renovation intervals, types of measures, targeted subsidies) to obtain the desired effects (energy savings, decarbonization)

Renovation is an occasion to introduce ambitious energy conservation measures.
If you miss it you have to wait 30/40 years for the next one.

It is like a running train...

...if you don't know the schedule you may miss it!