Energy transition and co-housing:

opportunities for collaborative self-management

Ir Lidewij Tummers
Delft University of Technology, Faculty of architecture and the built environment,
Department Urbanism L.c.tummers@tudelft.nl

Paper to be presented at the IASC 2017 Conference, Utrecht (NL) session 11E

Abstract

This research looks at two developments in contemporary Europe: on the one hand the transition towards renewable energy with decentralised sources; on the other the increase of grass-root initiatives for collaborative housing (co-housing). Co-housing is the overall term for groups of households that together manage their living environment. From recent research on co-housing in Europe it becomes clear that most initiatives consider themselves pioneers for energy-transition.

From this combination of trends, the question arises how the design of co-housing can match the decentralised energy flows, in a way that supports collaborative self-management. 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, implement recycling mechanisms, organise collective learning or divide tasks in managing and monitoring. This paper relates the specific built form to the organization of self-governance 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. The conclusions argue that the application of renewable sources can be optimised as a direct result of the social architecture of co-housing. The use of common (shared) utilities and equipment can however only be successful when the self-management aspects are taken into account during design phases.

Keywords

co-housing; self-management; Netherlands; shared utilities; energy transition

Introduction

In 2017, the Dutch government took the historic decision to abandon household natural gas supply, introduced and rapidly implemented since the early 1960s[1]. This political decision implies a radical change in the Dutch national energy system. System changes

[1] Nota de Pous inzake het aardgas, Minister of economic affairs 11 July 1962; Agreement 1963 shareholders: 50% State, 25% Esso, 25% Shell (together: NAM).

form an opportunity to rethink, and probably reset, conventions and make adjustments in the operational elements of the system concerned. This paper proposes an exercise to re-thing the energy-system connecting it to two pan-European developments: on the one hand the transition towards renewable energy with decentralised sources; initiated with the Brundtland report[2], carried further by EU policies and recently confirmed in the Climate Change agreement 2015. On the other the increase of grass-root initiatives for sustainable alternatives, such as transition town, urban agriculture, energy-coops, and collaborative housing (co-housing). In Europe, Co-housing is the overall term for groups of households that increasingly take initiatives collectively to create and manage housing projects as living environments [Tummers, 2015b; Wohnbund, 2015; Krokfors, 2012; Lafond, 2012]. The clusters vary in size between approximately 15-100 units, forming an organisational entity, such as cooperative or Residents' Association (RA). Every households inhabits its own, independent unit, with a large variety of social interaction. Residents-led housing initiatives look for qualities not available on the local housing markets, such as: affordability, mutual care, shared responsibility, child-friendly, healthy and low-impact living environments. In the 20th century, they were generally seen as small-scale experiments. Since the turn of the century, the interest is rising in self-organised housing practices, as promising alternative besides institutional housing provision, with self-management, co-creation and sustainability at its core. From recent research on co-housing in Europe it becomes clear that most initiatives consider themselves pioneers for energy-transition.

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, implement recycling mechanisms, organise collective learning or divide tasks in managing and monitoring. Professional experience[3] indicates that the potential contribution of self-managed co-housing to energy transition, climate change targets and sustainable urban policies is under-utilised. The question arises how the design of co-housing can match these characteristics with decentralised energy flows, in a way that supports collaborative self-management. How many units, for example, is the optimal cluster size? Which criteria for the urban layout influence the energy-demand? What type of engineering is suitable for 'commoning' its maintenance? Such questions can not be answered at present, because there is insufficient insight in the energy-flows of the new typology of co-housing. To date, only a few scholars have studied energy-flows in co-housing. Moreover, as Tine de Moor writes in the Dutch report on the REScoop 20-20-20 project: energy systems are highly technology-dependent[4].

The following paper endeavours a mapping of energy-related features of collaborative housing projects, as a first step toward an alternative domestic energy

[2] 'Our common future' United Nations, 1987: http://www.un-documents.net/our-common-future.pdf

[3] Approximately 20 years as consulting engineer for sustainable building in the Netherlands and working with grass-root initiatives

[4] www.rescoop.eu, published 2015 with ISBN 9789082366617

system based on principles of the commons. The paper argues that incorporating the *technosphere*[5] is necessary to understand the possibilities regarding renewable energy sources and energy efficiency that co-housing may hold and apply them during design and building process. In the present situation, resident-led co-housing projects are mostly seen as incidents or minority interest, and as a consequence there is no continuity of decision-making or institutional support. The different paradigms on which regulations are based, and officials, technicians/engineers operate, cause frictions during the realisation process. For example, housing institutes still seems to know just two categories: the public (state) and the private (market) and the single household unit and individual home-ownership prevail as preferred options. This paper relates the specific built form to the organization of self-governance and the patterns of living in co-housing. It is based on field-studies in different European countries, gathering specifically information on Dutch 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 project visits.

Structure of the paper:

After introducing the technosphere, the paper outlines the Dutch context for self-organisation related to housing and energy. It then gives examples of co-housing, emphasizing aspects that affect energy performance and engineering. The conclusions discuss the benefits and bottlenecks of collective energy engineering as in the design, management and maintenance of co-housing, and how engineers can learn from commons theory.

Connecting to the 'technosphere'

Changing the energy source from fuel to non-fuel does not necessarily involve system change. For example: 'Natural' gas as fuel for cars can be replaced by Biogas without changing its infrastructure of fuel station, and central plants for electricity can remain in operation when the coal-fuelled appliances are transformed to bio-mass-fuelled parts. At the same time, the harvesting of renewable and clean sources such as wind and solar, is characterised by decentralisation and discontinuity of availability. This requires adaptation of grids, usually seen as a technical matter (developing software and new transformation devices for example). Yet the hardware that connects co-housing to the urban metabolism is also dependent on dominant perceptions of engineering [Bueren et al, 2012].

Homes require energy, ever more so, to be comfortable or even useable. Electricity drives the security, lighting and climate system as well as numerous devices such as computers, refrigerators, toasters, microwaves, hairdryers, toys and radio's. Depending on climate, homes need to be heated or cooled for comfort, dehydrated and ventilated. Fire-alarm systems need to be reliable and lamps available at time when there is no daylight. This is possible through the delivery of energy, which requires a device that captures the source or transforms it to home proportions; distributes it over the different rooms according to demand, and connects to appliances that enable its use. A

[5] technosphere = imprint from cultural and technological processes [Veteikis & Jankauskaite, 2008] Redman and Miller, 2015 theorise the technosphere in relation to Earth Stewardship.

heating system for example involves a kettle of some sort, pipes and radiators with switches, thermostats or other to control their output.

Traditionally, technological research, investigating into the 'hardware of housing' concerned the structural and material components of architecture. Comfort standards introduced increasingly sophisticated utilities into the homes. The need for environmental awareness has brought the interaction between housing construction and the engineering of services such as heating and ventilation into focus. Sustainable energy studies are still concerned primarily with supply and technology, for examples designing and monitoring the 'passive house' typology. Finding that technical solutions and calculation models are not optimal indicators, researchers increasingly look at the interface between users and technology. Addressing the impact of behaviour and demographic profiling on energy consumption has amongst others identified the rebound effect [see for example Gram-Hanssen, 2014]. This enhanced attention to the demand side of energy-cycles determined by the complex social practices of households [Shove, 2003]. Most recently, civil mobilisation for energy transition, such as energy co-operations and the Transition Town movement, has drawn interest of researchers [e.g. Avelino et al. 2015; Gupta et al. 2014; Schwencke 2012, Seyfang 2008]. A number of authors argue in favour of 'community-based action'. For example: Karvonen [2013: 571] argues that community-based domestic retrofit programmes can achieve more than approaching individual home-owners. He particularly stresses the importance of long-term involvement. Commitment is intrinsic to housing, with longer and deeper involvement compared to energy co-ops or other community actions.

Figure 1 illustrates the convergence of these strands of research: hardware, social practice and civil initiative. Studying co-housing is timely because it is a living lab on the crossing of these developments.

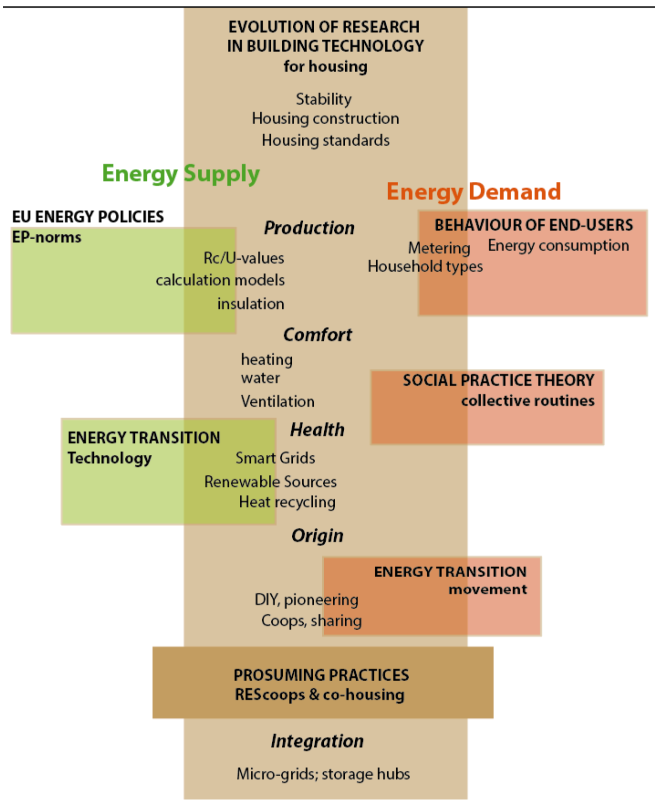

Figure 1: positioning co-housing research in the overall research concerning energy-transition in housing [source: author 2016]

In how far do the 'community-based' proposals include community-based technology? The building industry and engineering concepts used for housing are to the large majority thought for individual homes and apartments. Collective installations, such as district heating, have a bad reputation due to failing metering systems, exergy (leaks in the system) and lack of individual comfort control. Partly, technological improvements can take such inconveniences away, but installing communal utilities requires also installing a communal management and administration system. Individual owners or tenants seldom have the means to do this, and large housing associations do not have an incentive to facilitate residents in this way. Yet collective installations have advantages over individual systems, such as creating critical mass for larger investments, needed for example to mobilise geothermal heat. More efficient maintenance, basis for custom-made appliances or distribution systems, and so on. As the co-housing cases below will show, in addition the clusters can act as intermediary between end-user and general grid, to buffer surplus energy and mitigate disturbances.

The next section outlines how resident involvement is on the increase in the Netherlands, which makes it all the more relevant to look at possibilities for engineering to respond to self-organisation, and incorporate residents' associations in the innovations needed for energy transition.

Self-housing and bottom-up energy in the Netherlands

IN the 1990s the idea of the 'participation society' [Lans and Hilhorst, 2013] as an alternative to the welfare state was introduced. Increasing the share of self-developed housing fitted this line of thinking, and in 1998, Parliament demanded the Dutch government to double the share of self-developed housing production (*Particulier Opdrachtgeverschap*, PO) to 30% in 2005. As a result, in 2000, parliament approved the Memorandum "*Mensen Wensen Wonen*" ('People, Preferences, Dwelling' Ministerial vision on housing in the 21st century). It proposed more influence for inhabitants on housing and the environment. The memorandum specifically mentioned the need to produce custom-made housing and more 'ecological housing', at the same time urging citizens to 'take responsibility for their environment' [Remkes and Pronk, 2000: 65-66]. A ten-year implementation program was to follow in a threefold strategy:

1. Stakeholders agreements (notably HA and local authorities)
2. Adjustment of the legal framework
3. Development of new instruments and experiments

In the national statistics of 2005 private, non-professional housing still represented only about 15% of building licenses, i.e. between 9,000 and 10,000 units/year (CBS 2014). This was assumed to be due to lack of demand, as well as of available plots, but research commissioned by the (then) Ministry of Housing, Spatial Planning and Environment ('VROM') pointed at the Dutch planning culture, which is based upon collaboration between professional parties without structural involvement of end-users [SEV 2006]. After the dissolving of the Dutch Ministry of VROM in 2010 after its executive departments had already been outplaced to a semi-public agency SenterNovem[6]. Housing became the responsibility of the Ministry of Internal Affairs, which installed a 'Self-building Expert team' to assist municipalities in their working with citizens in development[7]. In 2015, the team launched a course for officials from Municipal planning departments to introduce the new ways of working. By now customised, participative development has become an accepted housing strategy, primarily based on individual home-ownership.
At the same time, in the Netherlands, grass-roots alternatives for energy-supply are booming, raising the interest of decision-makers, professionals and researchers

[6] nowadays part of Rijksdienst voor Ondernemend Nederland (Dutch Service for Enterpreneurs)
[7] http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/woningbouw/nieuwbouw/eigenbouw/expertteam-eigenbouw (accessed 12-9- 2015)

[Elzinga & Schwenke 2014]. Grassroot initiatives for Renewable Energy (REScoops[8]) are aware of the possibilities of collective effort, for example to build a wind-turbine with rotating capital of the village or community. Sources like wind and sun are seen as common good, and the 'Production' devices to harvest this energy are placed close to the end-users, who have a large extent of control or at least insight over them, although REScoops do not explicitly incorporate the seven rules of the International Cooperative Association[9] [Viardot, 2013], or the six Principles for Ruling the Commons [Ostrom, 2007].

Both housing and energy (privatisation) policies induced self-organisation in the Netherlands, as the previous sections have shown. While residents are taking initiative because they perceive government or market as being too slow; on the other hand, government perceives a lack of support from the general public for the measures it seeks to implement. Recently, in the Netherlands, decision-makers, professionals and researchers take a different interest in grass-roots alternatives [Elzinga & Schwenke 2014]. Consequently, statistics and research agents CBS and PBL of the government have reached new insights on the potentials from bottom-up projects. The non-institutional initiatives primarily consist of energy cooperatives, but, according to the same study, a large part of the population is not involved in energy-transition [CPB/PBL 2014:50]. A study of *Motivaction* (2013) concluded that a quarter of the respondents was not prepared to self-produce solar energy. The study speculates on the motives of this refusal: it may be lack of awareness, but also lack of available roof-space or finance. Also, the general impression has long been fed with the idea that solar energy is expensive and unfeasible. The majority of people may be interested in applying new energy technology, when the impact becomes easily visible (in terms of reduced bills or other). The statistics and planning agencies advise to connect the technological innovations to local initiatives already engaged in environmental or social concerns. This is however a late insight: our case-studies show that already thirty years ago co-housing initiatives have found their way to governmental programmes and market-innovations as energy-pioneers.

REScoops make use of the main grid to deliver the energy (in most cases power, but increasingly also heat) to the end-users. These distribution-networks have been privatised under neo-liberalism but regain public status with the increased self-production. This creates new tensions and questions on the right to access, responsibility and liability, and (financial) risks. In the Netherlands, a preliminary response was found by the Ministry of Economic Affairs in a postcode system, which limits the (formal) circle of clients for REScoops (or similar initiatives) to the radius of postcode areas adjacent to the source. Local energy producers receive a special licence and pay regulated fees for access and thus do not become competitors of national energy suppliers [SER, 2013].

---

[8] www.rescoop.eu

[9] http://ica.coop/en/whats-co-op/co-operative-identity-values-principles

New energy practices in collaborative housing

But what happens on the other end? How is the demand and use of energy influenced by communing its production harvesting)? And what is the effect of sharing spaces and devices on energy demand? Major devices that use energy in the household can be found in laundries, kitchens, and transport, which in co-housing constitute typical elements for sharing (see for example Jarvis, 2011). Moreover, in general these are now subject to changing cultures, replacing artefacts as individual status symbol with sharing as community identification, and property with leasing. Share-car programs, Peerby, Freegle and similar examples are illustrative of this movement. The next section looks at experiences with sharing in self-managed housing environments.

Many co-housing initiatives aim to be energy-efficient and reduce toxic emissions, as part of their holistic view on 'low-impact living'. As such, they present relevant models or visions for reducing the energy consumption of the general housing stock. Their proportional overrepresentation in demonstration programs and sustainable innovation subsidies indicates the extent to which such ambitions can reach [see for example Buis, 2000].

Some examples from very different conditions (although all north-European) but build on similar principles illustrate the possibilities (see table for an overview of projects' characteristics):

Munksøgård is an eco-village in Roskilde (Denmark) of 100 housing units, build in 2000. The planning criteria included offering a large variety in dwelling types to accommodate diverse households, and the application of low-impact, environmental materials and engineering. This applies also to the open space, which is car-free thanks to car-sharing and the proximity of public transport. It uses open paving to ensure rainwater integrates the soil, which is then filtered and used for laundry. Sub-clusters have their own community room, one common house is a self-build straw-bale unit. The settlement also includes a former farm which buildings have been re-used for café, food- and recycle shops, co-working and repair-workshops, bicycle storage and guestrooms. Residents can participate in a think-tank to keep the villages' green profile up to the latest standard.

Baugemeinschaft **Hohe Strasse** in Hannover (Germany) is a typical urban initiative of individual house-holds that build collectively to optimise costs and efficiency, and continues to share the responsibility for the project. Cost reduction is seen on the long term by investing in energy-saving construction and installations. It follows the (then relatively new) so-called Passivhaus standard, applying collective heating with pellet stove, heat-recovery and thermal solar panels. The individual apartments are built in 3 storeys over a semi-underground parking, which is used collectively. All units have private outdoor space, as terrace or balcony, sharing a large part of the garden and shed.

Equilibre (equilibrium) is a Geneva-based Swiss housing coop. Its name refers to the first priority: ecology, which translates into design principles such as high density, low-energy and low-impact construction. Accommodating diverse household types and play a positive part in the neighbourhood is the other pillar of its philosophy (Charter 2006, authors' translation). Construction is of high insulation standardized wood-panels and to keep costs low (future) residents participated in building works. Heating comes from a district heating system, and there is a water recycling system. In contrast with two other projects built simultaneously on the land, Equilibre choose not to create underground parking, reducing the need for parking space through a car-sharing system. Instead, the (concrete) basement contains common rooms, such as. It is equipped with dry (compost) toilet systems.

IEWAN, located in a suburban expansion area of Nijmegen (NL) was initiated by an ambitious group of residents. They did not only aim for energy-neutral, sustainably build houses but also a wide variety of dwelling types, in affordable rental categories, and a large share of common spaces. Through intense collaboration with a local housing association (the formal owner) and the local authorities most of the goals were achieved. Key in the success is the choice of straw-bale construction-method which is the guiding principle in the design. In this way, as one resident put it 'sustainability is not an add-on that can be eliminated when there is need for budget cuts, but it is guaranteed until the building site'. The gaps in the budget were filled by self-building (unpaid voluntary hours on site). The buildings have greened roofs and winter-gardens to moderate both hot and cold outside temperatures. Garden and common house contain extensive shared facilities, which are managed by the residents' organisation.

De Groene Mient (Green common, Den Haag, NL) is a similar initiative with a different form of tenure (33 individual home-owners). The residents' association formulated high ecological ambitions and decided on a joined construction scheme, of high-insulation wood-panels. The individual households design (and build) their own interior and choose from three engineering concepts: basic all electric; basic + solar or basic + heat-pump. Common ground is the garden, which is designed along climate change mitigation principles, emphasizing water management by the residents themselves.

What these projects have in common that as collective clients they have been able to purchase equipment and building tech that performs better (energy-wise), but is too expensive for single households. We don't know how exactly the decision-making took place, but we can suspect that they choose the solutions for engineering based on professional consulting engineers telling them this was the best value for money. In other words: applying what is available on the market, if not mainstream but niche-markets. The professionals involved, notably the energy-engineers, play an important role in making this work- or steering the collective towards more familiar and therefor less risky grounds. A lack of acknowledgement of the specific possibilities for co-housing means that certain innovations are overlooked. For example, Tillie et al. [2014] point at the possibility to re-use energy flows on an intermediate scale (that applies to most co-housing projects):

> (for cascading) ***It is much more difficult to purify waste water on an individual building basis than a collective to reclaim biogas.*** *Some technologies are feasible at the individual scale, e.g. PV panels and solar collectors,* ***other forms of***

generation are potentially more feasible at the neighbourhood level – e.g. ground source heat pumps and wind.
The introduction of new vast infrastructures for this heat exchange in cities may be uneconomical when compared to traditional systems. This is, however, dependent on the way things are solved and exactly the reason why low-temperature systems should be tackled at neighbourhood level (typically with a radius of not more than 300 m).
[Tillie et al., 2014]

Table: energy systems and other characteristics of the projects (author, 2017)

IASC 2017 case-studies	**Units, tenancy**	**Building tech**	**Engineering**	**Shared spaces**	**Govmtal / institutional partners/ subsidies/other**
Munksøgard (2000, Roskilde, Dk) http://www.munksoegaard.dk/index_en.html	100 units, mixed tenure, 5 sub-groups each with own administration and residents' association	Woodpanels with recycled paper for insulation, natural finishing	Solar panels, collective biomass heating, rainwater capturing and purification beds, central urine-collection for fertilizing	Variable per sub-group, central common house and garden, working spaces, guestroom and recycling station	ecovillage, negotiated low parking ratio and separated waste-fractions collection with local authorities
Baugemeinschaft Hohe Strasse (2003, Hannover, De)	11 units, home-ownership, various sizes and custom layout, residents' manage the project	concrete structure on underground parking floors	Central pellet-stove for heating, solar, *Passivhaus* standard, heat-recovery;	Parking, storage and garden	Inner city, Initiated by architect, participative design
Equilibre (2011, Geneva, CH) www.cooperative-equilibre.ch	13 units, 3-storey apartment building on	Woodpanels on concrete cellar	District heasing, compost toilets	laundry, meeting, guestroom and outdoor garden, playground water purification	Suburban, land leased by municipality, residents are coop-members first of the coops projects
IEWAN (2015, Nijmegen) www.iewan.nl/	Clustered multi-storey 24 rental units; common house plus workspaces	straw-bale self-build, green roofs Bufferzones/ semi-collective spaces Energy-neutral	collective pellet heating; collective solar, water recycling through local reedbed	central common house and garden, working spaces, food coop and cafe	Suburban, Subsidies from local authorities
Groene Mient (2016, Den Haag, NL) http://www.groenemient.nl/	33 individual home-owners	Woodconstruction with high insulation level	Households could choose amongst 3 concepts: all electric, heat-pump; solar	Common garden and house, PV panels	Heat recovery from ventilation air and shower in all units

Table: Overview of studied projects (Tummers, 2017)

Conclusions

Making use of the potential for collective low-impact engineering in housing is becoming more relevant, if not urgent, to comply with the globally agreed climate targets. Especially countries in the global and European North have to reconsider the 'footprint' of housing. Cities have to mitigate the consequences of climate change, such as extreme rainfall and flooding. From the decentralised water system in Sydney [10], to the Dutch program to enforce the dykes: when inhabitants are not mobilised to harvest and re-use rainwater, top-down water-management will not be sufficient. The co-housing projects show that the application of renewable sources for energy and water can be optimised as a direct result of the 'social architecture' (Jarvis, 2015) of co-housing.

Co-housing residents' associations unite the demand and supply (of energy, housing and services) in a new status of 'prosumers', producing as well as consuming housing, services, water and energy, adapting building technology in the process. The projects provide ample qualitative evidence of experimenting with low-impact solutions. In particular, they demonstrate how the social, economic and technical choices are integrated in design decisions. However, although some projects monitor the energy-consumption, there is no reliable quantitative evidence to the effectiveness of the 'low-impact' innovations that co-housing projects adopt. Moreover, models to measure, calculate and monitor energy demand and supply are based on individual households and housing units. By not taking into account the dynamics of shared spaces and common rooms, the results do not do justice to the real-time results.

In the book for its 10-year existence (2006-2016) *Equilibre* presents calculations on the impact of its sustainable design. The use of compost-toilets and share-car schemes for example lead to a significant reduction of the ecological footprint of its inhabitants: 50% compared to the average Swiss person. This is one of few available quantitative indicators to show that co-housing projects, in all their variety, present an alternative for high-impact, energy-consuming housing. They have achieved this through sharing and collaborating: managing common spaces, rather than changing behaviour or lifestyle.

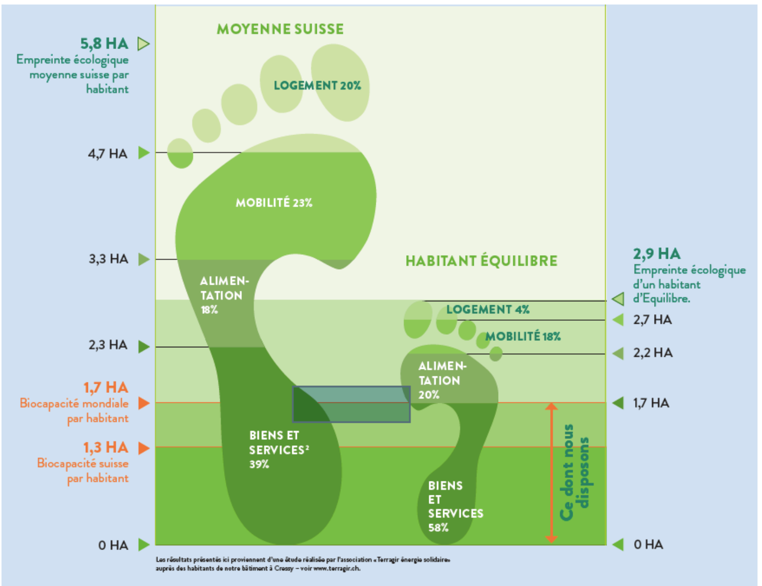

Figure 2: Housing Coop Equilibre calculating the footprint of its members, 2016, as compared to average Swiss inhabitants [From: http://www.cooperative-equilibre.ch/wp/wp-content/uploads/2016/09/EQ_LIVRE_10ans_BD.pdf accessed 6 June 2017]

10 http://www.cityofsydney.nsw.gov.au/vision/towards-2030/sustainability/water-management

Commoning residential energy systems

Clustered design (instead of individual unit) residential energy systems is promising for a number of reasons:

First, the cluster as intermediate level between grid and individual unit can moderate the consequences of peaks in supply (for example, on sunny days) and interruptions.

Most co- housing projects have shared cars, laundries and so which can use surplus energy instantly or buffer it for peaks in demand. Examples are: peak times management by shared e- cars, priorities of daytime washing to take advantage of photovoltaic power (PV), and cooling food supplies in common storage.

Second, co- housing residents have shown to be willing as well as capable of organising the technical and administrative management, using creative (DIY) solutions.

Third, decisions of a community can have more impact than individual decisions, and they can address energy demand and distribution systems in housing, and include production for the common good.

Fourth, the dynamic of sharing creates opportunities for learning or developing together, but this strongly depends on the efforts of the co- housing members (Baborska et al., 2014).

Finally, energy-related mechanisms that will be handled by residents need to be more transparent than electronics the functioning of which very few people are capable of controlling or supervising. The use of common (shared) utilities and equipment can only be successful on the long term when the self-management aspects are taken into account during design and operation phases.

Co- housing puts into practice what international policies aim to achieve on paper. They connect national and global strategy to the everyday needs, aspirations and realities of urban households. Engineers who aim to support this development, can learn from commons theory, applying the rules of the commons as design-criteria for innovative low-impact systems.

Acknowledgements:

A heartfelt *thank you* to all co-housing residents and professionals who shared their experiences and were willing to open the technical rooms, even when thinking ‘there is nothing really to be seen here’. All working well, energy is just a means to an end!

References:

Avelino, Flor; Adina Dumitru, Noel Longhurst, Julia Wittmayer, Sabine Hielscher, Paul Weaver, Carla Cipolla, Rita Afonso, Iris Kunze, Jens Dorland, Morten Elle, Bonno Pel, Tim Strasser, René Kemp and Alex Haxeltine (2015) ‘*Transitions towards new economies?*’ Transit working paper #3, Avalaible from: http://www.transitsocialinnovation.eu/ (januari 2016)

Baborska-Narozny, M., F. Stevenson, P. Chatterton (2014) “A Social Learning Tool - Barriers and Opportunities for Collective Occupant Learning in Low-Carbon Housing.” *Sustainability in Energy and Buildings*, 10.

Bueren EM van, Bohemen H van, Itard L, et al. (eds) (2012) *Sustainable Urban Environments: An Ecosystem Approach*. Dordrecht Heidelberg London New York: Springer.

Buis H (ed.) (2000) *Duurzaam bouwen een kwestie van willen en weten. Voorbeeldprojecten duurzaam en energiezuinig bouwen.* Utrecht: Nationaal DuBo Centrum.

CPB, PBL & SCP (2014) Kruitwagen, Sonja, Jan Ros, Johannes Bollen, Johannes Boelhouwer, Anja Steenbekkers, and Andries van den Broek. "*Monitor Duurzaam Nederland 2014: Verkenning. Uitdagingen voor adaptief energie-innovatiebeleid*." www.pbl.nl of www.cpb.nl.
Elzenga H and Schwencke A (2014) *Energiecoöperaties: ambities, handelingsperspectief en interactie met gemeenten De energieke samenleving in praktijk*. Beleidsstudie, Den Haag: Planbureau voor de Leefomgeving.
Gram-Hanssen, Kirsten (2014) "New Needs for Better Understanding of Household's Energy Consumption – Behaviour, Lifestyle or Practices?" *Architectural Engineering and Design Management* 10, no. 1–2 (April 3,): 91–107. doi:10.1080/17452007.2013.837251.
Gupta, Rajat, Laura Barnfield, and Tara Hipwood (2014) "Impacts of Community-Led Energy Retrofitting of Owner-Occupied Dwellings." *Building Research & Information* 42, no. 4 (July 4,): 446–61. doi:10.1080/09613218.2014.894742.
Jarvis, Helen (2011) "Saving Space, Sharing Time: Integrated Infrastructures of Daily Life in Cohousing." *Environment and Planning* 43, no. 3 (2011): 560–77.
Jarvis, Helen. "Towards a Deeper Understanding of the Social Architecture of Co-Housing: Evidence from the UK, USA and Australia." *Journal of Urban Research and Practice* 8, no. 1 (March 2015).
Karvonen, Andrew (2013) "Towards Systemic Domestic Retrofit: A Social Practices Approach." *Building Research & Information* 41, no. 5 (October): 563–74.
Kido, H., Y. Nakajima (2011) "Predicted Energy Conservation by Use of Common Areas in Co-housing." Helsinki, Finland: Kogakuin University
Krokfors, Karin, ed. (2012) "Co-Housing in the Making." *Built Environment* 38, no. 3 309–14.
Lafond, Michael, ed. (2012) *CoHousing Cultures: Handbuch Für Selbstorganisiertes, Gemeinschaftliches Und Nachhaltiges Wohnen / Handbook for Self-Organized, Community-Oriented and Sustainable Housing.* Berlin: Jovis Verlag GmbH,.
Lans J van der and Hilhorst P (2013) *Sociaal doe-het-zelven. De idealen en de politieke praktijk*. Amsterdam: AtlasContact.
Marckmann, B., K. Gram-Hanssen, T. Haunstrup Christensen (2012) "Sustainable Living and Co-Housing: Evidence from a Case Study of Eco-Villages." *Built Environment* 38, no. 3 413–29.
Motivaction (2013): see CPB, PBL & SCP (2014)
Ostrom, Eleanor. "Frameworks & Theories of Environmental Change." *Global Environmental Change*, no. 18 (2008): 249–52. doi:10.1016/j.gloenvcha.2008.01.001.
Remkes J and Pronk J (2000) Mensen Wensen Wonen. Nota wonen in de 21ste eeuw. Den Haag: Ministerie VROM.
Schwenke, Anne Marieke. "Energieke BottomUp in Lage Landen. De Energietransitie van Onderaf." Leiden: AS I-Search, 2012. Available from: http://www.asisearch.nl/energieke-bottomup-in-lage-landen. (accessed March 2016)
SER (2013) The Agreement on Energy for Sustainable Growth: a policy in practice. Social and Economic Council. Available from: www.energieakkoordser.nl.
Seyfang, Gill (2008) "Grassroots Innovations in Low-Carbon Housing." ESRC. ISSN 0967-8875. The Centre for Social and Economic Research on the Global Environment (CSERGE),
Tillie N, Dobbelsteen A van den and Carney S (2014) Planning for the Transition to a Low-Carbon City: A New Approach. In: Lehman S (ed.), *Low Carbon Cities: Transforming Urban Systems*, London: Earthscan, pp. 173–190.
Tummers, Lidewij, ed. "Taking Apart Co-Housing. Towards a Longterm Perspective for Collaborative Self-Managed Housing in Europe (Introduction to the Special Issue)." *Urban Research and Practice,* 8, no. 1 (March 2015). doi:doi.org/10.1080/17535069.2015.1011421.
Tummers, Lidewij. "The Re-Emergence of Self-Managed Co-Housing in Europe A Critical Review of Co-Housing Research." *Urban Studies*, May 23, 2015, 1–18. doi:10.1177/0042098015586696.
Viardot, Eric. "The Role of Cooperatives in Overcoming the Barriers to Adoption of Renewable Energy." *Energy Policy* 63 (December 2013): 756–64. doi:10.1016/j.enpol.2013.08.034.
Wohnbund (ed.), (2015) *EUROPE: Cooperative Housing/EUROPA: Gemeinsam Wohnen*, Berlin: Jovis,