Interactions between summer and winter thermal comfort, effects of climate change on optimal renovation actions

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Monday 20th January, 2025

Abstract

Energy efficiency building renovation, particularly through thermal insulation, is a key factor in the transformation of the building stock to reduce greenhouse gas emissions and adapt dwellings to future climates. Thermal renovation of buildings is a particularly costly operation that rarely pays off for the person carrying out the work. In France, many renovation projects are financed in part by the state, and this funding involves targeting the most effective works. However, this efficiency is only measured in terms of heating needs, while the critical nature of the inadequacy of housing for future heat increases year on year. Taking account of climate change, its future evolution, and the need to adapt homes will therefore influence the optimum renovations to target as a priority now. Here we show that the displacement of the optimum differs according to the type of building and the intensity of warming, and according to the type of renovation work. This study presents a first way of considering dynamic, energy and economic optimisations, with RC modelling of building typologies. The conclusions are different depending on the type of action carried out: for example, the insulation of opaque walls does have an antagonistic effect on heating and cooling needs (but this is particularly visible in the coldest meteorological years and without night-time natural over-ventilation), but total energy needs are always decreasing. Thus, inter-annual variations in typology and weather play a decisive role in defining the optimum. The results call into question the selection criteria for subsidised renovations, as well as the renovations carried out in practice in France. The question of the interaction between summer and winter comfort has been raised in official reports in France, because adaptation is underdeveloped, and the majority of measures are focused on winter thermal comfort. We could ask the following (deliberately provocative) question: 'Do we need to renovate buildings on a massive scale if the French climate warms up significantly between now and the end of the century? The answer is yes, but not for all buildings or all regions in the same way.

Keywords – Thermal insulation, Heating and cooling needs, Adaptation, Mitigation

Contents

1 Introduction

consommations des batiments dans le monde et en France (UNEP 2024, SDES 2023, SDES and CEREN 2023)

changement climatique en France (physique et scenarios officiels) (IPCC 2021, Ouzeau et al. 2016, Ministère de la Transition Écologique 2023)

consommations futures des batiments (Larsen et al. 2020,Moreau 2023,Filahi 2024, Tao 2024)

inadaptation du parc aux temperatures futures (Cour des Comptes 2024, I4CE, Dolques, et al. 2024)

rentabilité et cout des renovations (ADEME, Vouillamoz, et al. 2019, I4CE and OID 2023, Giraudet et al. 2024)

2 RC analogy modelling

2.1 RC analogy and computation

2.1.1 RC analogy

Fourier 1822, Bolmont 2003

2.1.2 Model construction

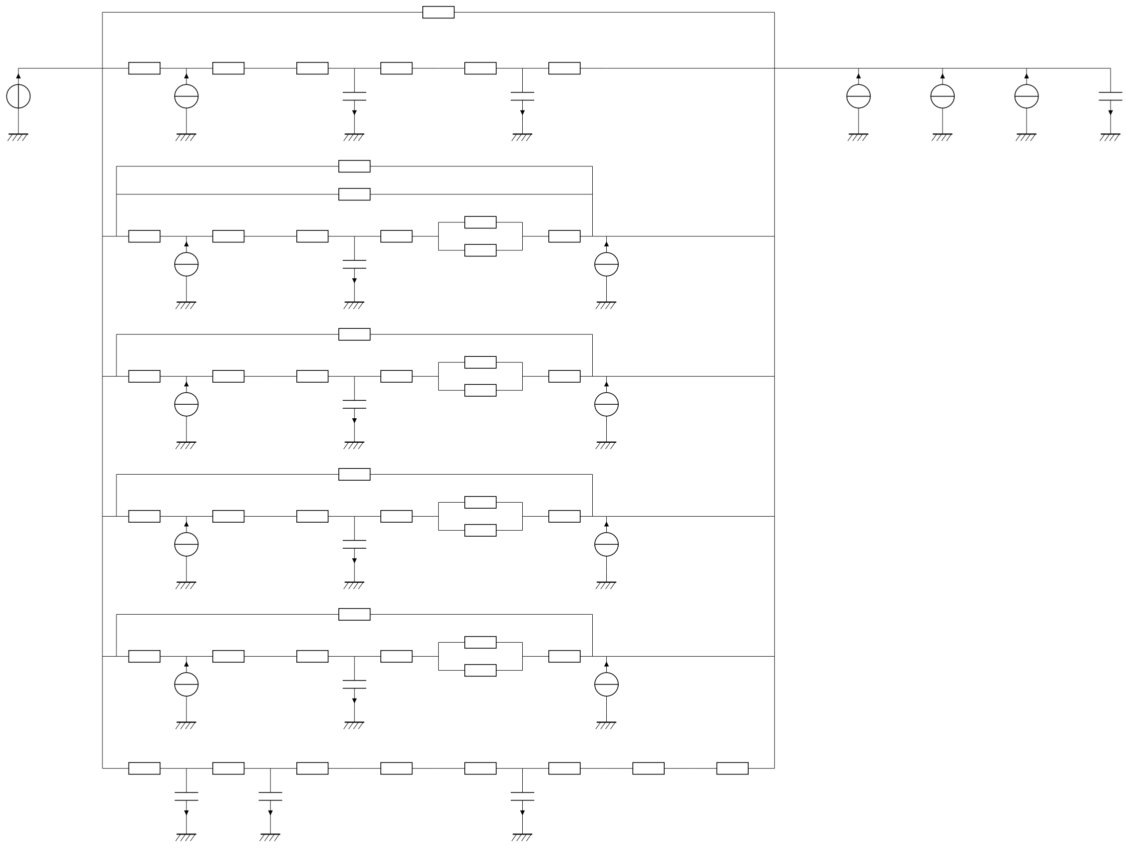


Figure 1: Diagram of the general RC model.

Description. il faut ajouter les noms des composants

2.1.3 Model computation

mathematiques derriere le calcul Madsen et al. 1995, Rouchier 2018

2.1.4 Model verification

resultats de comparaisons avec TABULA

comparaison avec Pomianowski et al. (2023) (en faire d'autres)

2.2 TABULA typologies

2.2.1 Typologies definition

historique et description Pouget Consultants et al. 2015, Loga et al. 2016

valeurs moyennes d'interet pour les typologies et les 3 niveaux (tableau)

typologies non isolées

2.2.2 Typology representation in the French building stock

representativite des typologies dans le parc français

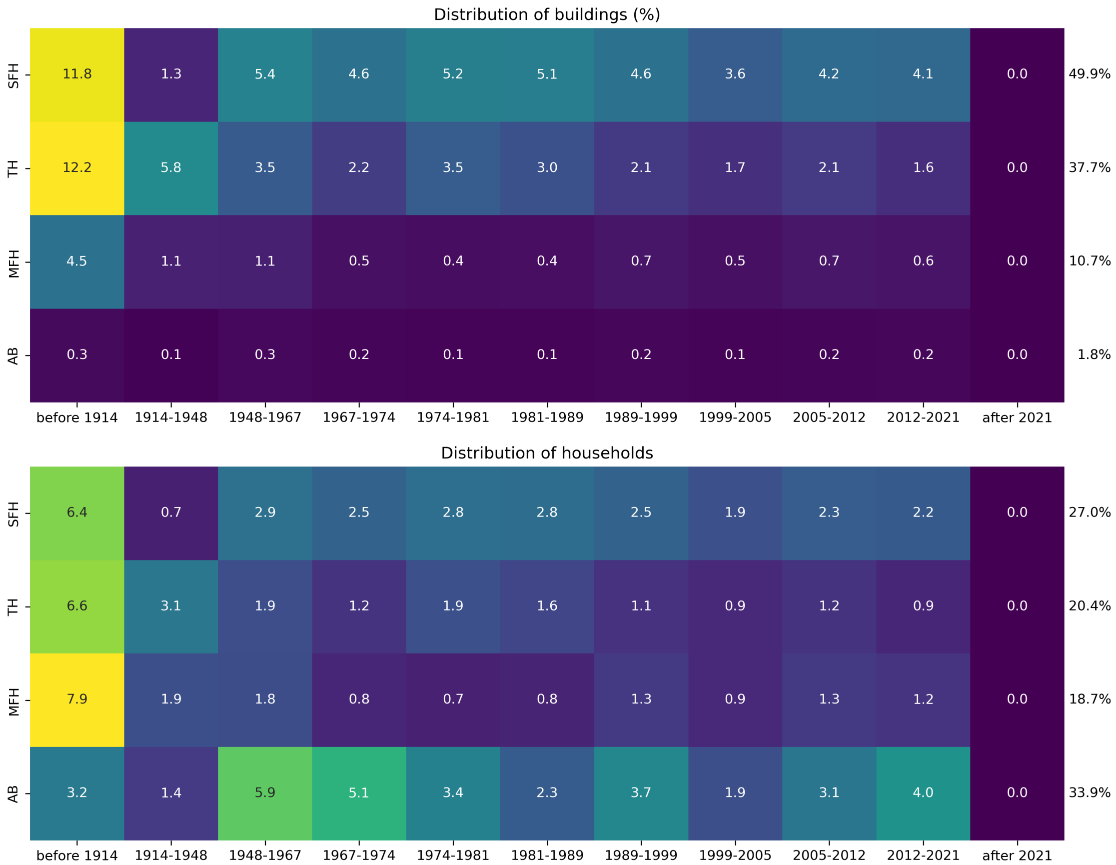


Figure 2: Distribution of TABULA typologies in the French building stock.

(top to bottom) Description.

detail de la methode pour la séparation entre SFH et TH

2.3 Weather data

2.3.1 French climate zones

utilisation des zones climatiques françaises : limiter les calculs, la complexite, mais aussi s'inscrire dans les politiuqes de renovations qui les utilisent (CEE (ADEME 2011), MPR (ANAH 2024))

definitions des prefecture centrales (Figure 3)

$$p_c = \min_{d \in \mathbf{d}_c} \left(\|\mathbf{c}_c - \mathbf{c}_{dp}\|_2 \right) \tag{1}$$

With,

$$\begin{cases} \mathbf{d}_c & : \text{list of departments } d \text{ in climate zone } c \\ \mathbf{c}_c & : \text{geographic coordinates of climate zone } c \text{ centroid} \\ \mathbf{c}_{dp} & : \text{geographic coordinates of department } d \text{ prefecture} \end{cases}$$

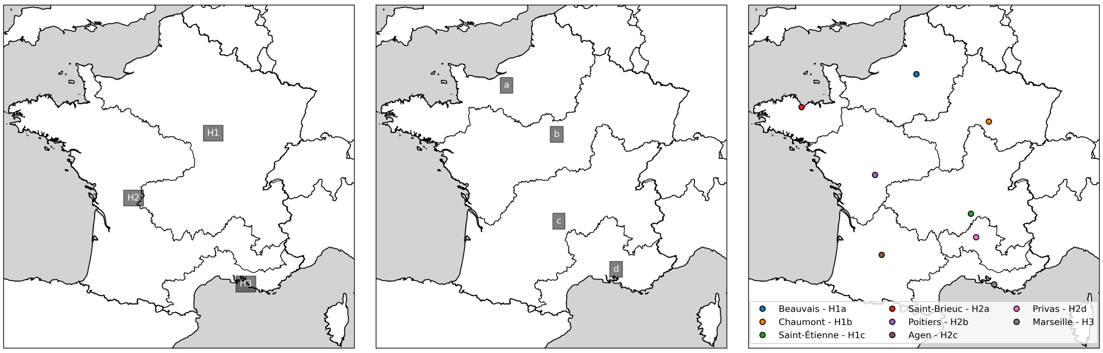


Figure 3: Maps of french climate zones.

(left to right) Map of “winter”, “summer” and combined climate zones. The winter climate zones were defined in a 1988 decree on the thermal characteristics of residential buildings (JORF 1988). Corsica is part of region H3. Summer climate zones were defined in 2000 in parallel with new thermal regulation laws (JORF 2000). The 8 climate zones are a combination of the two zone types (JORF 2012) and the map shows the “central prefectures” used to define the meteorological data for each zone, as defined in (1).

2.3.2 Historical and projection data

source des données (Hersbach et al. 2020, Zippenfenig 2024)
periode de reference 2000-2020
projection : Sauquet et al. 2021 cf DRIAS

2.3.3 Standard weather data

pour economiser en temps de calcul, a chaque fois ets auf mention contraire, une année moyenne des périodes, définies tel que

2.4 Behaviour definition

3 Interactions between summer and winter comfort

3.1 Single renovation actions

actions monogestes : grande part des travaux de renovations (ADEME, Jauneau-Cottet, et al. 2019, ONRE 2022a)
liste des actions et details du choix (I4CE and OID 2023, **)**
plus choix des typologies, des climats

3.1.1 Roof insulation

grosse figure, detailler le choix des 4 typologies

3.1.2 Walls insulation

grosse figure

3.1.3 Floor insulation

3.1.4 Color of external surface

3.1.5 Ventilation efficiency

3.1.6 Shading of glazed surfaces

3.2 Energy needs for TABULA typologies

4 Climate impact on optimal renovations

4.1 Optimal energy efficiency

4.2 Optimal economic efficiency

5 Generalisation across the whole French building stock

5.1 Building stock calibration

utilisation de la base DPE (statistiques)

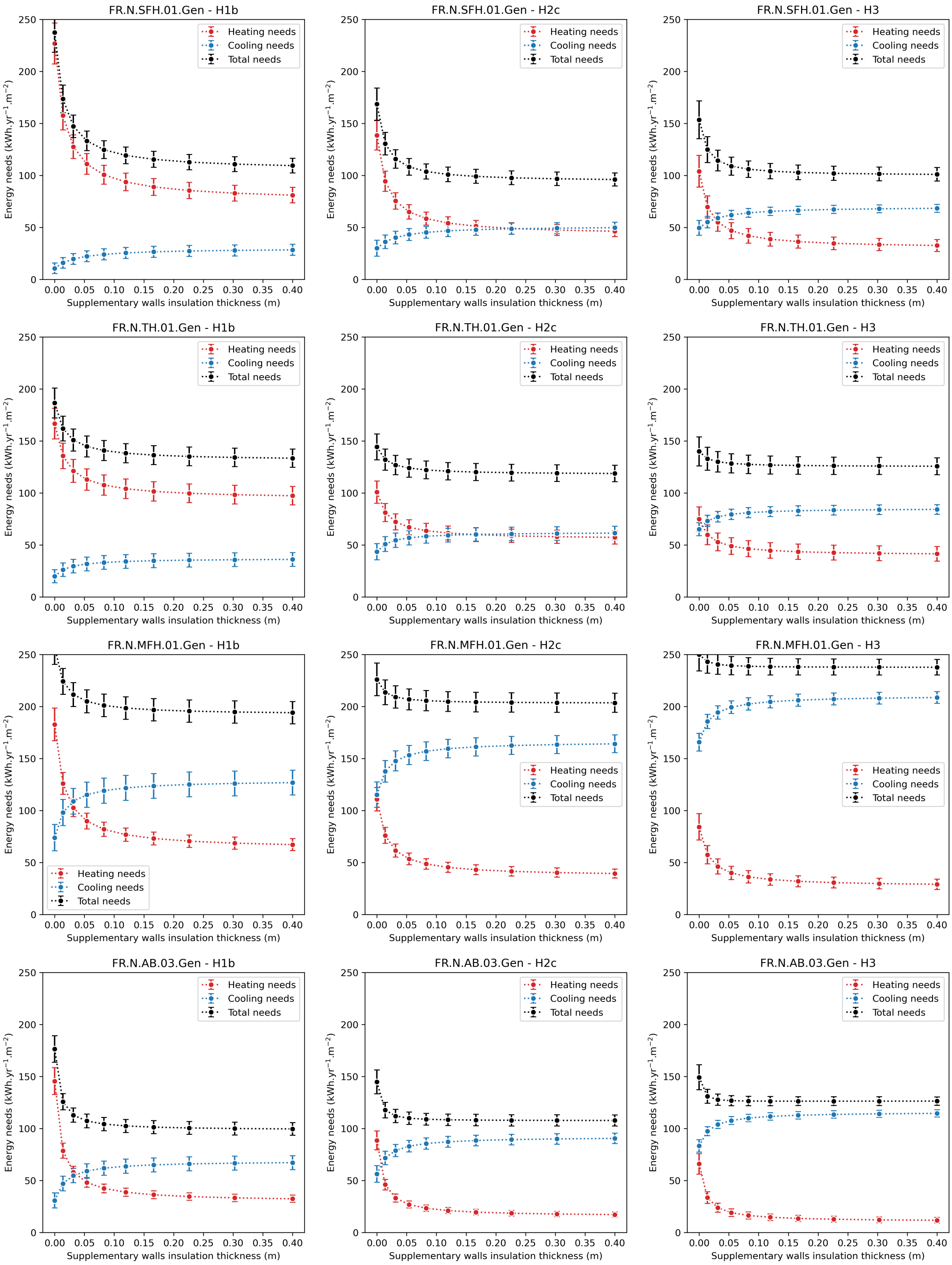
description de la représentatitivté de la base DPE (BDNB)

5.2 Projection of heating and cooling needs

5.3 Projection of annual and instant energy demand

6 Discussion

7 Conclusion



(left to right, top to bottom) Description

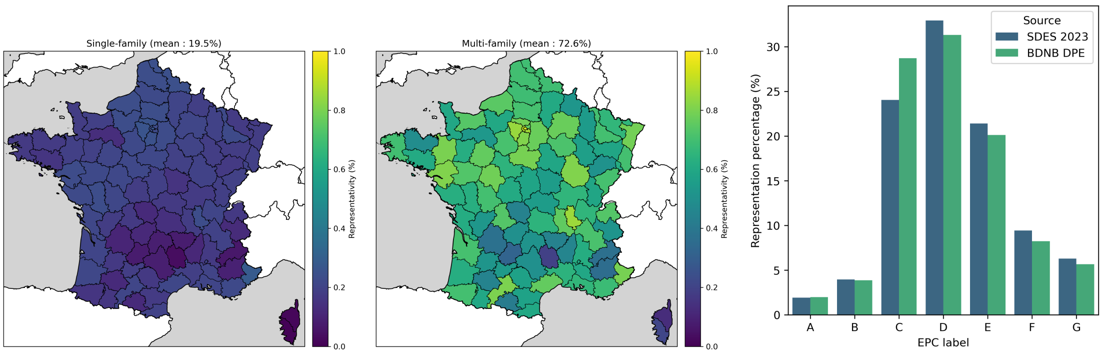


Figure 4: Representativeness of EPC data in terms of number of dwellings and in energy performance labels.

(left to right) Representativeness maps for single-family homes (SFH + TH) and multi-family homes (MFH + AB), and comparison of the distribution of energy performance labels in France (ONRE 2022b) and in the BDNB database. Data from the BDNB (CSTB 2024), version 2023-11-a, aggregating data from the DPE database and the property database (ADEME 2024, CEREMA 2024).

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