# Assessing energy demand in self-managed clustered housing

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## Abstract

Co-housing is the overall term for groups of households creating and managing their own living environment. From recent research on co-housing in EU member states it becomes clear that co-housing initiatives consider themselves as pioneers for energy-transition. Nevertheless, the value and contribution of co-housing initiatives to housing provision and sustainable urban development, both quantitative and qualitatively, have hardly been assessed. Fitting the design features of co-housing buildings into energy-performance calculation models already poses some problems. In addition, everyday practices such as sharing domestic services make energy-demand in co-housing (potentially) different from single-household residence. This paper first presents an inventory of key-elements illustrated by Dutch co-housing projects. On this basis it proposes a model for energy performance assessment that goes beyond the building-related normatised EP-models.

## Keywords:

co-housing, self-management, energy-saving, shared utilities, energy performance assessment

## Introduction

The incentive for this research was sparked by the combination of two contemporary developments in Europe: on the one hand the transition towards renewable energy-sources that need decentralised, flexible grids; on the other the increase of grass-root initiatives for collaborative housing clusters (co-housing). From the point of view of spatial planning, the question arises how spatial development patterns of the future can match decentralised supply to decentralised demand (and increasingly also supply)? How many units, for example, is the optimal cluster size? Which design criteria for the urban layout of the cluster influence the energy-demand? Such questions can not be answered at present, because there is insufficient insight in the energy-flows of the new typology of co-housing.

Compared to the conventional ways of housing provision, and to single-family units, sharing the building volume and managing the buildings' utilities holds extra opportunities to optimize the energy-household, for example: creating critical mass to enable investments, organise collective learning or divide tasks in managing and monitoring. The following paper endeavours a mapping of energy-demand in collaborative housing projects, as a first step toward energy-optimised urban design. This paper focuses on the energy-demand related to the specific built form and the patterns of living in co-housing. It is based on field-studies in different generations of Dutch co-housing projects, gathering information on grass-root initiatives through interviews as well as participative research. Energy-related information in projects was found in the technical briefings for the building stage, and verified during visits. Seminars, handbooks and other publications by co-housing networks provided a wider perspective[1]. To date, only a small number of scholars have studied energy-demand in co-housing, hence the academic literature is concise.

After introducing the main features of co-housing, the paper outlines first an approach that we developed to identify the specific aspects that affect energy performance in co-housing differently from standard housing [Tummers & van den Dobbelsteen, forthcoming]. It then applies the approach on different generations of co-housing in the Netherlands, creating a profile of energy-demand within the projects. Thirdly it presents the benefits and bottlenecks of collective energy engineering as in the design, management and maintenance of co-housing. The outcome of the research explains how that the reduction of energy-demand and the application of renewable sources can be mapped as a direct result of the social architecture of co-housing. The conclusions argue that reduction of energy demand can only be successful when the self-management aspects are taken into account both during design and engineering phases.

## What is co-housing?

All over Europe, both east and west, groups of people take initiatives to collectively build and maintain their accommodation [Wohnbund 2015, Krokfors 2012]. Co-housing initiatives address the fundamental issues of sustainability: climate change, independence of imported fossil energy, and supporting the transition to a circular economy [Tummers 2015]. In general, co-housing residents accept some impact on lifestyle, consumption patterns and mobility (car-sharing, integrating work-home). More importantly: they actively seek such changes, and the co-housing project is just one of the ways to achieve this. Through realising co-housing projects, residents move away from being 'consumer' and become active as '(co-) producers' of housing, but also of daily services such as childcare, catering and laundry together with alternative forms of management [Jarvis 2011]. Pooling resources makes it possible for co-housing residents to apply renewable energies, waste and water recycling within the project. Some projects show how direct management by residents can lead to sustainable solutions as well as financial benefit, which is re-invested in the cooperative. Such experiments can be classified as 'grassroots innovations' [Seyfang 2008].

[1] see for example Locatelli et al 2011 ; Chatterton 2015

Co-housing is raising interest as innovator of housing and sustainable environmental technology [Tummers 2015]. Co-housing residents are receptive to innovations in renewable energies and apply ecological materials as well as waste- and water recycling together with alternative forms of management[2]. Through co-housing practices residents move from being 'consumer' to '(co-) producers', of housing, care, energy, services and so on. From recent research on co-housing in EU member states as well as field studies in the Netherlands, Belgium, France, Germany, Spain and the UK, it becomes clear that co-housing initiatives consider themselves as pioneers for energy-transition. Nevertheless, the value and contribution of co-housing initiatives to housing provision and sustainable urban development, both quantitative and qualitatively, have hardly been assessed. Nor is there any insight in questions such as: what are optimal dimensions for a co-housing cluster from an energetic point of view? What is the influence of location choice on the energy performance of a project? In how far are clustering and layout really based on energy- and environmental ambitions?

The change of roles to upon starting a co-housing project has profound implications: the former 'consumers' (of market housing) or 'beneficiaries' (of subsidised or special-needs housing) become commissioners and producers of housing, energy and services. The 'rationale' of energy production is very different from the 'rationale' of energy usage [see for example: Gram-Hanssen, 2014; Ingle et al, 2014]. Collective housing initiatives intending to become '*prosumers*' need to bridge this gap and harmonize both rationales. Two factors stand out: the ambitions are generally higher than mainstream housing or legal demands of the same period; and more often than not the ambitions can not be realised fully. As in all housing types, the quality of the design depends on the expertise of professionals, who need to interpret the clients' wishes. In co-housing, design and engineering is decided in intensive interaction with the inhabitants, who act as the direct client. Moreover, they may find regulations for energy suppliers in their way. Some recent studies indicate that co-housing initiatives have great potential but meet difficulties realising them fully under existing planning conditions [Baborska et al 2014; Chatterton 2014; Seyfang 2008].

## What is different from mainstream housing, with respect to energy?

To date, few publications on co-housing research that address energy-issues explicitly [see reference list]. However fieldwork suggests multiple ways how energy consumption in co-housing differs from average single-unit housing models [Tummers 2013]. Given the different spatial model, Co-housing does not fit in vigilant EP calculation models, which are based on single-household units. Looking primarily at the demand side, a number of factors stand out:

First, literature on co-housing has looked at the benefits of sharing resources such as laundry installations, meals, play or meeting rooms, or other facilities [Kido 2011, Stevenson et al. 2013]. Potentially this can save energy depending on whether the shared spaces are seen as 'extra' or as a matter of efficiency and every-day practice. One project for example has a small room for music-rehearsal, with soundproof insulation, that is used a few times a week. It does not need heating, and ventilation takes place between uses. Another project includes a large room equipped for yoga practice, which is open for the neighbourhood and separate from the residential units. With the

[2] see for example: www.ecohabitatgroupe.fr ; http://ecodorpennetwerk.nl ; www.balticecovillages.eu/ ; www.samenhuizen.be

same intensity of use as the music room, this facility requires heating and cooling because of the type of use as well as the build structure. The spontaneous use of common living rooms depends also on the level of comfort [Stevenson et al, 2015]. The common-house-fire burning might invite residents to join in but could also be wasting its fuel. On the other hand, if the contemporary home-fire is understood as an XL-screen home-cinema, in co-housing one projector could replace that of 10 to 40 households running parallel.

Secondly, the collective design and operation process could imply learning processes. This may not always happen, but some Dutch case-studies do show a marked difference with subsidized mainstream experiments in this respect. It is one of the topics around which national co-housing networks provide the most information. Collective learning and adapted behaviour influence are preconditions to make the hardware function optimally, and thus influence the real performance. A Leeds based co-housing project Lilac, for example, encourages residents to use the launderette during day-time so the washing machines run on self-generated (PV) power [Chatterton 2015:120]. This does not necessarily reduce demand in kWh, but it does reduce the costs of energy. While in this project there was a common understanding of the need to save energy and the wish to apply renewable energies, however different levels of understanding the energy-related equipment. [Baborska et al, 2014].

Thirdly, the design and engineering of the buildings have a large impact on the ecological and energetic footprint of housing. Typical for co-housing is a strong involvement of (future) residents and ambitious environmental claims. The consequent generations of co-housing articulate the energy-standard they are striving for in different ways, while On many occasions, the residents association operates in a formal partnership, which makes the energy-related design choices also dependent on how they are able to negotiate with institutional partners. The Dutch cases show that institutional partners such as housing associations and building firms may not be willing or able to experiment. Due to the 'split-incentive' they are less prone to pre-invest in order to reduce energy-costs during the life-span of the project. One early (1989) project in Haarlem for example, did not convince the partner Housing Association to apply energy-saving design principles, although the project is located in an urban extension under sustainability regime and the residents association hired its own experts to make concrete proposals [interviews and minutes of planning process, 2012]. On the other hand, the first co-housing project in Zwolle (1995) cooperated with a housing associate that was open to innovation. The partnership obtained subsidies to experiment with (then) new solar panels. The homeowners discovered through monitoring that the technology was not functioning properly, and together the problem was resolved.

Fourthly, co-housing initiators remain in the lead during the whole lifespan of the project, not only as tenants or dwellers, but also in the management, administration and maintenance. This would enable them to influence the energy consumption not only by behaviour, but also by the choice of technology and sources, keeping up with new development or even own inventions. Those projects that have been built around 25-30 years ago, now face the need to renew the engineering components. Again the partnership with institutional housing associations can be problematic; an Eindhoven project for example saw its collective heat-pump replaced with conventional gas-heating but the reason why the change of source was decided is not clear to the residents association.

Finally, co-housing projects articulate their ecological or energetic ambitions in an integrated, or holistic way, that fluctuate over generations [see for example Palojärvi et al. 2013, Locatelli et al, 2011]. Since the 1980s, concepts have evolved from 'save the planet' via 'reduce our footprint' and 'low-carbon settlements' to the care for health and future generations. The ambition is to reduce energy demand, but also to apply clean and renewable resources. And beside the direct use of energy, the indirect energy in the production of materials and water is considered, often installing recycling mechanisms. Low CO2 is not only a standard for design and construction; its use and management is also taken into consideration. Managers and inhabitants are the same entity, therefor the 'split-incentive' principle does not apply. Co-housing may also affect the energy demand for mobility, for example by integrating proximity services or employment, and by sharing means of transport or combining trips. This aspect of demand is significant, and should not be ignored when the overall footprint of projects is established. But there are limitations to the possibilities for self-decision, especially the choice of location is subject to local land-market ; its property-structure and prices.

## An approach to assess energy-demand and performance in co-housing

The different aspects that connect co-housing and energy-transition can thus be grouped in in five categories: sharing, learning, designing, engineering and managing. When these are crossed with the main energy flows: demand, production and transport (losses), a co-housing specific 'energy-profile' can be constructed: see table 1. The emphasis varies for each project, and as a consequence the weight of each aspect will differ. Once all the aspects have been assessed it becomes clear which way the energy-balance goes.

Table 1: Co-housing and Energy [source: Tummers, 2015]

| *TABLE 1: Co-housing and energy Potential* | | *L. Tummers* | | *December 2015* |
|---|---|---|---|---|
| VARIABLES | **Energy-demand** | **Energy-production** | **Exergy**<br>**(reduce losses/**<br>**optimise flowes)** | **Overall CO2 balance** |
| **Sharing resources** | Community rooms; laundry, tools, transport (car-sharing) | On-site water purification; solar, e-car loading point, heat storage | Reduce pipe length & assets when replacing indiv; professional equip,ment for common rooms | Depends on intensity of community-life; Joined Investment capacity |
| **Learning process** | Collective setting of comfort standards; joined design process; Behaviour/peer pressure; | joined design process; benchmarking and feedback<br><br>Pioneers/early adaptors : | knowledge exchange on operational matters | High Footprint awareness;; formal and informal feedback, out-reaching educational activities. Being the first matters |

| | | | | |
|---|---|---|---|---|
| **Design** | Dimension/ Efficiency Buffer-zones/ semi-collective spaces; choices may be negotiated with institutional partner | Cluster orientation | Clustering for reduced external surface and transport losses; choice of location | User-perspective and Urban insertion (mobility) |
| **Engineering** | System choices may be negotiated with institutional partner; build form, surface, shell-proportion | Geo-thermal; WKK; collective solar | Compact internal circuits (eg hot tap water or heating); cascading /Storage | integrating Energy-concept (Insulation & heat & ventilation) |
| **Self-management** | Monitoring Billing system | Decisions on investments & benefit return system | Peak-shaving | critical mass as client; Available expertise? (advisors) |

## Energy-demand and supply in three Dutch co-housing projects

For the comparability of results, the co-housing projects selected for this study are all located in comparable geographic situation; urban extensions of medium towns in the Netherlands. They were realised during different generations, corresponding to energy/sustainability policy-eras in the Netherlands. Initially, o-housing projects in the period of introduction of concepts of sustainability and the need for reduction of CO2 and fossil fuel had difficulties realising their environmental ambitions due to lack of knowledge, incomplete information and non-acceptance. When instruments such as LCA, EP, financial incentives, handbooks became available, co-housing intiatives were amongst the first to benefit, the Zutphen project illustrates. The credit crunch brought stagnation to the Dutch building sector between 2007-2012. Nevertheless, the second-generation project in Zwolle), realised an EPC score about half the then vigilant norm. A society-wide 'energy-agreement signed in 2013 [SER 2013] renewed interest in civil initiatives. An initiative for ecological housing in Nijmegen, realised a cluster of social rental units in straw-bale construction and without connection to the natural gas-network, an exception for housing in the Netherlands.

### Project 'Green common' [3], ZUPTHEN

In Zutphen, a group of households seeking a sustainable life-style, already formed in 1991, applied for a location in the municipality's VINEX plan. The project was delivered in 1996 with fifty residential units and units built around a "Green Common" of about 4000 m2. To realise a mixed-tenure structure, including 25% low/medium rental, the cooperative collaborated with a housing association (HA), which delivered professional services such as financial administration, and supervision on the building works. The HA also acted as formal client for the contractor, but the residents elaborated the design and technical brief with a local architect highly motivated to implement the then new insights of sustainability. The initiators describe the decisions on energy and sustainability as 'random':

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[3] http://www.middenhuis.nl/vwz.html

> *"Most of the sustainable building ideas came from the architect. We had both social and ecological aims. We were very motivated, because of the situation in society. We also had members who were very well informed. We choose what we know and felt affinity with. We wanted breathing houses and no toxic radiation" [interview 27-2-2012].*

The architect classified the concept as rather 'eclectic'. He wrote the briefings himself: one standard (following the HA) and a second with a consultant with 'sustainability measures' as add-ons. The contractors had to make two cost-estimates, standard and environmental. "This was very difficult for the calculators, but we negotiated good prices in the end." Nevertheless, the rental apartments are equipped with the Housing association standard whereas home-owners had options to (self-)install wall-heating and solar panels. Currently, the residents association is considering installing a heat-pump to replace the gas-heating for the common house.

### Second 'people and planet friendly' project (MMWZ2)[4], ZWOLLE

Candidates on the waiting list of a co-housing project In Zwolle took the initiative for MMWZ2, in 2001. The residents' collective establishes partnership with the local housing association (HA), the local housing association (HA) and an architectural firm specialised in sustainability. Situated in an urban extension, the project was completed in 2008 including 53 housing units, small business, meeting rooms and common bicycle shed. The energy concept is based on 'high insulation rather than complex technology'. The innovation was therefor sought in wood construction with high insulation, using new products such as cellulose; *Pavatex* panels and insulated wooden window-frames, imported and adapted from Scandinavian model and applied for the first time in NL. The flats are however provided with conventional heating system (Dutch standard at the time): individual gas heater with radiators, dimensioned at 80/60 degrees (Utilities specification 2006). Vegetation roofs were desired, but not permitted because the urban plan specified that the neighbourhood had to look 'like the 1930s'. The residents planned to harvest rainwater but were told this would have little environmental benefit, because of the cities' infiltration system. The average EPC score was 0.65 at a time when the norm was still about twice as high (1,2).

### initiative for ecological housing[5], NIJMEGEN

The Initiative Ecological Housing (IEH) is part of an urban extension of Nijmegen Noord that since 2008 has become a pioneering field for self-building. IEH created partnership with the local HA but also involved *Woningbouwvereniging Gelderland* (WBVG[67]), the municipality Nijmegen as well as the Provincial authority of Gelderland. The initiatve built 24 units with common rooms and services that are inhabited since may 2015. A second smaller building provides working spaces and function rooms. Ecological and energy ambitions were high, hence the choice for clustered building in straw-bale construction with high insulation values. The dwellings are situated to capture sun especially in winter, additional heating is provided with a collective pellet incinerator. Tap-water is heated through heat recovery from ventilation air. There is no connection to the natural gas-network, an exception for housing in the Netherlands. Rainwater is captured in a local reed bed and recycled for toilet flushing. The residents organise monthly tours and workshops for candidate-self builders.

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[4] http://www.meanderhof.nl/

[5] http://www.iewan.nl/bouwontwerp/

[6] WBVG.nl is specialised in self-managing housing collectives

Table 2, overview of energy-profile 'demand side' of case-studies [Tummers 2016]

| *TABLE 2: Dutch Co-housing examples* | | *L. Tummers* | *February 2016* |
|---|---|---|---|
| **demand** | **Groene Marke**<br><br>**(1995, Zutphen)** | **Meander**<br><br>**(2008, Zwolle)** | **IEWAN**<br><br>**(2015, Lent)** |
| **# units, tenure** | 77 units (14 rental plus 3 price-levels of ownership) | 53 units (XX rental plus some workspaces) | 24 rental units (plus workspaces) |
| **Sharing resources** | On-site water purification; Community house; bicycle shed; playground & green common | Community rooms; bicycle shed, playground | Community rooms; laundry On-site water purification; roof terrace; bicycle shed, vegetable garden |
| **Learning process** | Learning from architects' earlier experience. self-constructing Common House based on evaluation of mistakes of home-building | High ambitions by consensus, limitations of regulations. Prioritizing community-building (semi-public spaces) | Self-build, self-operation; outreaching in monthly workshops and tours |
| **Design** | Community building prevailed over environmental criteria. Relatively large share of outer walls. Roof orientation for solar. | Part Cluster part terraced; reduced parking space | Clustered multi-storey; straw-bale self-build Bufferzones/ semi-collective spaces |
| **Engineering** | 'Random' System choices before EPC. Now assessed label A or B. Land available for soil-heat-exchange | 'high insulation prevails over sophisticated equipment' EP=1,2 Individual HR++ heating | Energy-neutral; collective pellet heating; collective solar |
| **Self-management** | Monitoring and Billing system for common house & land, & grey water not energy | Individual for energy matters | Monitoring and Billing system form common spaces |

*Note: Demand is the focus of this conference, supply-side to be added in next step*

## Preliminary conclusions on energy-demand in co-housing

This paper looked at Dutch self-managed housing initiatives to develop a method for integrated and realistic assessment of the energy-performance. In all of the projects the incentive was the lack of low-energy housing on offer. The initiatives set out with high standards, ahead of mainstream housing at the time, and part of pioneering programs subsidized by energy-polices. While these did allow them to apply innovative materials, building with wood (un-usual for the Netherlands) and applying renewable insulation such as cellulose and pressed straw, the engineering is rather conventional in the Green Common and MMWZ2. This is partly due to the institutional partners who preferred individual utilities (together with the individual tenure-contracts). However IEH succeeded in collaborating with institutional partners to create highly experimental housing in an affordable regime, with low energy-demand and renewable sources. All of the residents' associations have accumulated vast knowledge during the design process, which they are now applying for maintenance and operation. The also reach out to share their experiences with other initiatives. In how far "The facilitation of everyday practices can actually help to reduce consumption" remains to be established, since there are no appropriate feedback loops in place yet. [Vlasova et al, 2014]. Nevertheless, the above qualitative analyses indicate that the possibilities that clustered self-managed housing offers are not fully exploited. Some **recommendations** for the design and engineering of co-housing to optimise energy-demand can be made:

Apply technology that is suitable for self-management. This is not to say self-operating: some residents may want to become utility-technicians, but in most cases they are primarily critical consumers. In other words the benefits and drawbacks of applied energy-supply and distribution need to be transparent. Especially important are the options for accessing the regulation mechanisms and finetune climate control in common rooms. This does not only concern comfort, but also a reliable and fair billing system. High-tech solutions may offer more possibilities for example to differentiate the distribution of heat or time electricity-demand, but they are also more vulnerable to disruptions. Low-tech solutions, such as reedbed water-purification can be more resilient, however seemingly easy-to-handle technology may also invite uses without proper instruction that will make it decay faster.

When the capacity-range of technical equipment is brought into the design process, clusters can be dimensioned in such a way that it creates critical mass for investments. For example; how much subsoil heat exchange capacity does the location offer, and how does the investment compare to individual air-based heat-pumps with the number of units projected on the site?

Consider collective learning as an on-going process, starting in the design stages, re-intensifying in the initial phase of occupancy but in permanent need of updating. Using the collective effort for energy-efficiency and peak-shaving is still in an experimental stage. Although turn-over in co-housing projects tends to be low, new residents come in, outsiders may use common rooms and new insights may require new options such as adding solar panels. New choices also can be made at the time of replacing end-of life-span components.

Ultimately, co-housing projects offer 'living labs' for collectively dealing with energy-flows, primarily demand but increasingly also onsite production. The experiences do not only offer opportunities for residents, but also instructive practices for professionals that are waiting to be scaled out. This brings about a dialogue between 'hard' and 'soft' forms of knowledge, forming an interface between technology and social practices. Mars and venus communicating and paving the way to energy-neutral housing.

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