A design process for a resident-oriented, sufficiency-based energy renovation approach for dwellings

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KNOWLEDGE IN ACTION
FACULTEIT
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Energy efficiency of buildings

- Energy efficiency (EE) is considered a key measure against climate change

- Definition of energy efficiency (EPBD)

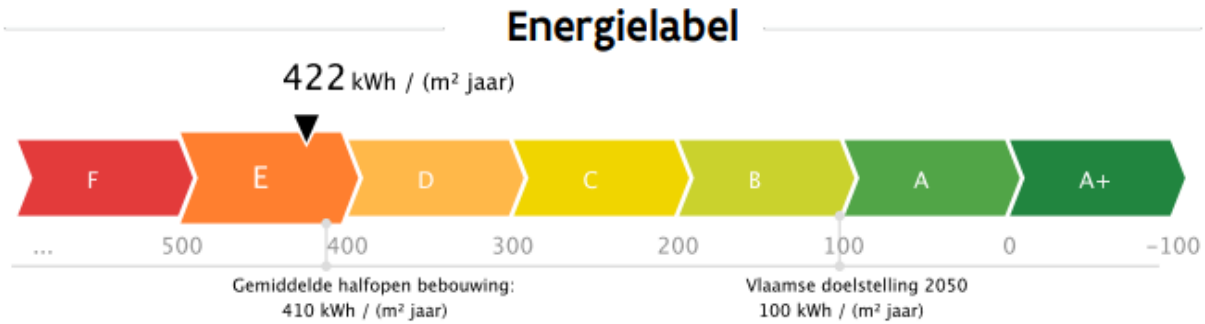
  = ratio of output of performance, service, good or energy to input of energy

  e.g. energy service = heating a building → in an EE building, heating requires less energy input

  Aim = more service for same input or less input for same service

Focus = energy input, not the energy service

e.g. Flemish Renovation Pact: all residential buildings <100kWh/m² by 2050



Energy efficiency of buildings

Focus = energy input, not the energy service

- 3 characteristics of EE jeopardize effective energy savings

1. **Relative scale** (kWh/m² floor area):
   Energy labels compare buildings on EE and neglect impact of building size on absolute consumption

2. **Standardised norms for thermal comfort**
   Acclimatisation systems are typically designed to provide thermal comfort in rooms as a whole, regardless of the effective space use

3. **Abstraction of social context**
   EE designs often overlook residents' actual and dynamic everyday behaviour
   Designers expect residents to behave rationally and according to how the design is intended

Energy sufficiency

- Growing call to implement energy sufficiency (ES)

  not to replace, but **to supplement energy efficiency**

- Focus = energy service

  Energy sufficiency **rethinks quantity and/or quality of an energy service** in a way that a provided service is 'enough' whilst also avoiding 'too much' of a service

  "Living comfortably within the limits" (ENOUGH)

Interested in more information on (energy) sufficiency?

Energy Sufficiency website (by eceee) https://www.energysufficiency.org/
New wiki-page https://en.wikipedia.org/wiki/Eco-sufficiency
Join the ENOUGH research network (contact network coordinator edouard.toulouse@netcourrier.com)

3 types of energy sufficiency interventions

1. Reduction of quantity/quality of energy service

   = **quantitative reduction in needs** or in the demand of energy to provide the needs

   - lower indoor temperatures
   - less space: smaller living area

2. Adjustment of quantity/quality of energy service

   = **adjustment of the energy service to the actual needs** to avoid waste

   - smart radiator valves that adjust the heating to the occupation of space
   - flexible spaces on dwelling-level and on room-level

3. Substitution of quantity/quality of energy service

   = **different transformation of basic needs** into energy needs

   - using a washing line instead of a cloth dryer
   - sharing spaces: more communal and less private spaces

Problem statement

- **Current energy policy**:
  - New houses have to meet **energy efficiency standards**
  - Energy labels for existing houses express energy performance as efficiency (consumption /m²), not sufficiency (overall consumption)
  - Policy campaigns to convince home owners to renovate their house in an energy efficient way.

- **Current reality**:
  - In **old, large, under-used dwellings**, residents already tend to adopt an **energy-sufficient attitude** because of high energy costs
    - Heating only some rooms
    - Migrating within the house along the seasons
    - Making large rooms smaller
  - In old houses residents tend to **consume less energy than calculated** (prebound effect)
  - **After typical EE renovation**, risk that residents are nudged to acclimatise the whole house because of lower energy costs (rebound effect)

Research focus

Considering the **high use of resources** (costs, materials) in EE renovation of large, under-used houses, is there **no alternative renovation approach** to reduce the actual energy consumption?

Research methodology

- Case study of 3 large, under-used houses
  (residents eager to participate, struggling with the same questions)

- In depth study of dynamic residents' behaviour and comfort experiences throughout the seasons
  - Semi-structured interviews, guided tours, photographic journals
  - Coding and visualisation of residents' behaviour and experiences
  - Mapping (inter)actions, including energy sufficiency interventions by the resident

- How to design for energy sufficiency?
- How to support designers towards designing for energy sufficiency?

Residents' interaction with the dwelling in an energy-related context

BEHAVIOUR-RELATED FACTORS

Actions

- Actions on building components
  - Use of doors
  - Use of blinds
  - Use of windows
- Actions on heating installations
  - Use of thermostat (mobile or not)
  - Use of radiator valves
  - Use of electrical (mobile) devices
- Alternative actions
  - Migration
  - Use of textile (blankets, clothing)
  - Activities (cooking, showering)

Occupancy

- Duration
  - Long, short, medium
- Frequency
  - Often, not often, medium
- Rate
  - Number
- Mode
  - Active, passive
- Activity
  - Leisure, work, home-life, personal care

COMFORT-RELATED FACTORS

Type of comfort

- Functional comfort
  - Effortless in use: maintenance, access, circulation
  - Amount of space
  - Malfunction, presence, absence of product/service
  - Design of products/spaces
  - Flexibility in use
- Physical comfort
  - Visual
  - Thermal
  - Acoustic
  - Air quality
- Psychological comfort
  - Restfulness
  - Cosiness
  - Privacy and connectedness
  - Aesthetics
  - Openness

Level of comfort

- Negative
- Positive
- Neutral

Subjective comfort

- Perception
- Priorities
- Preferences

Residents' interaction with the dwelling in an energy-related context

ENVIRONMENT-RELATED FACTORS

Built factors

- Constructive elements
  - Floors
  - Elevations
  - Ceilings
  - Walls
- Infrastructure
  - Technical systems (HVAC, sanitary, other electrical appliances)
  - Structural (stairs, others)
  - Components (blinds, doors, windows)
- Materials
  - Wood, glass, carpet….
- Interior design objects
  - Vases, picture frames, candles…
- Furniture
  - Chairs, tables, bed….

Spatial factors

- Connection between spaces
  - Physical
  - Functional
  - Climatic
- Dimensions of spaces
  - Width
  - Length
  - Height

Natural factors

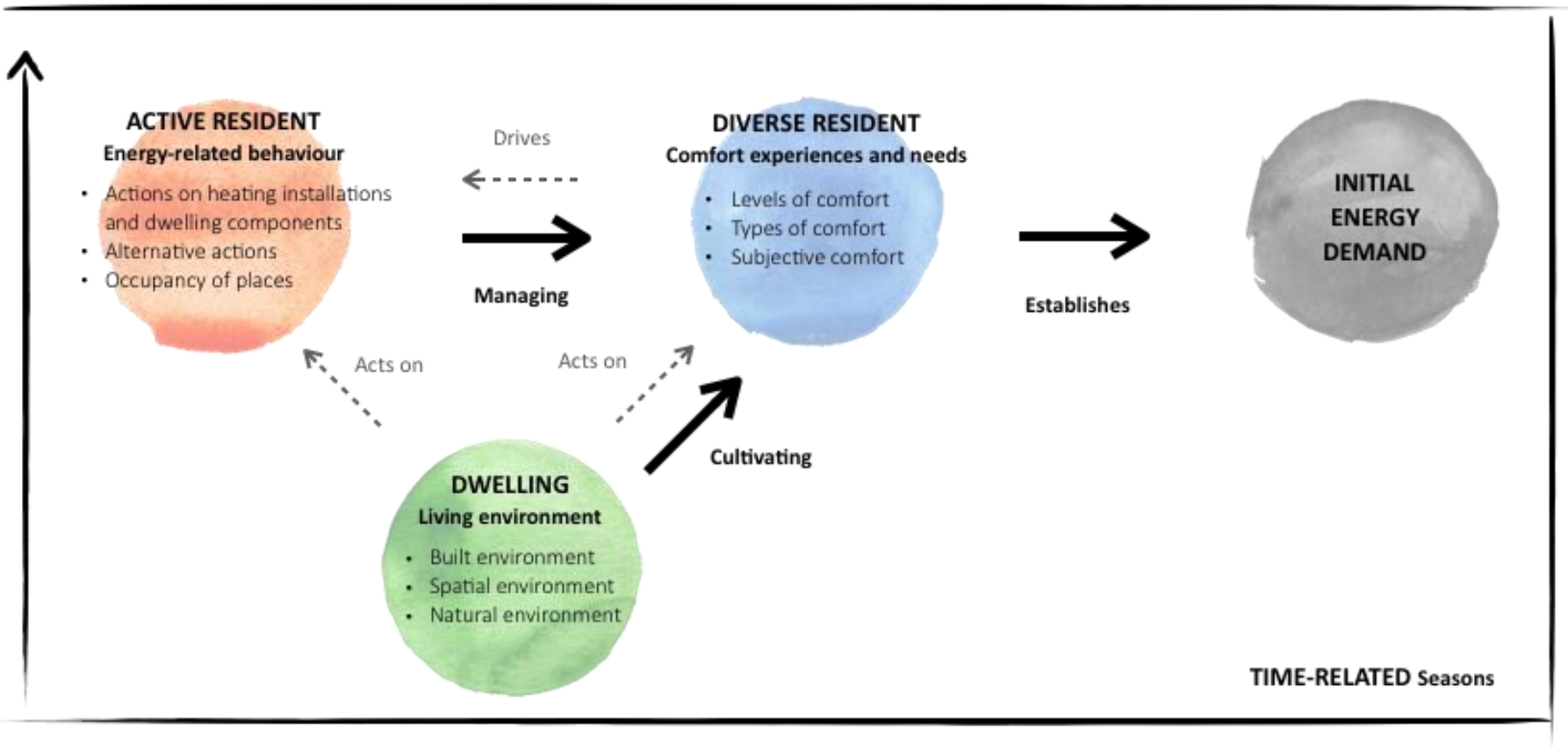
- Vegetation
  - Greenery
- Climatic
  - Warmth
  - Draughts
  - Humidity
  - Daylight

TIME-RELATED FACTORS

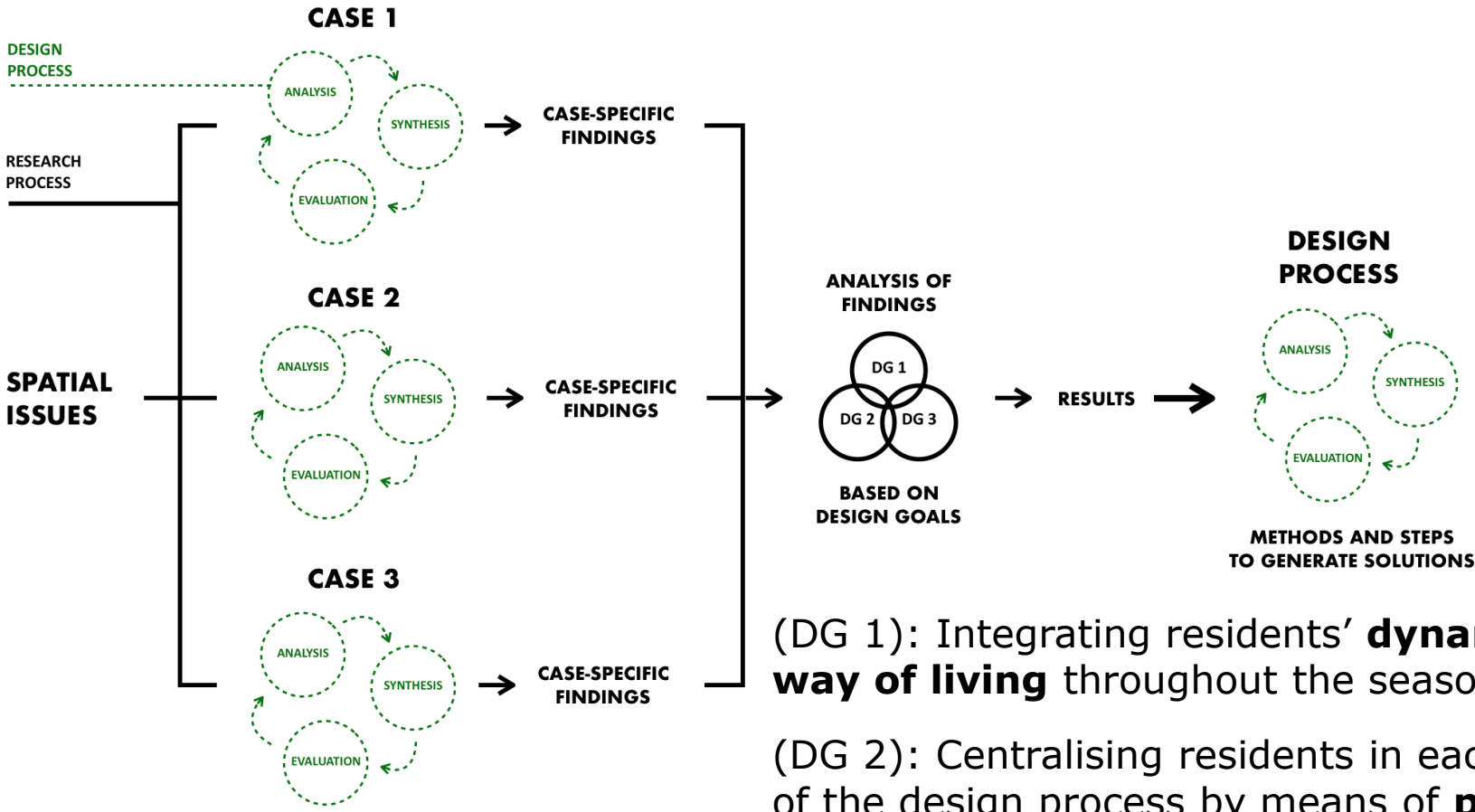
Periods

- Winter
  - Day (Morning, day, evening, night)
  - Week (Weekday, weekend)
- Spring
  - Day (Morning, day, evening, night)
  - Week (Weekday, weekend)
- Summer
  - Day (Morning, day, evening, night)
  - Week (Weekday, weekend)
- Autumn
  - Day (Morning, day, evening, night)
  - Week (Weekday, weekend)

Relation between residents and energy needs



Research by design exploration of ES renovation



(DG 1): Integrating residents' **dynamic way of living** throughout the seasons

(DG 2): Centralising residents in each phase of the design process by means of **place-making**

(DG 3): Increasing ES of spaces and stimulating a more ES way of living by means of the **three ES-interventions**

Designing for place-making and energy sufficiency

Places exist through the eye/experience of the resident.

Dwelling = collection of places and non-places

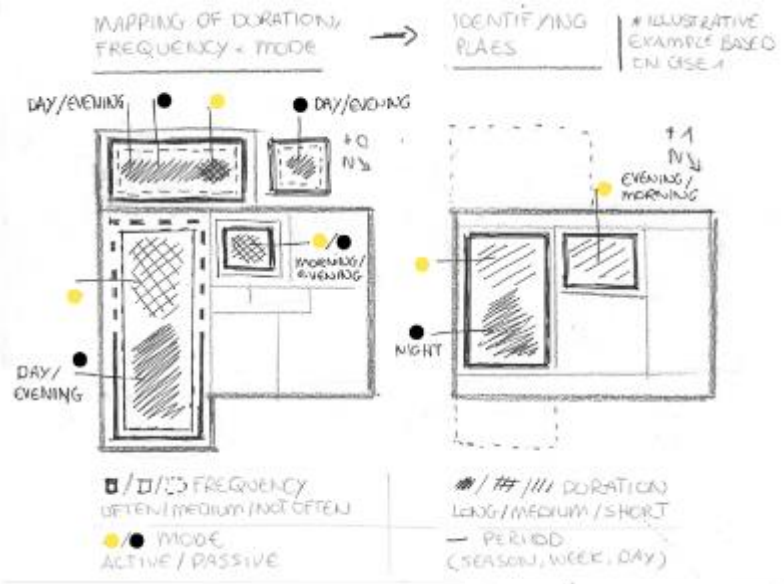
1. Analysis:

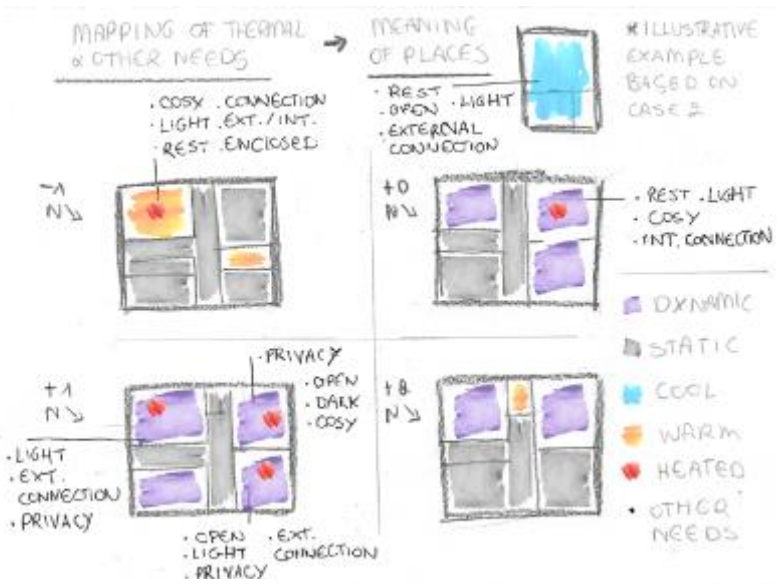
Identifying places and identifying opportunities for energy sufficiency

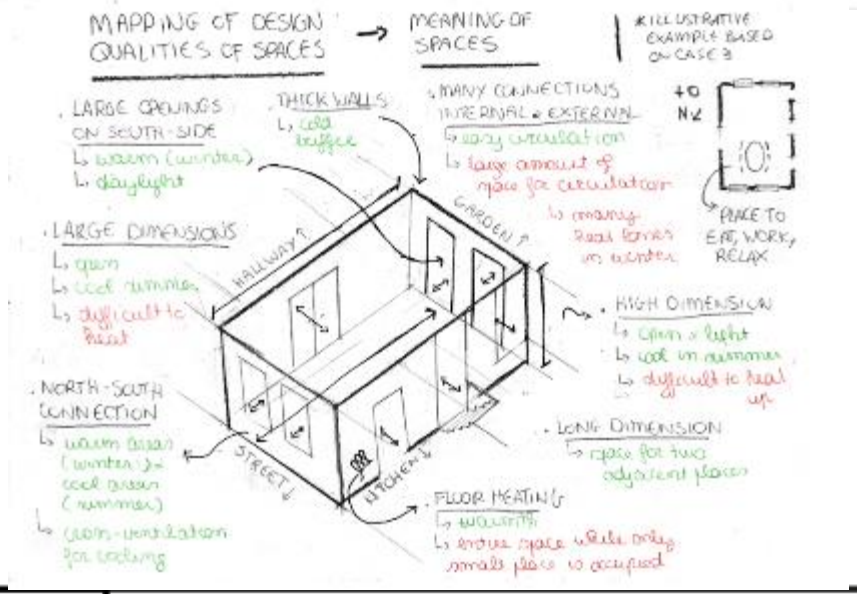
1. analysis of residents' behaviour, comfort experiences and interaction with dwelling
2. analysis of space

Via semi-structured ***interviews*** of the occupants + ***2D- and 3D-mapping***

Designing for place-making and energy sufficiency



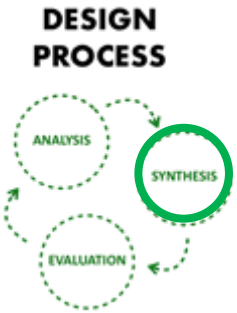




Designing for place-making and energy sufficiency

2. Synthesis:

1. Conceptual design - **grouping of places**



GROUPING OF PLACES * MATRIX

* ILLUSTRATIVE EXAMPLE BASED ON CASE 2

PLACE TO...

REQUIREMENTS / PROPERTIES / REQUIREMENTS	WINTER / SUMMER	COOK, EAT & REST	REST & RELAX	WORK	SLEEP	WORK	...
→	THERMAL	WARM / COOL	WARM / COOL	WARM	WARM / COOL	WARM / COOL	
PROPERTIES	FREQUENCY	OFTEN	OFTEN / NOT OFTEN	OFTEN	OFTEN	OFTEN / MEDIUM	
PROPERTIES	DURATION	LONG	MEDIUM	LONG	LONG	LONG / MEDIUM	
PROPERTIES	PERIOD	MORNING, EVENING, DAY	EVENING	DAY, EVENING	NIGHT, EVENING	EVENING	
→	OTHER TYPES	· EXTERNAL CONNECTION · LIGHT · ENCLOSED	· LIGHT · INTERNAL CONNECTION	· LIGHT · EXTERNAL CONNECTION · INTERNAL SEPARATION	· INTERNAL SEPARATION · OPEN · DARK	· LIGHT · EXTERNAL CONNECTION · INTERNAL SEPARATION	

SOCIAL PLACES

PERSONAL PLACES

(FOR INSTANCE) GROUP ACCORDING TO 'PERIOD'

OR ACCORDING TO DURATION / FREQUENCY / THERMAL / OTHER TYPES

GROUP FOLLOWING ORGANISATIONAL PRINCIPLES :

GROUP A

- PLACE TO COOK, EAT, REST
- PLACE TO WORK

GROUP B

- PLACE TO REST
- PLACE TO WORK
- PLACE TO SLEEP

LINEAIR + PERIOD

CENTRAL + WARM

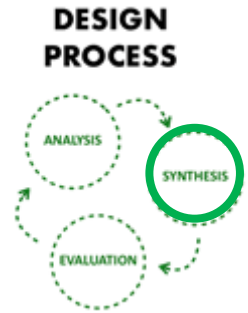
DECENTRAL + LIGHT

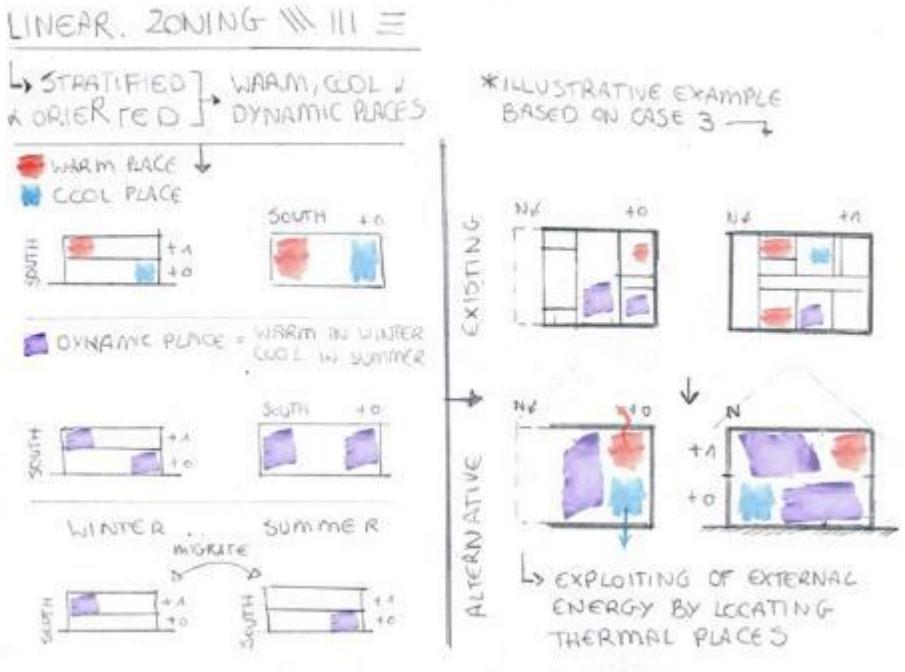
CLUSER + FREQUENCY

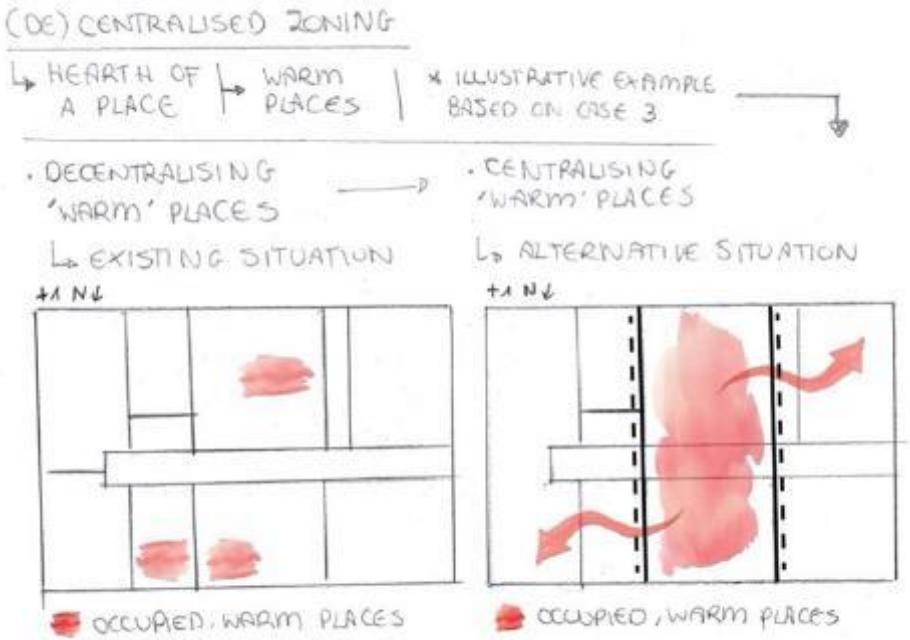
Designing for place-making and energy sufficiency

2. Synthesis:

2. Preliminary design – **zoning places**



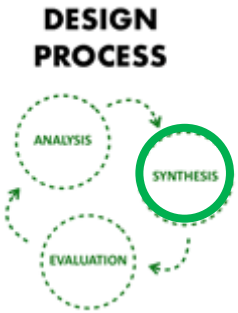


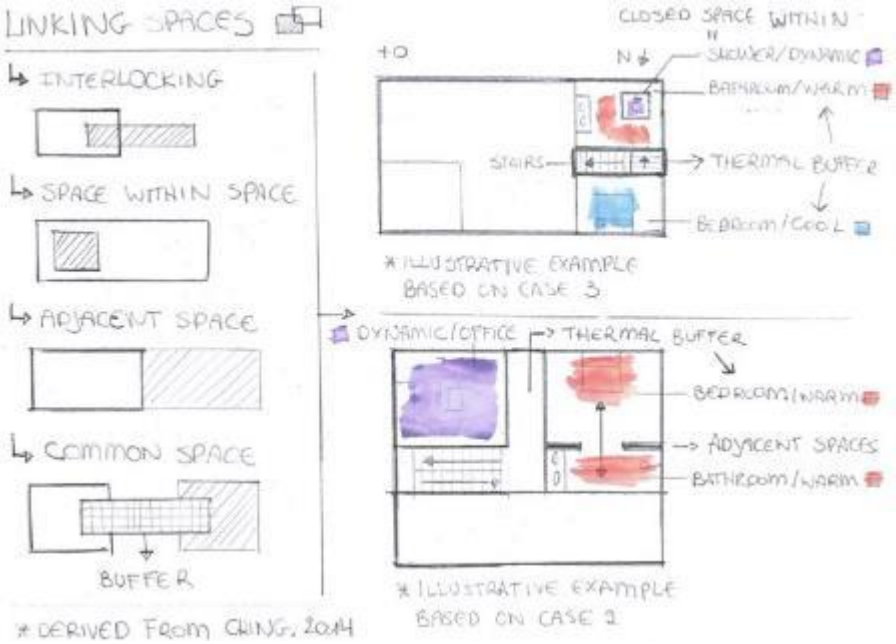


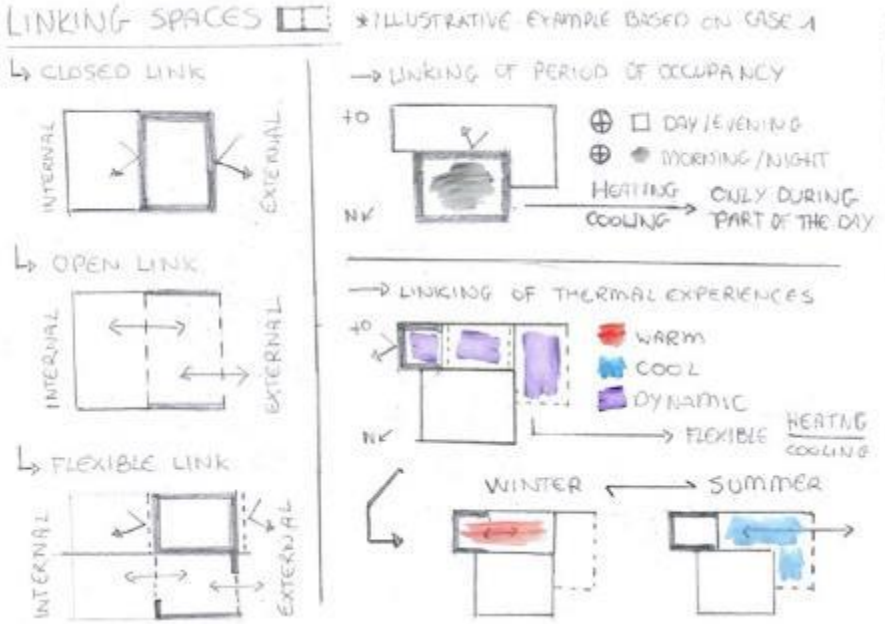
Designing for place-making and energy sufficiency

2. Synthesis:

2. Preliminary design – **linking spaces**



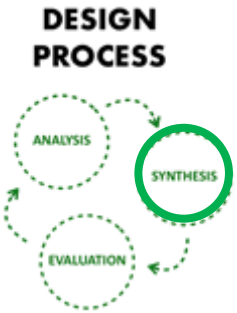


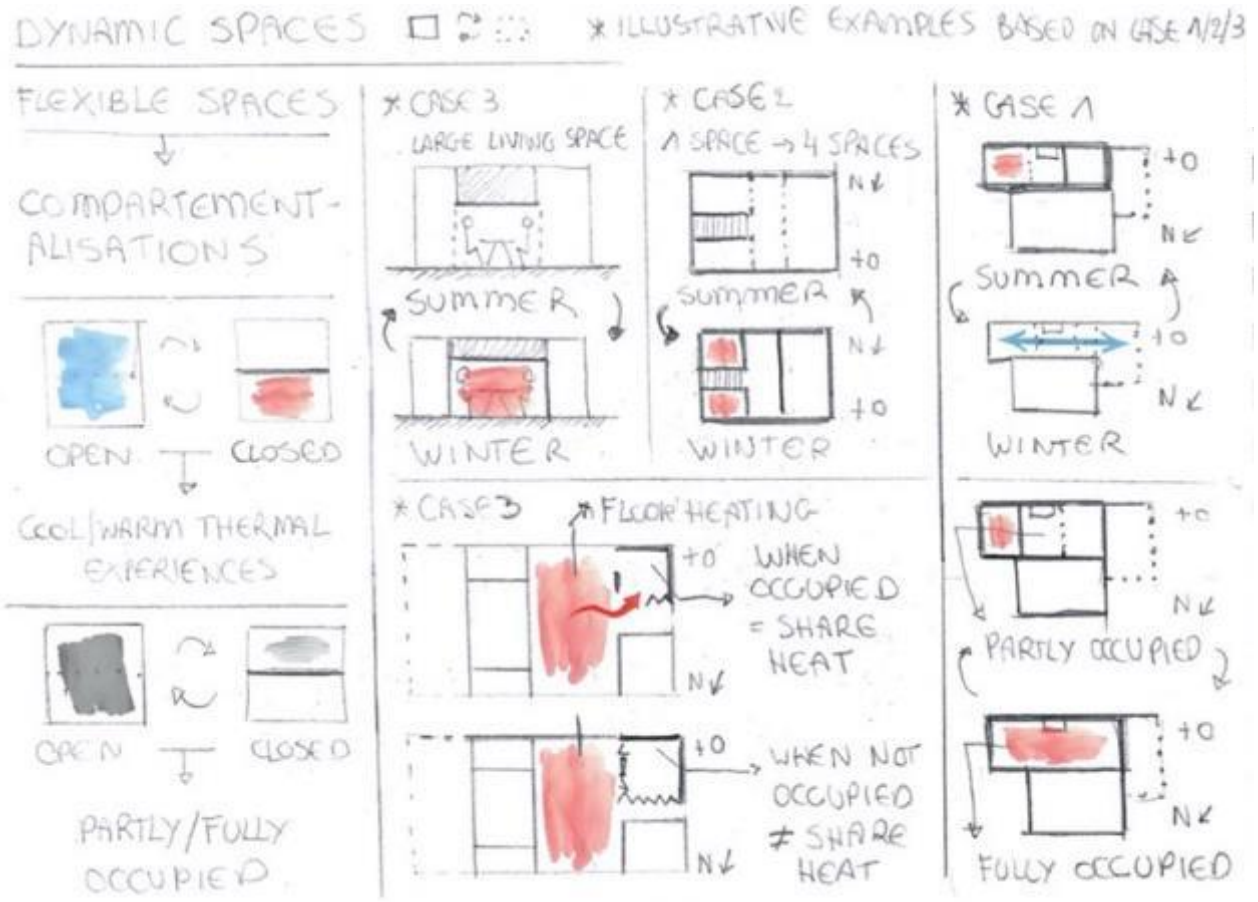


Designing for place-making and energy sufficiency

2. Synthesis:

3. Detailed design – **creating dynamic spaces**





Designing for place-making and energy sufficiency

3. Evaluation = qualitative

Based upon 2 design criteria and 2 boundary conditions

Design criterion 1: The design intervention limits the energy demand compared to the existing situation and/or a design based on an object-centred approach

1. Does the design intervention lead to heating/cooling of a smaller space (volume)?
2. Does the design intervention lead to heating/cooling a space less often?

Design criterion 2: The design intervention limits the use of active HVAC-installations compared to the existing situation and/or a design based on an object-centred approach

1. Does the design intervention cultivate a warm/cool thermal experience by harvesting internal/external passive energy flows?
2. Does the design intervention cultivate a warm/cool thermal experience by limiting actively gained energy flows?

Designing for place-making and energy sufficiency

3. Evaluation = qualitative

Based upon 2 design criteria and 2 boundary conditions

Boundary condition 1: The design intervention avoids thermal discomfort and possible other types of discomfort

Does the design intervention cultivate a (thermal) experience of comfort that aligns with the residents' individual needs in that place in summer as well as in winter?

Boundary condition 2: The design intervention avoids inducing inefficient behaviour that counteracts the increased sufficiency.

Does the design intervention avoid stimulating energy-related actions that bring forth unneeded energy losses and/or gains?

Conclusions

Different concepts

energy efficiency	↔	energy sufficiency
↓		↓
product		process & practice
energy efficient <u>house</u>	↔	energy sufficient <u>dwelling</u> (=act)

Different design approach

object-centered	↔	resident-oriented
apply list of EE measures		place-making (= identifying existing places and creating new ones)

Place-making = starting point for design oriented to the resident.
ES by making *places* comfortable instead of rooms and buildings

Source: Bosserez Ann, An alternative design approach for energy sufficiency in dwellings, PhD thesis (defense in Dec ‘20)

Object-centered design versus resident-oriented design

- Architects are trained in object-centered design
  - Design the building as a whole
  - Optimisation of building skin and building systems for energy efficiency

- Strong need for design supportive instruments to switch to resident-oriented design
  - Place-making = designing, starting from the meaning of places;
  - Meaning of places are always related to resident
  - Design enabling a dynamic way of living throughout the seasons
    - Development of design tools to get to know the places
    - Climate-responsive design
    - Building with adaptive ability
    - User-centered design / placemaking

Questions?

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