TRANSFORMING CONSTRUCTION NETWORK PLUS

UK Research and Innovation

INDUSTRIAL STRATEGY

UCL

Imperial College London

WMG THE UNIVERSITY OF WARWICK

THE TRANSFORMING CONSTRUCTION NETWORK PLUS (N+)

Stimulating participation, facilitating collaboration, and encouraging exploration

The N+ unites construction's academic and industrial communities to create a new research and knowledge base, dedicated to addressing the systemic problems holding back the sector.

UCL

Imperial College London

WMG
THE UNIVERSITY OF WARWICK

More information about the N+ can be find:

www.bit.ly/transforming-construction-network-plus

THE TRANSFORMING CONSTRUCTION NETWORK PLUS

- The N+ is funded **by UK Research and Innovation** through the **Industrial Strategy Challenge Fund**
- It is supported by UK Research & Innovation (UKRI) funding

The aim of the N+ is to provoke, enable and amplify innovation, through four main objectives:

- Knowledge
- Community building
- Business models
- Investment and legacy

WEBINAR: OFFSITE AND ENERGY EFFICIENT - INTERNATIONAL EXPERIENCE

TRANSFORMING CONSTRUCTION NETWORK PLUS

Dr.Ing Thaleia Konstantinou

Assistant Professor, Faculty of Architecture, Delft University of Technology, The Netherlands

Scientia Professor Deo Prasad AO FAIA

CEO, Co-operative Research Centre for Low Carbon Living

Dr Malay Dave

Sessional academic, University of New South Wales, Australia

Professor Paul Ruyseevelt

Chair of Energy & Building Performance, UCL Energy Institute

Co-Investigator of the Transforming Construction Network Plus

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TRANSFORMING
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ZERO-ENERGY RETROFITS:
AN INTEGRATED APPROACH TO DECARBONISING THE BUILDING STOCK

Dr.Ing Thaleia Konstantinou

Assistant Professor, Faculty of Architecture, Delft University of Technology, The Netherlands

TRANSFORMING
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Zero-energy retrofits:

An integrated approach to decarbonising the building stock

Thaleia Konstantinou, Dr.Ing.
t.konstantinou@tudelft.nl

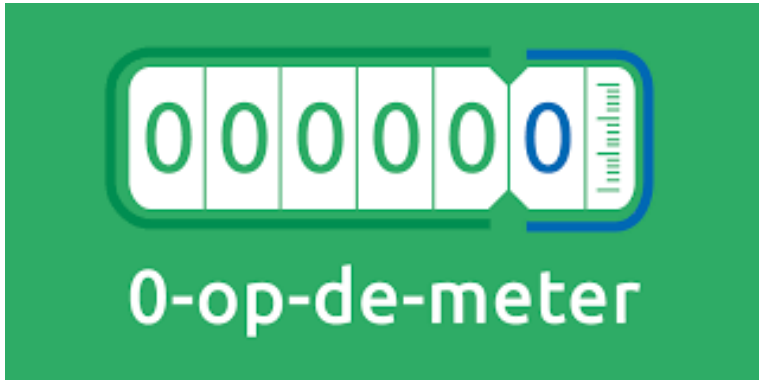
Department Architectural Engineering+Technology

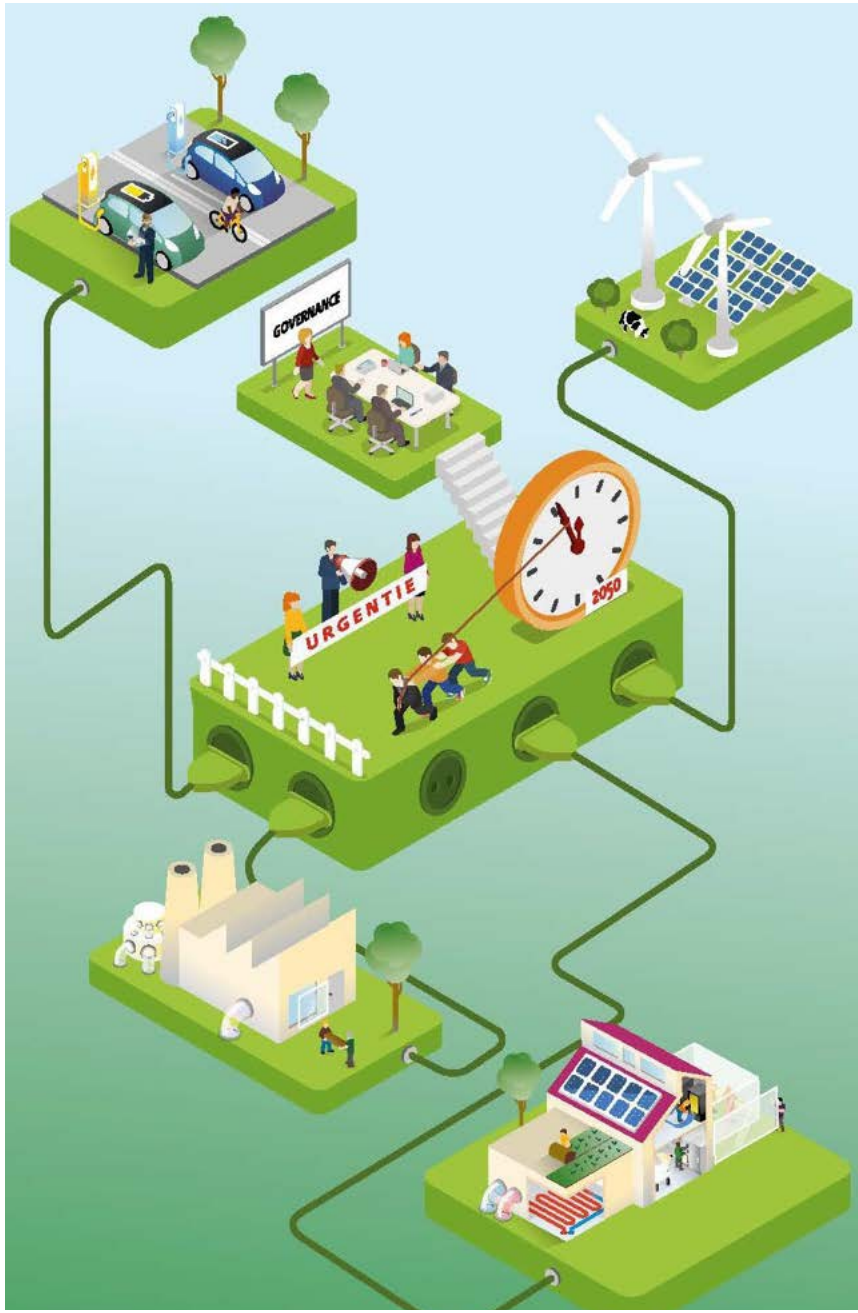
Faculty of the architecture and the Built Environment

TU Delft Delft University of Technology

Energy Use and Building Sector

- All new buildings must be nearly zero energy buildings by 31 December 2020
- Zero-Carbon Built Environment by 2050
- Clear ambition to refurbish the building stock

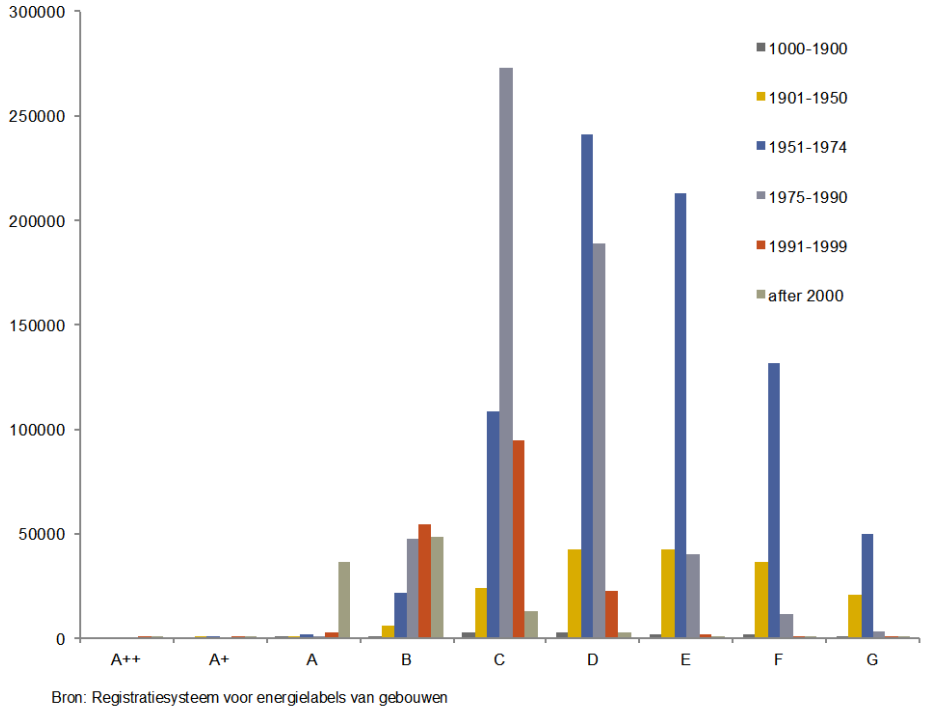




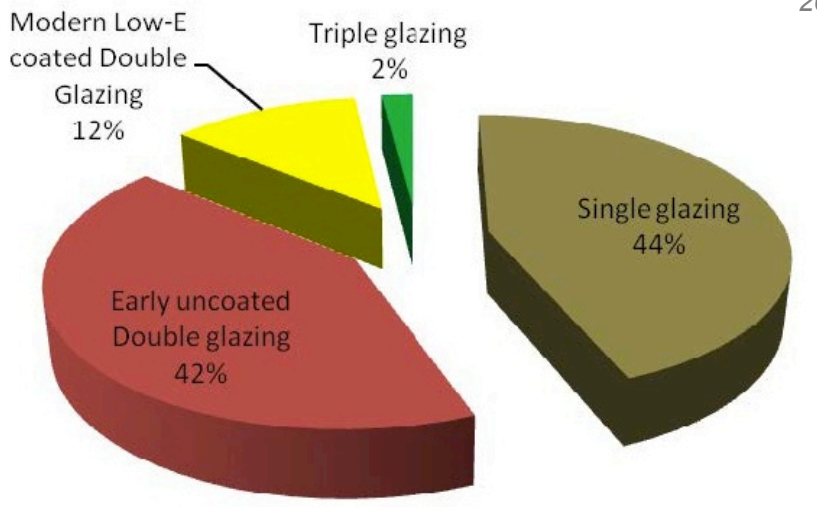
Energieagenda, 2016

Decarbonizing the building stock

- By 2050, 70% of the building stock
- Built under far lower energy and sustainability standards



Energy labels for non-residential buildings in the Netherlands in 2010 (source: AgentschapNL)

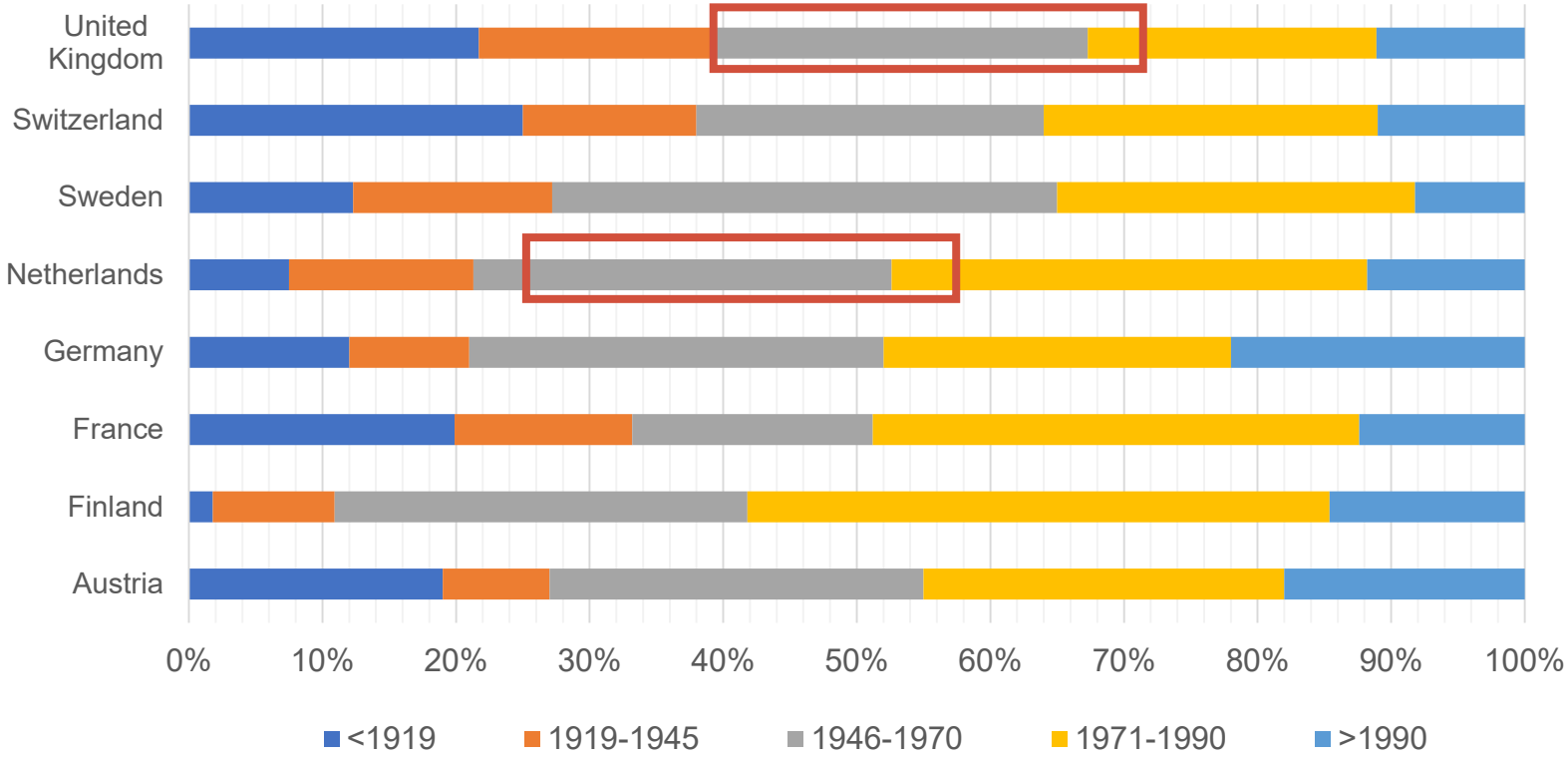


Glazing type distribution in the EU building stock – TNO-60-DTM-2011-00338 report (source: Glass For Europe. (2011). The Future EU Energy Efficiency Plan. Brussels: Europe's Manufacturers of Building, Automotive and Transport Glass)

Decarbonizing the building stock

- In the Netherlands:
  1/3 of the stock built in the postwar period

- Building of the period 1970-1990, also need attention



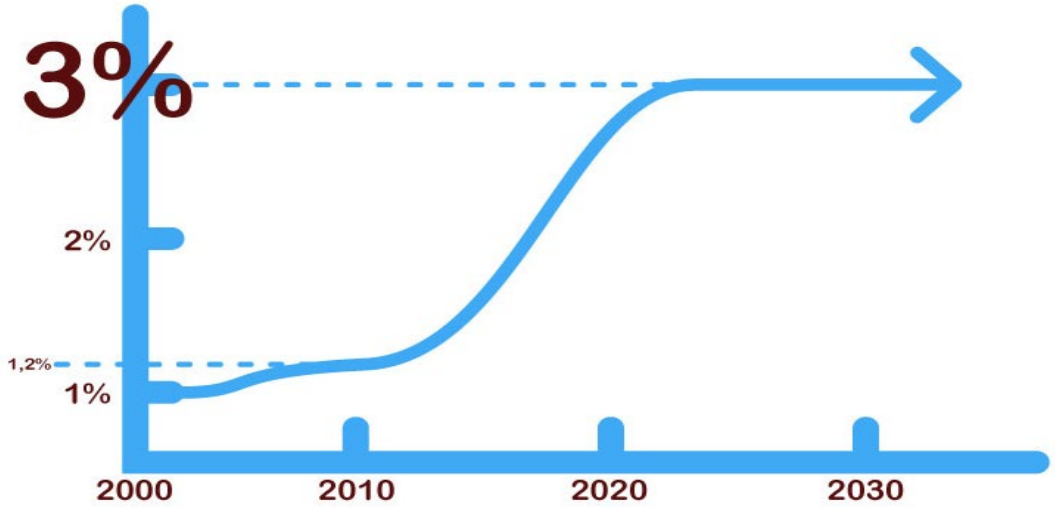
Age distribution of the residential building stock (source: Itard and Meijer, 2009, p. 35)

Refurbishment potential

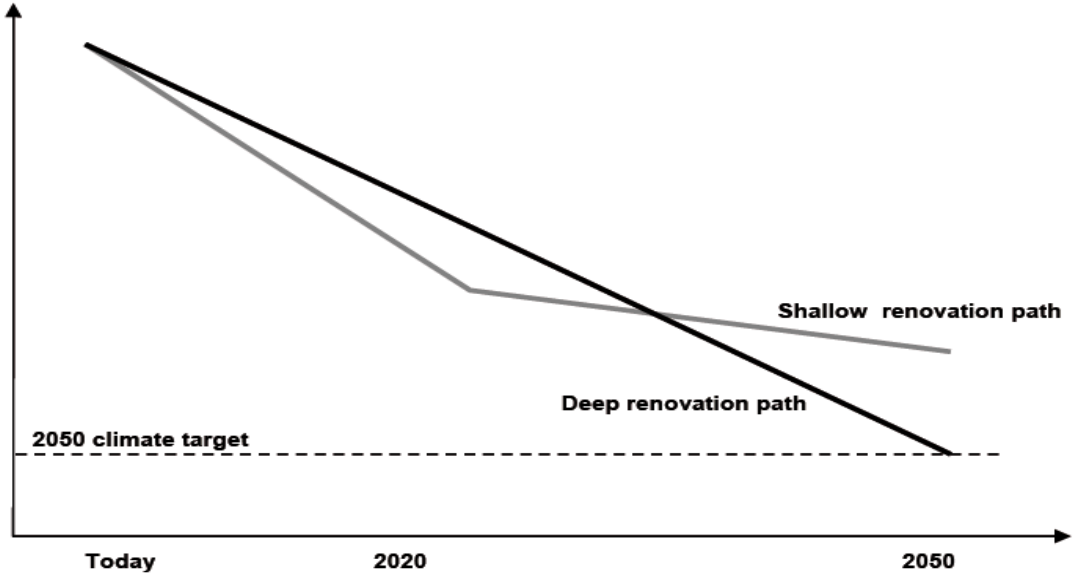
Both rate and depth need to increase

Deep Renovation to Zero-energy building

Higher numbers of renovated dwellings/yr (300k in the NL)



http://renovate-europe.eu/the-campaign/ambition-objectives/



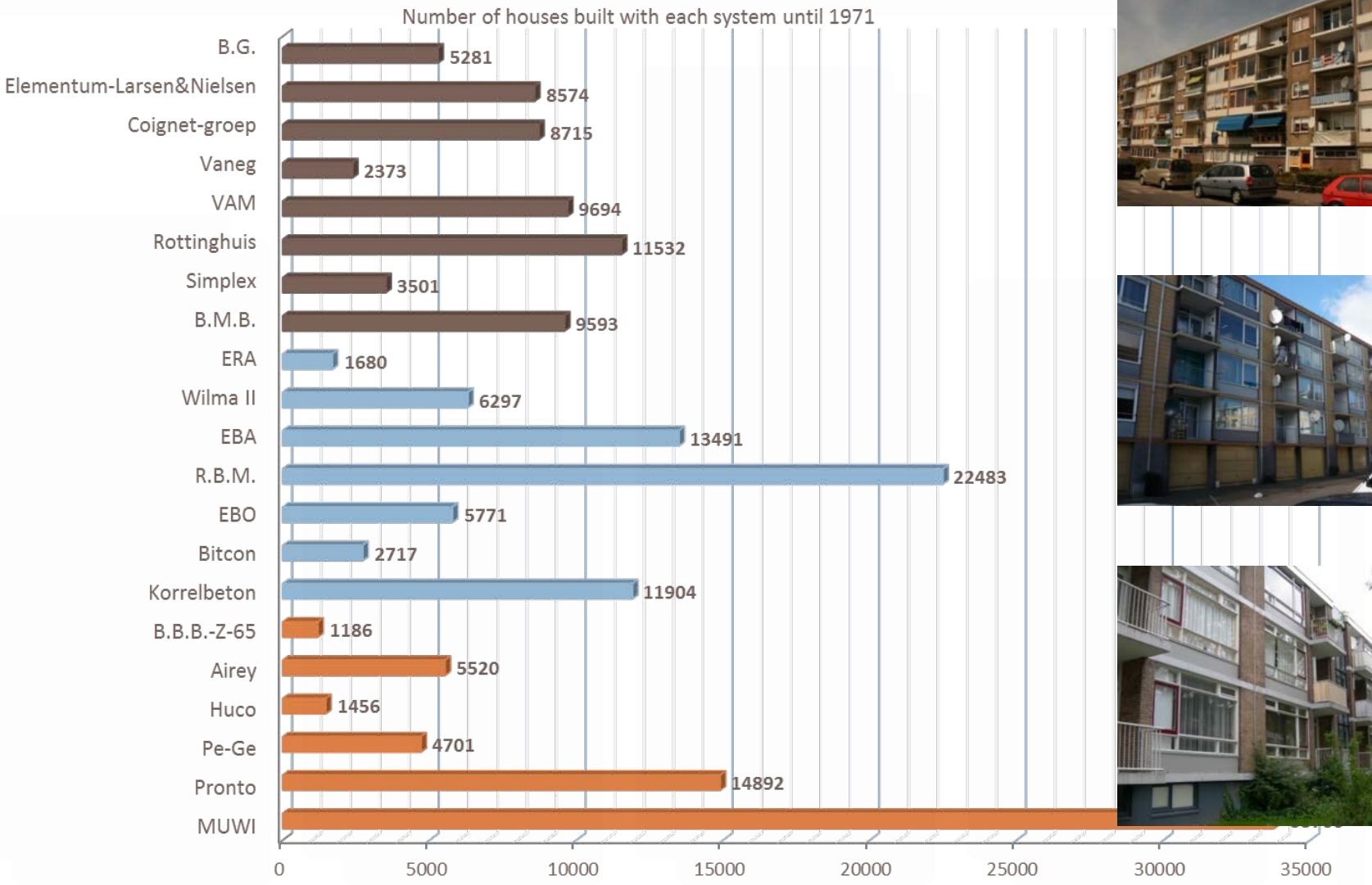
The "speed trap" of shallow renovation (source: Hermelink, Andreas & Müller, Astrid 2011. Econimics of deep renovation. Berlin: Ecofys by order of Eurima - European Insulation Manufacturers Association.

Prefabrication / Off-site construction

- “Industrialized construction” often used interchangeably with prefabricated construction
- Prefabrication is a subset of industrialized construction
- Other degrees of industrialisation include Mechanization, Automation and Robotics.

Richard, Roger-Bruno. "Industrialised Building Systems: Reproduction before Automation and Robotics." *Automation in Construction* 14, no. 4 (2005/08/01/ 2005): 442-51.

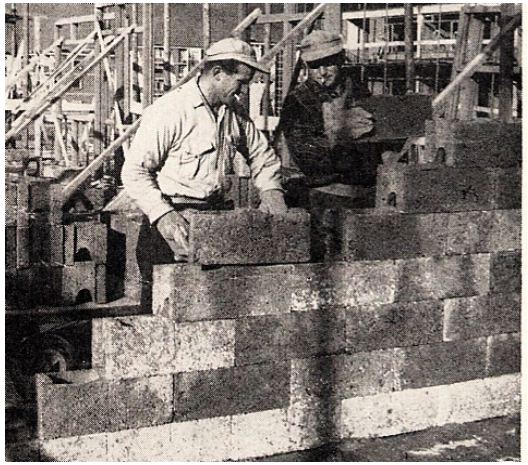
Niet-traditionele woningbouwmethoden



VAM

Rottinghuis

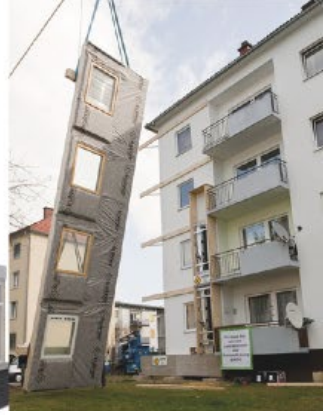
MUWI



Priemus, H., & Elk, R. S. F. J. v. (1971). *Niet-traditionele woningbouwmethoden in nederland* (Vol. 26). Alphen a/d Rijn: Samsom.

Industrialised retrofits

- Increase effectiveness, productivity and quality of construction
- Minimise on-site construction time
- High performance solutions
- Possible building services integration



Kapfenberg, Austria

TES EnergyFacade

Stromversnelling, Soesterberg

EnergieSprong

- Energiesprong is a whole house refurbishment construction and funding approach
- Long-term performance guarantee on both the indoor climate and the energy performance.
- Money normally spent on energy bills and maintenance pays for the retrofit.
- The concept has international expansion: Transition Zero (H2020), E=0 (InterregNWE) and Mustbe0 (Interreg NWE)

https://energiesprong.org/about/

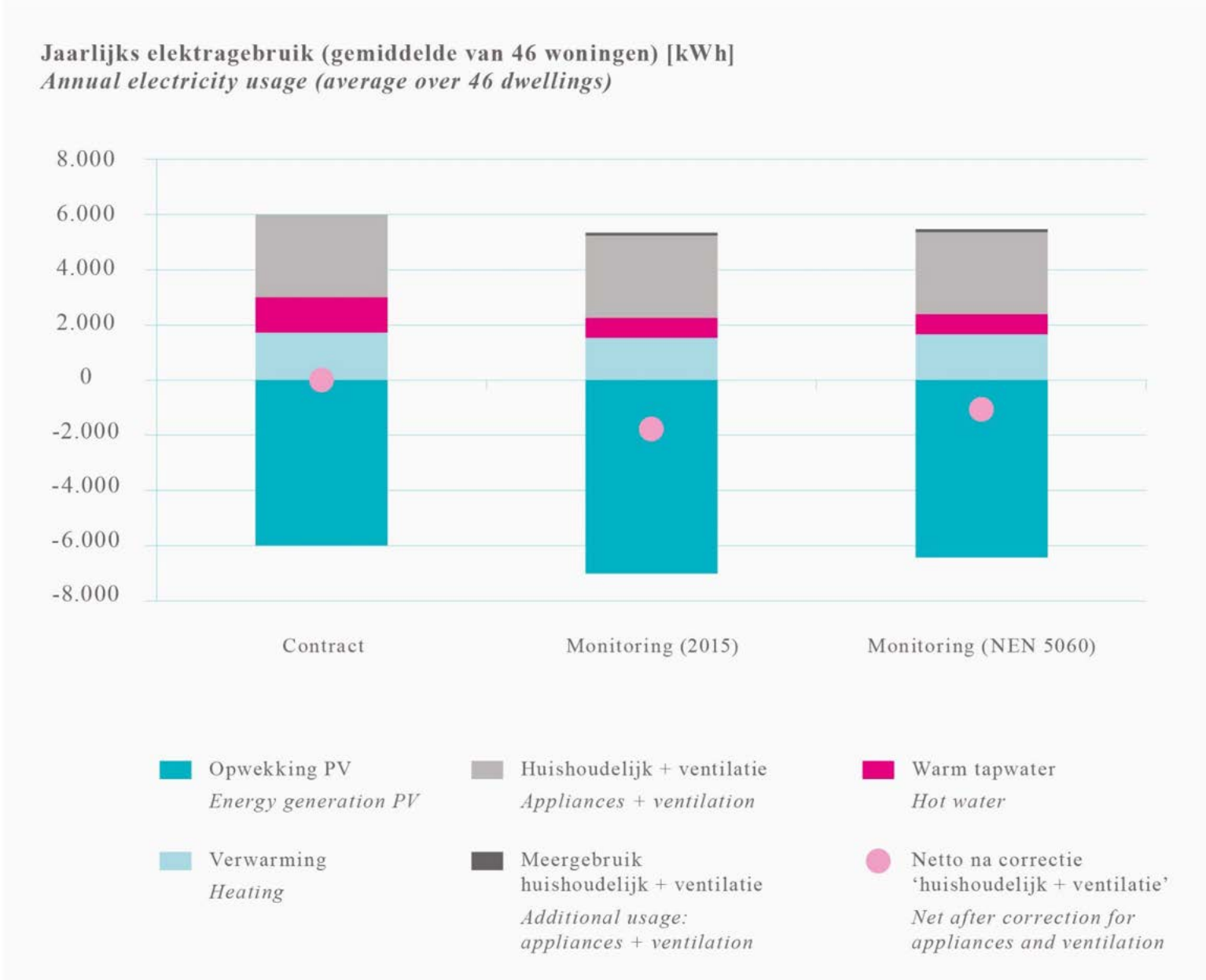
Case Heerhugowaard

- Renovated 55 terraced dwellings to a zero-on-the-meter dwelling
- Roof and façade elements are all prefabricated and arrive at the building site in one piece.
- Building services unit of 3m3 attached to the dwelling in the backyard.

Picture credits : https://www.rickakkerman.nl/portfolio/renovatie-bam/fotografie-rick-akkerman-196/

Monitoring results:
46 homes in Heerhugowaard monitored on execution, delivery and usage

- Energy performance matches design and performance specifications
- Space heating usage a little more than expected, whereas solar energy generation higher



Monitoring results of 46 houses in Heerhugowaard, indicating annual energy generation (opwekking PV), use of space heating (verwarming), household appliance & ventilation use (huishoudelijk + ventilatie) and hot water use (warm tapwater

Energiesprong. *Energiesprong Works!* Energiesprong (24.04.2019 2019). https://energiesprong.org/publication/.

2ndSkin

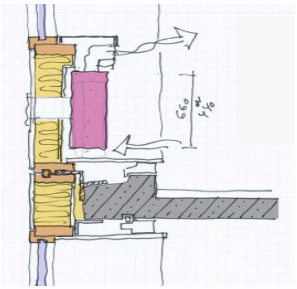
A zero-energy refurbishment solution for residential apartment buildings by applying an integrated, prefabricated façade module

The Delft Darmstadt München
Facades Education Project

2ndSkin Project Objectives

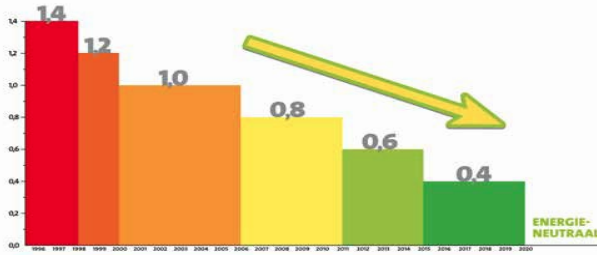
Innovative, integrated façade technology

- Zero energy consumption (Null op de meter)
- Minimum intervention to the interior



Business Development

- Low cost
- Upscalling
- New business model of supply chain



User Aspects

- Renovation acceptance
- Monitor behaviour and energy use
- Improve interaction with new systems

2ndSkin Project Phases

- Flagship 2014-2016 Mockup

- Demonstrator 2016-2018 12 NOM

- Scaler 2018-2019 180 NOM-ready

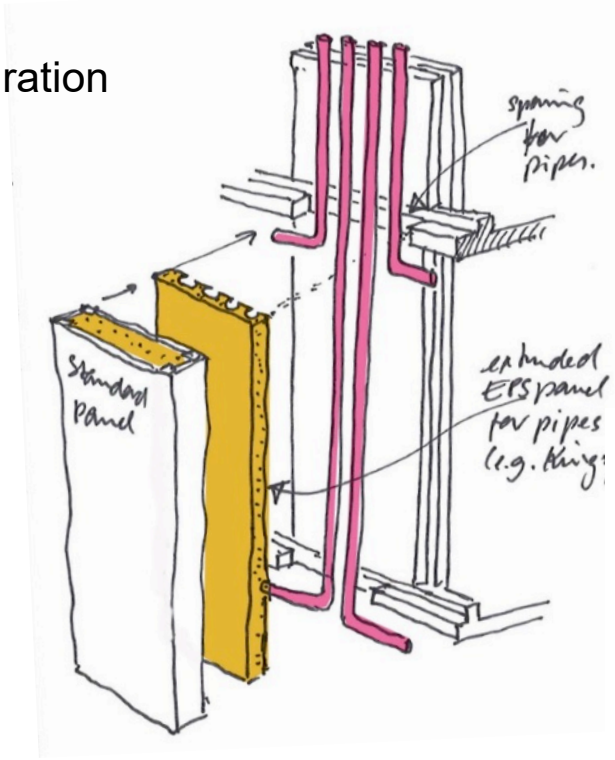
Product Development phases

A: Existing technology

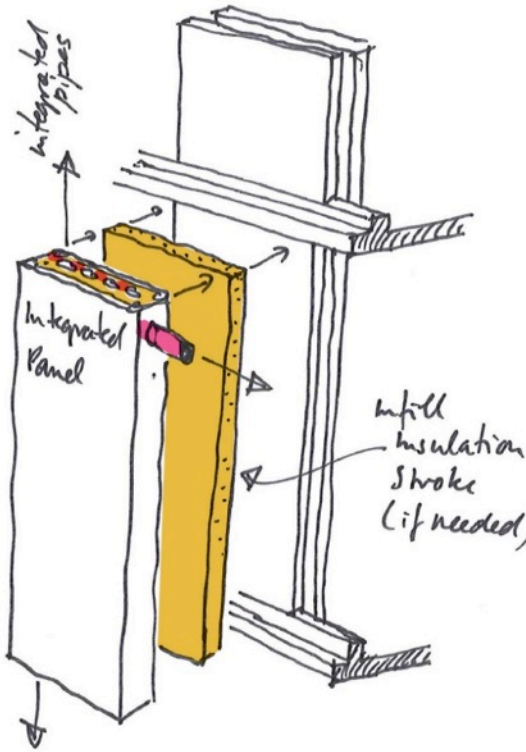
B: New development short term

C: Projected development

Example ventilation integration



A: Existing Technology



B: New development

Flagship Mockup

Testing technical feasibility

2ndSkin Technical solution

Remove existing windows

Ventilation layer

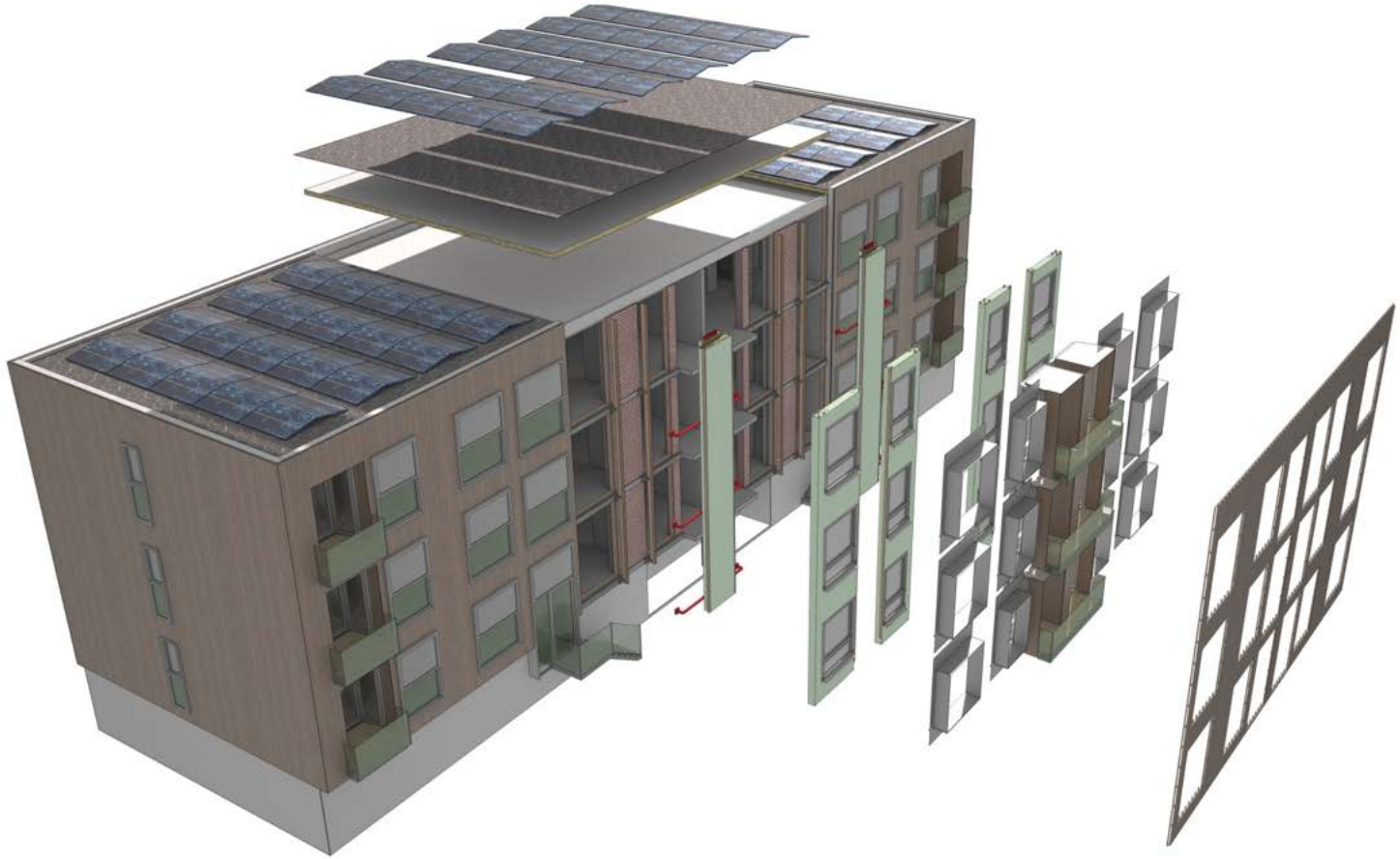
Wall insulation and new windows

Cladding

Roof insulation

Heat-recovery ventilation

PV panels



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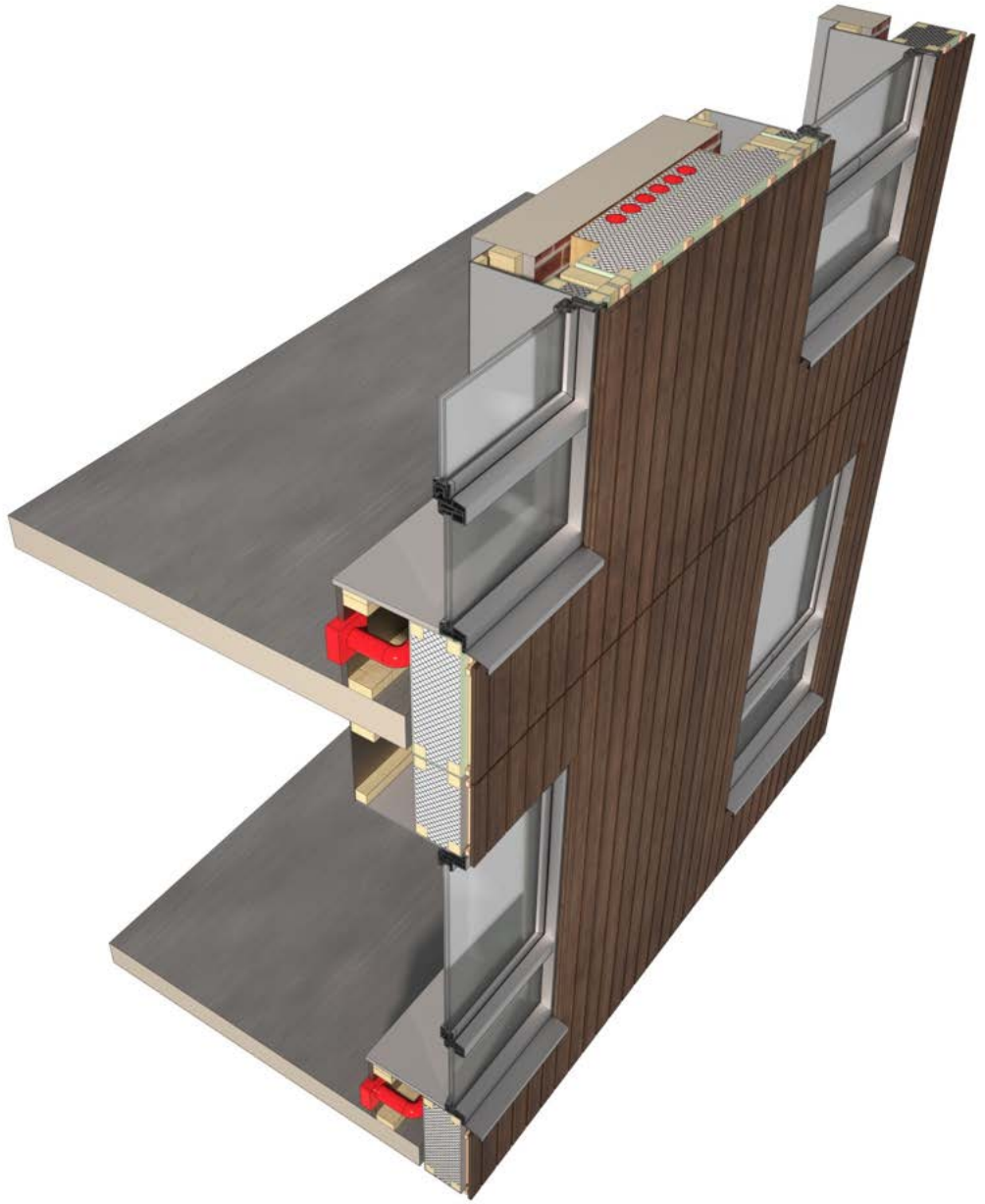

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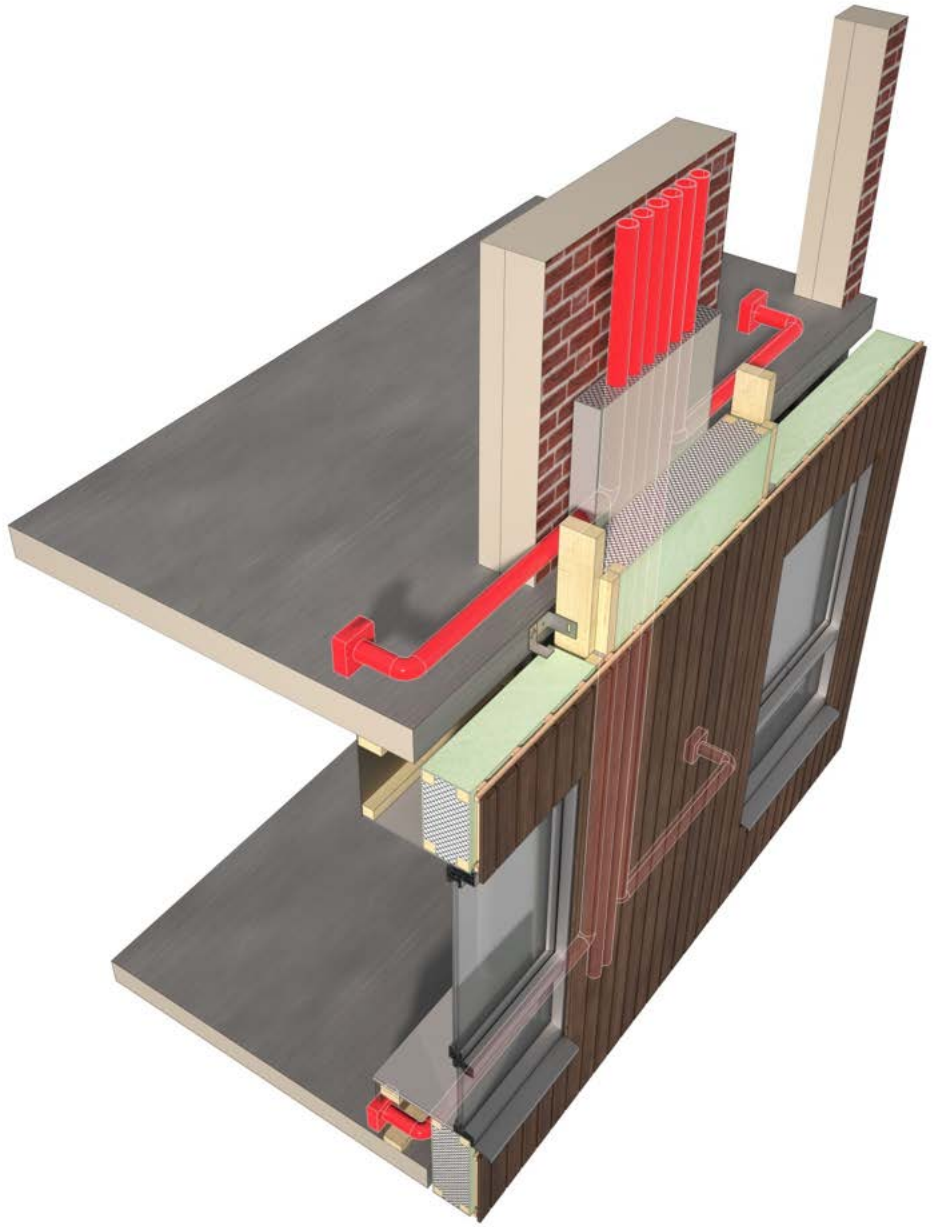


KOMO 31022 C1 E

12-apartment building zero-energy renovation
Soendalaan, Vlaardingen, NL

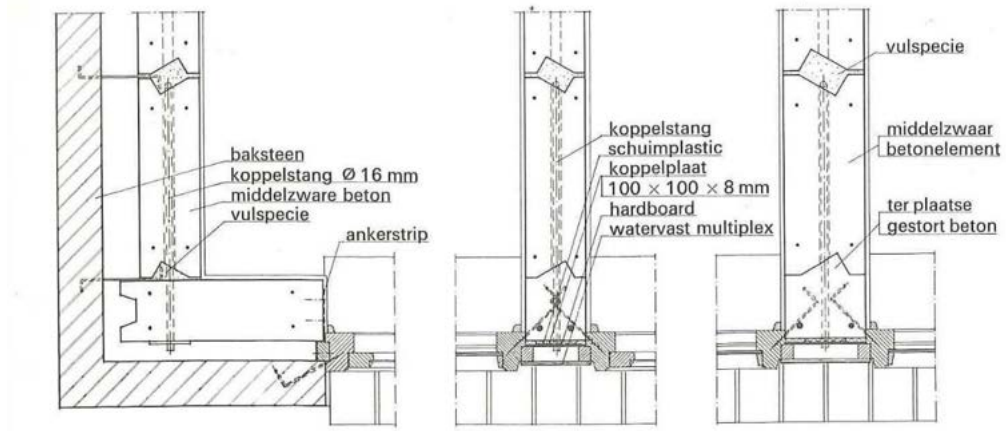
Urban, architecture, Design Concept

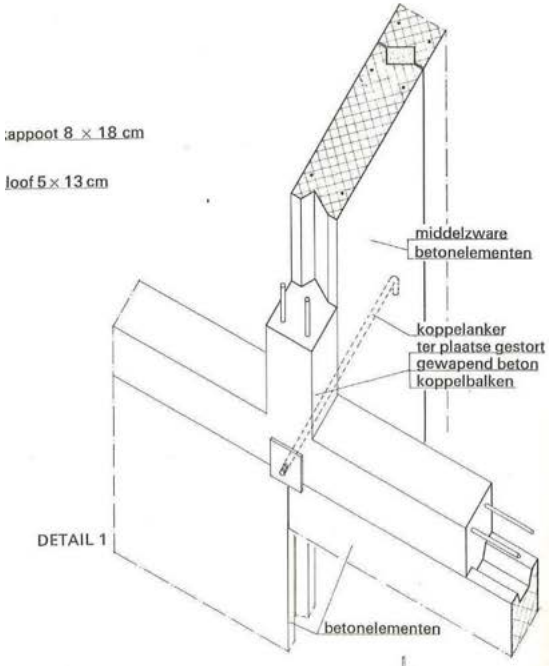
Post war (1952) district with identical blocks

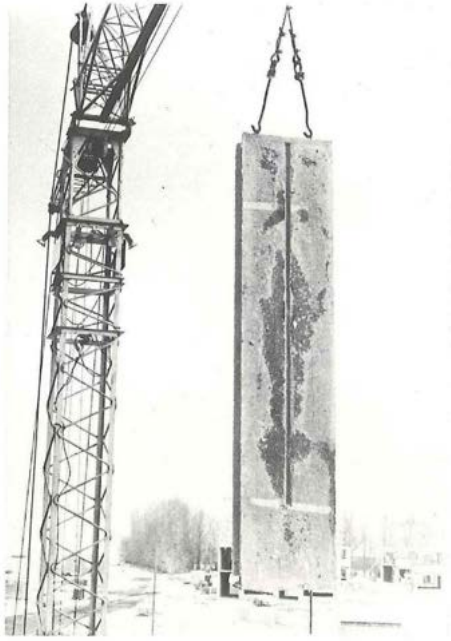
The project focuses on one block of 12 apartments

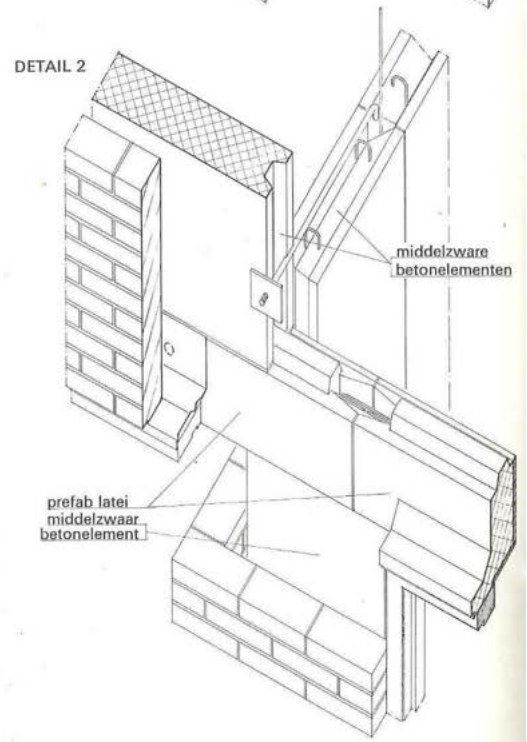
Existing building

Simplex construction system









Existing building

Simplex construction system

Proposed renovation

KAW Architecten

Façade system

External insulation

Façade system

Window replacement

u-PVC frames and

Triple glazing panes.

Façade system

Roof replacement with prefabricated panels

Façade system

Remove and replace balconies

Façade system

Remove and replace balconies

Building systems

New installation installed in an installation box on the balcony

Ventilation with heat recovery

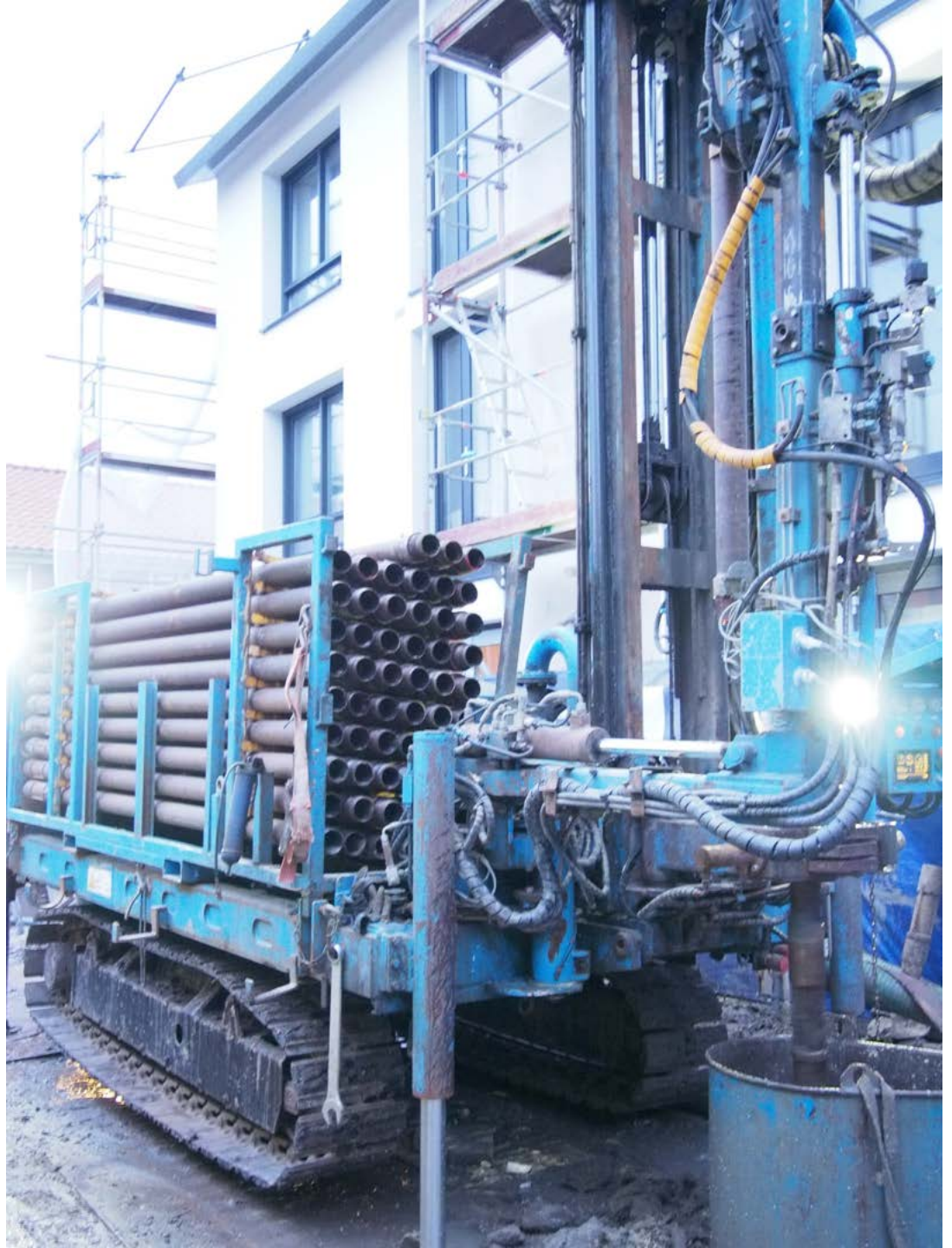
Ground Source heat pump COP6

Building systems

New installation installed in an installation box on the balcony

Ventilation with heat recovery

Ground Source heat pump COP6



Zero Energy guaranty

Zero energy performance guarantee by the building services provider for 25 years

Fixed amount per month

Achieved by

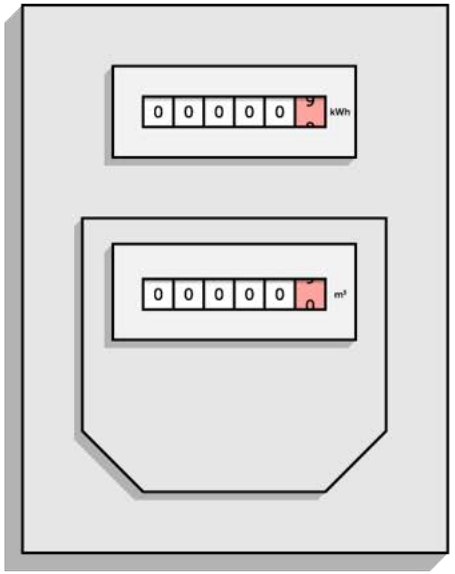
- eliminating the demand
- LED lighting
- on site energy generation

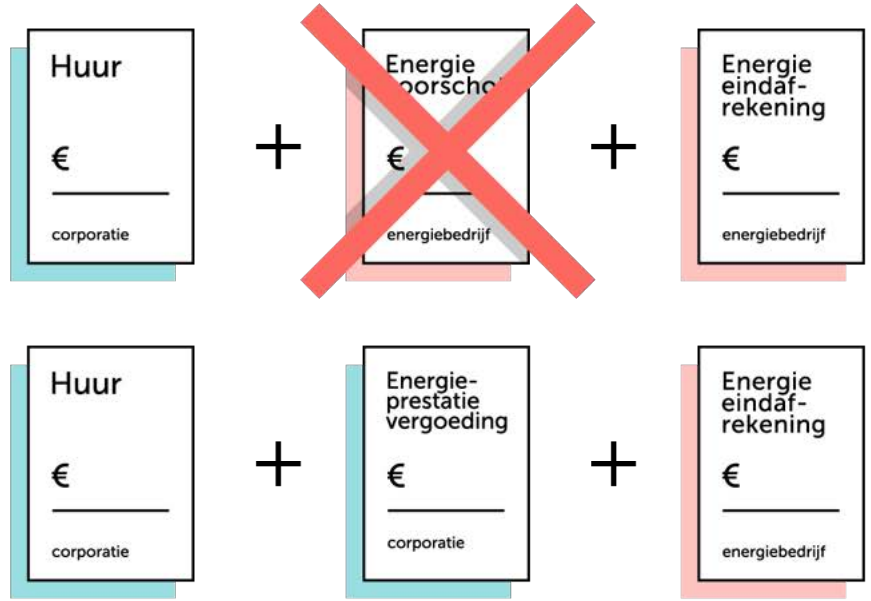
Energy Contracting

Between tenants and housing association

Based on

- Zero energy costs to Energy Supplier
- EPV: Energy performance subsidy





Energy Contracting

Energy performance subsidy covers the thermal energy

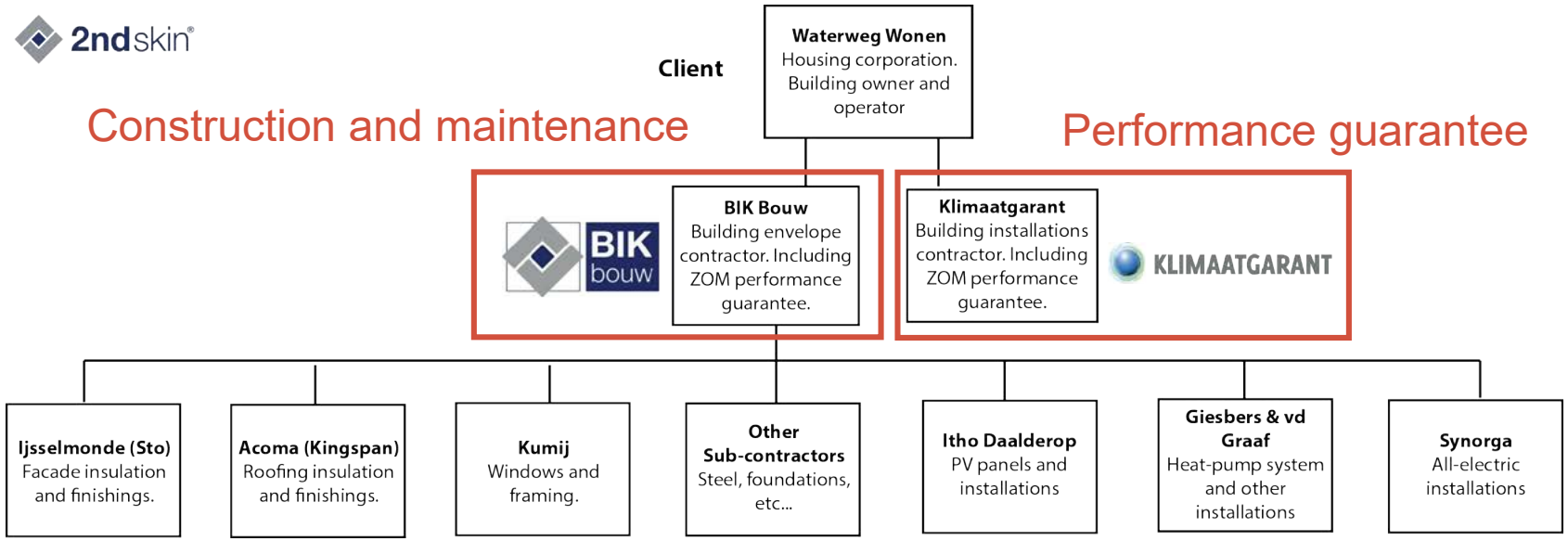
Appliances and lighting through PV production

Total energy budget
1800 Kwh

Heating 966 Kwh
78 lt DHW/day

Business Models

Current organisation

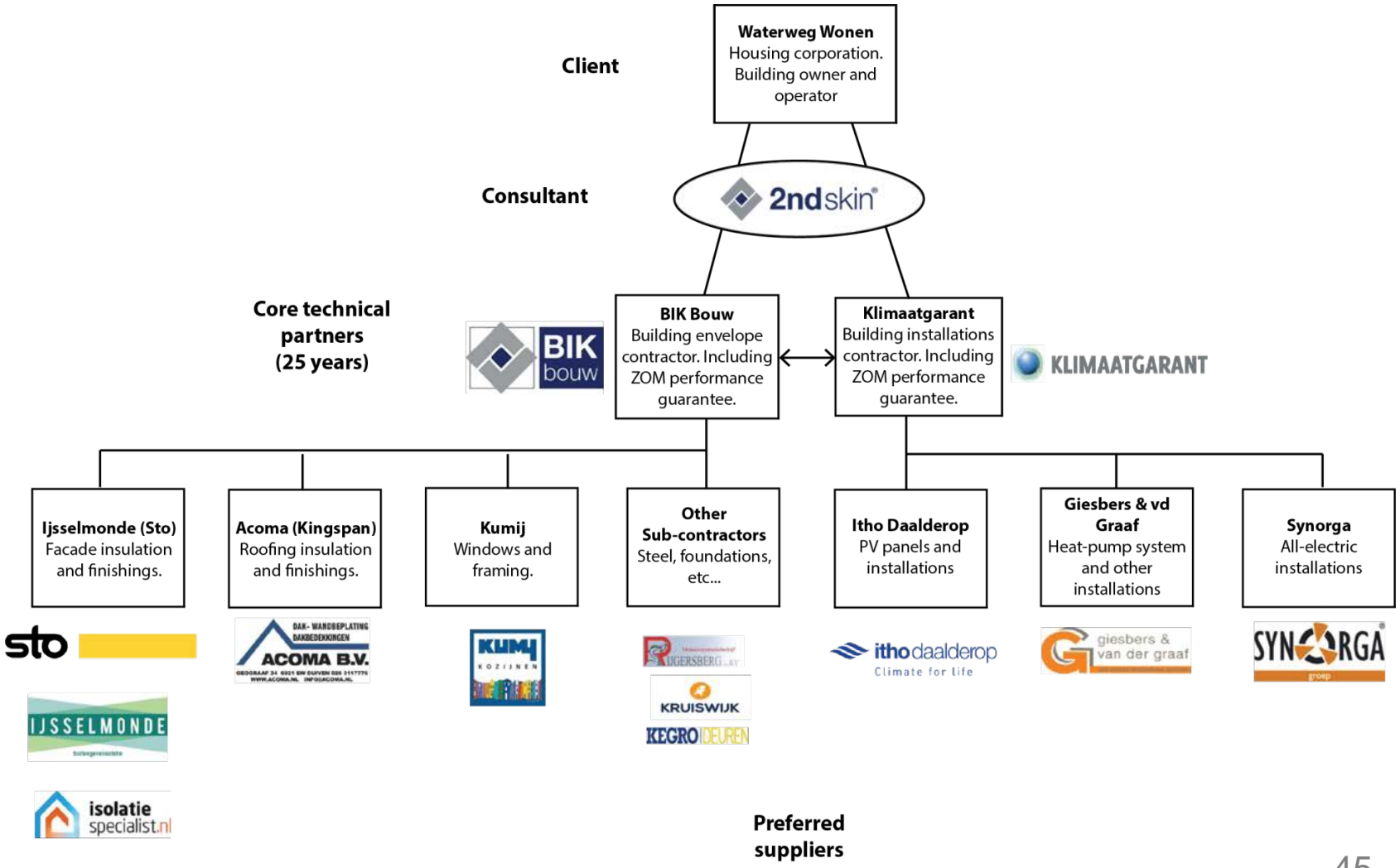


Proposed organization

Integral solution

Energy contract to be supplied by a central organization 2ndSKin

“One-stop-shop” for the building owner

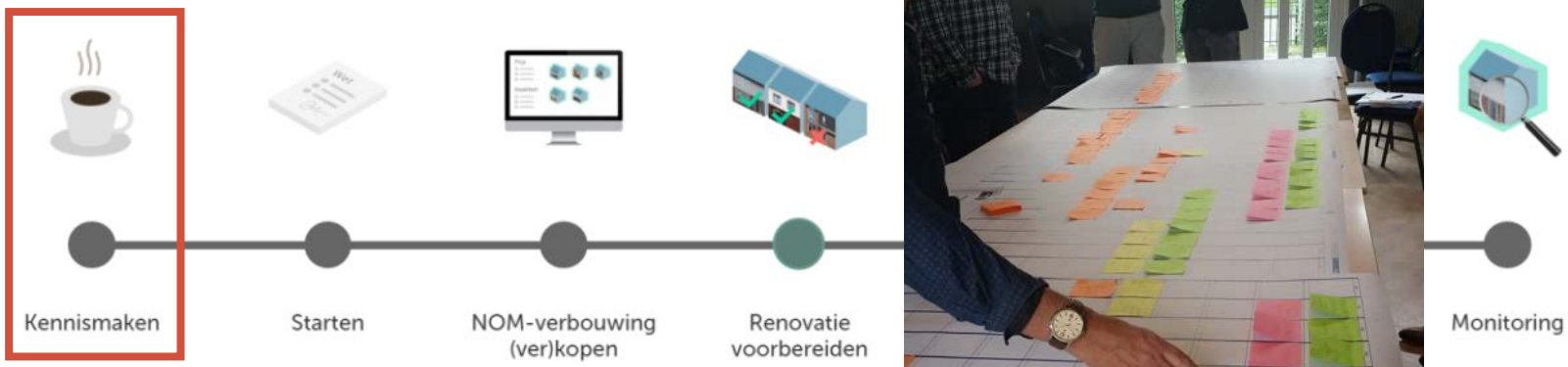


The role of the user

Acceptance and participation

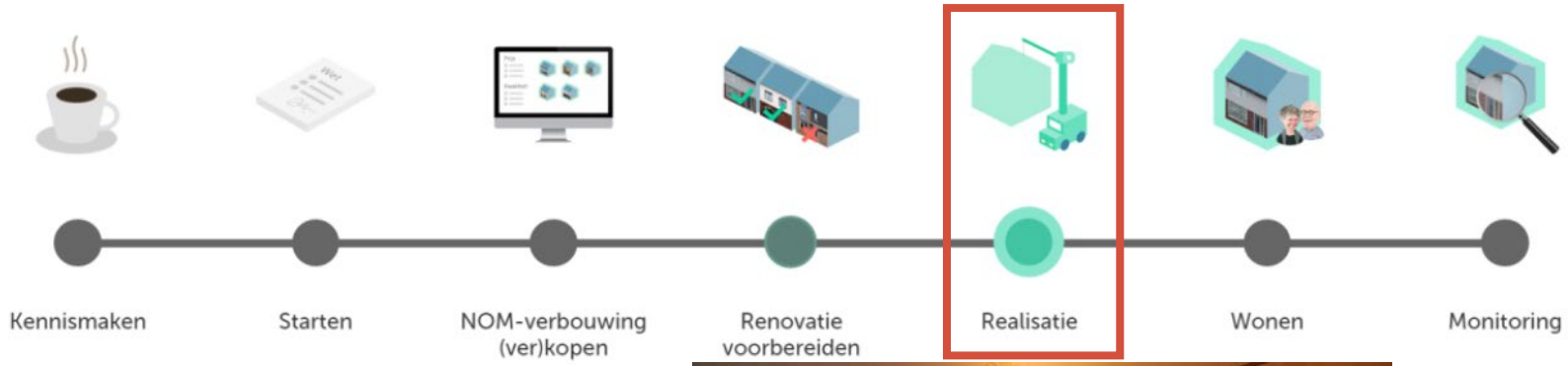
Series of appointments

- Renovation
- Planning
- Energy contracts



Realisation

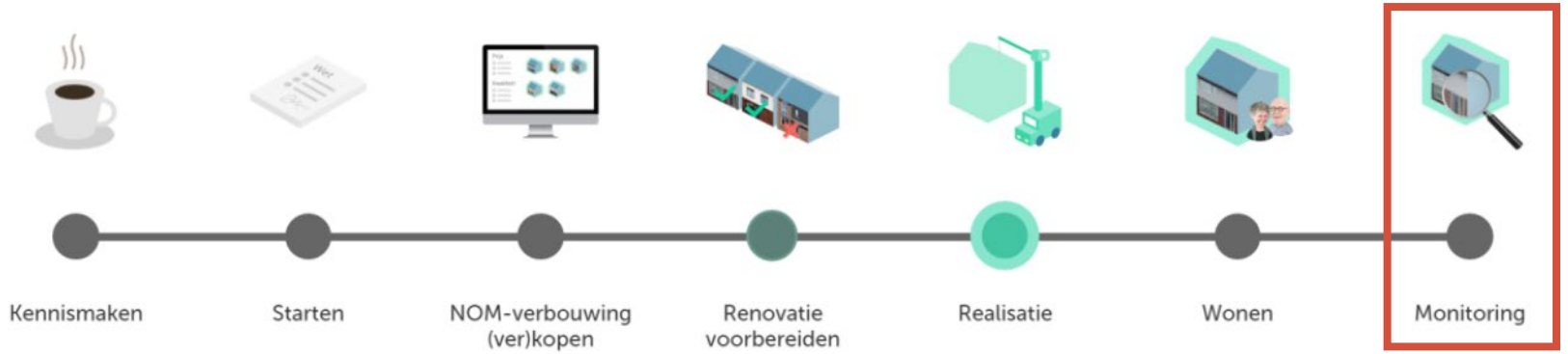
Continue living during the renovation



Monitoring

Currently ongoing

- Energy use
- Comfort questionnaires



Realised renovation

Zero energy retrofitting

- Zero energy refurbishment is achievable with current technology
- Potential for product development
- Business model with energy contracting
- Role of the user
- Main restriction is the high investment

Potential for upscaling

- Stepped renovation (NOM-ready, no-regret)
- Prefabrication and integration
- Alternative building systems
- Low temperature
- Synergy between building and district

Refurbishment is an integral part of buildings' lifecycle and it going to happen.

The challenge is to realise this task efficiently and effectively

Thank you for your attention

Thaleia Konstantinou, Dr.Ing.
t.konstantinou@tudelft.nl

Department Architectural Engineering+Technology

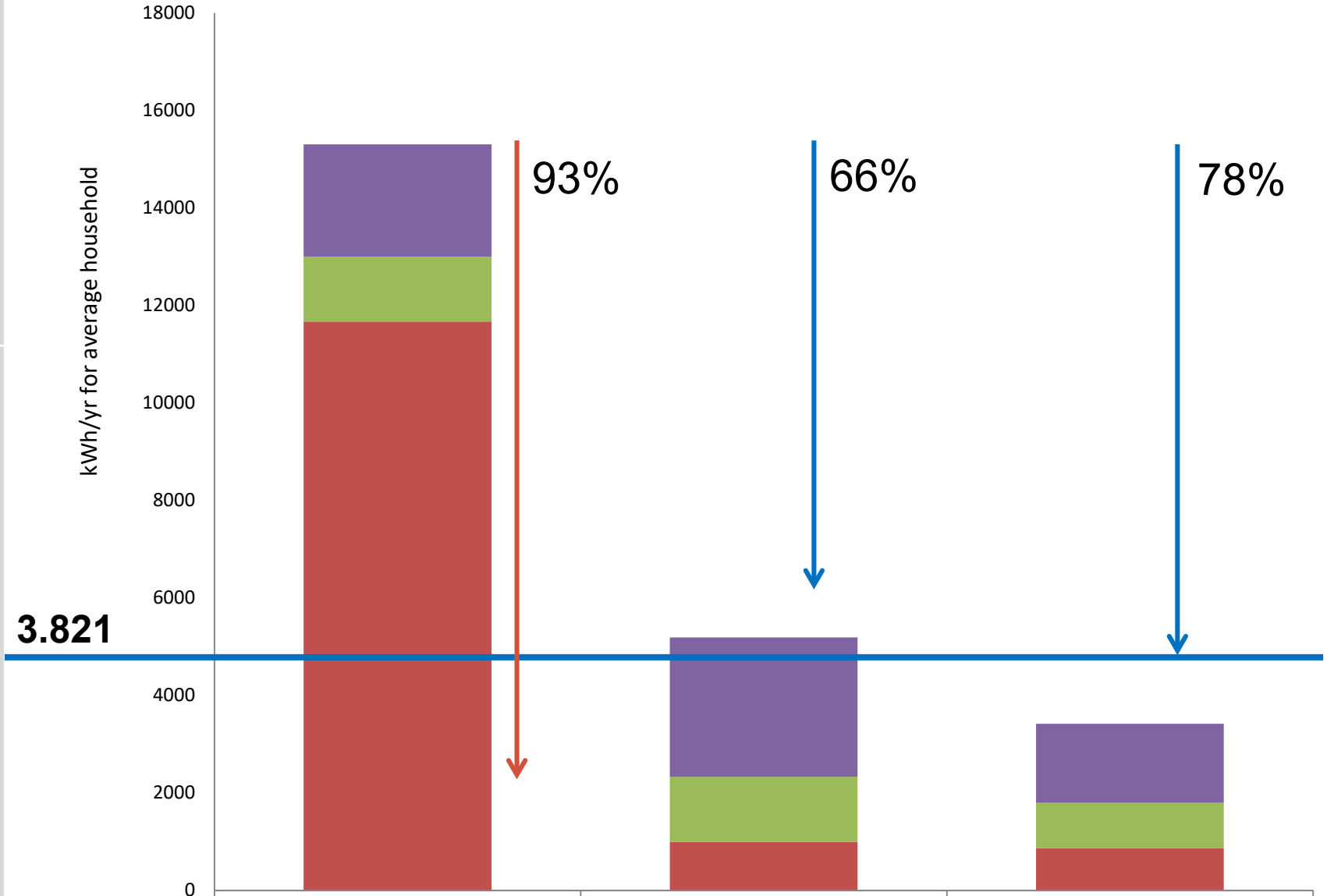
Faculty of the architecture and the Built Environment

TU Delft Delft University of Technology

Energy Performance

Zero-energy target can indeed be met, for specific cases

Heating demand can be covered



	Before renovation (apartment blocks, based on WoON)	After renovation (scenario 1. inefficient appliances, unchanged behavior)	After renovation (scenario 2. efficient appliances,heat recovery shower, adapted behavior)
Appliances	2306.6	2861.2	1625
DHW	1333.11	1333.11	933.18
Heating	11671.0026	997.9	862.5

Financial feasibility

- Positive financial performance
- Considering parameters beyond the energy savings

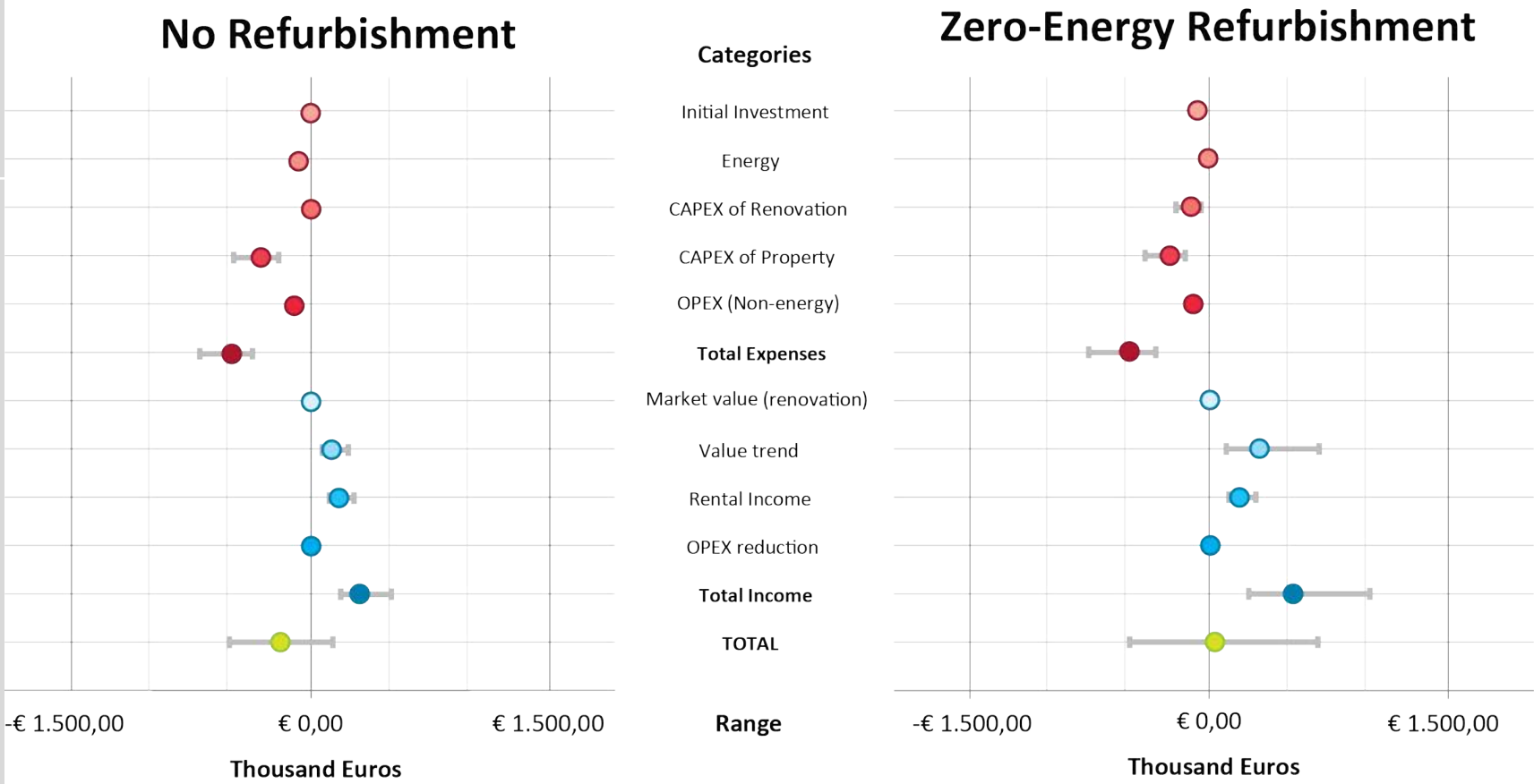


Fig. 6. Financial breakdown, over a 30-year period, of a non-refurbished and a zero-energy refurbished apartment.

TRANSFORMING
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ENERGY AND THE BUILT ENVIRONMENT: THE STATE OF PAY IN AUSTRALIA

Scientia Professor Deo Prasad AO FAIA

CEO, Co-operative Research Centre for Low Carbon Living

Energy & the built environment

The state of play in Australia

Prof Deo Prasad

Contents

Energy in buildings – Australian context

- Mandatory measures
- State Government - Victoria
- New South Wales
- Voluntary measures
  - Tools

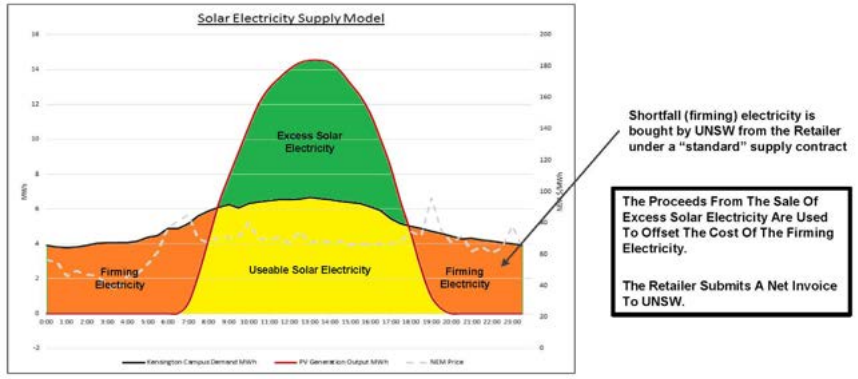
Climate emergency led Initiatives

- Australian Institute of Architects

High rise timber construction

Towards pre-fabrication/modularisation

Off-site renewable generation



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UNSW signs world-first solar energy agreement

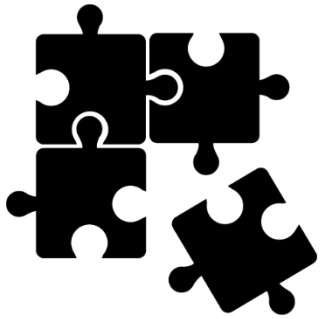
15 JAN 2018 | CATHARINE HEFFERNAN

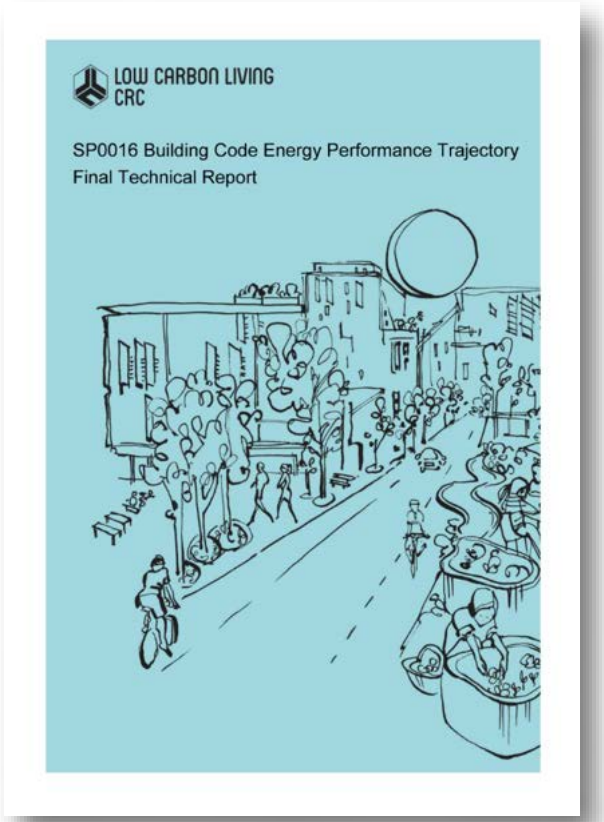
In the first deal of its kind in the world university sector, UNSW has reached an agreement with Maoneng Australia and Origin Energy to have 100% of its energy supplied by photovoltaic solar energy.

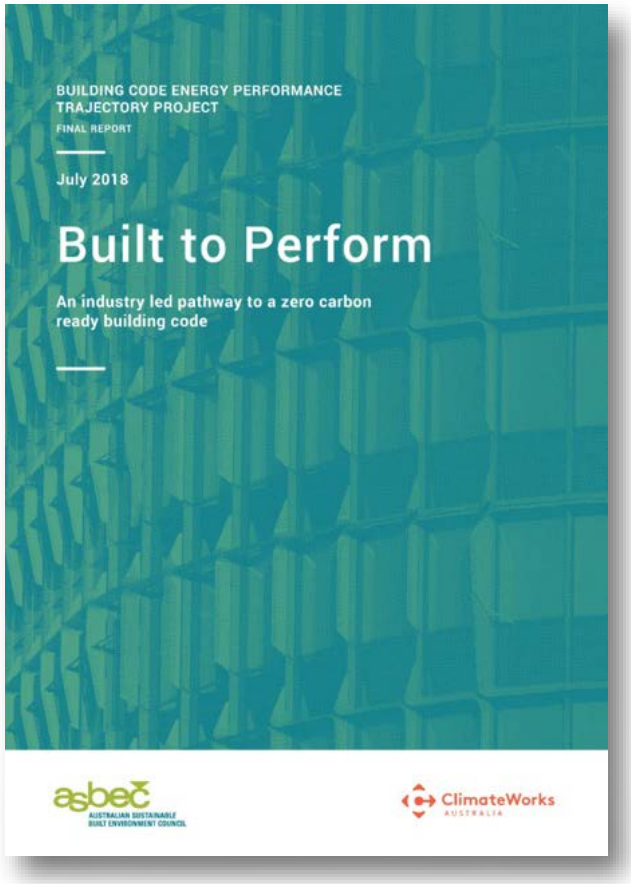
Mugga Lane Solar Park in the ACT, owned by Maoneng Australia, generates about 25,000 MWh per annum. Photo: Supplied

Building Code energy performance trajectory

One piece of the puzzle unlocking the NCC's full potential



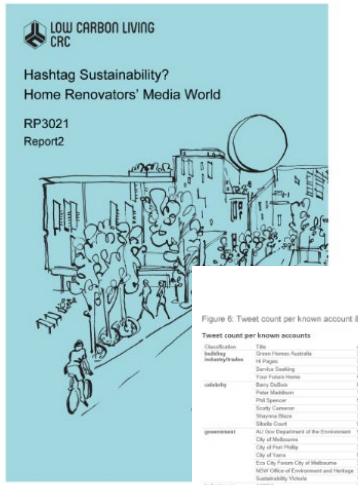




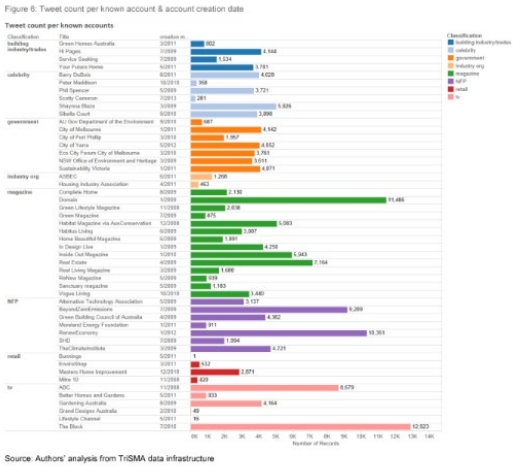
Josh's House

ZERO ENERGY HOME KICK-STARTS $2.18 MILLION ENERGY-EFFICIENCY PILOT PROGRAM

TRANSFORMING CONSTRUCTION NETWORK PLUS

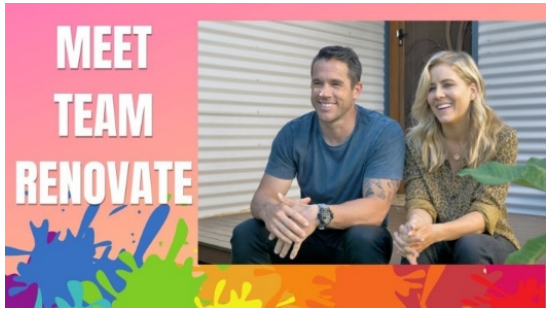


RENOVATE OR REBUILD

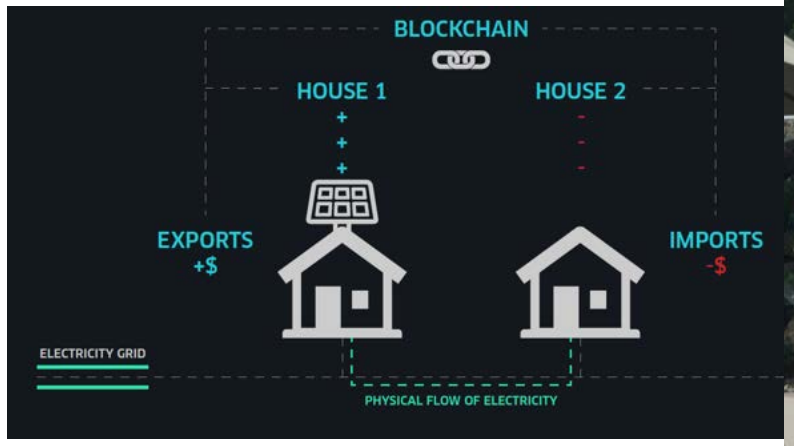


RENOVATE OR REBUILD Crew

28 May



POWER LEDGER



Review of RIBA and ASBEC Guides

Principles/methods to achieve 2030 goal

RIBA: Sustainable Outcome Guide

UKGBC Net Zero Framework
(1) Fabric First
(2) Efficient services, and low-carbon heat
(3) Maximise onsite renewables
(4) Minimum offsetting using UK schemes (CCC)
……

Move further to achieve zero carbon
(1) Offsite renewables

ASBEC: Built to Perform

(1) Increased insulation
(2) Increased thermal mass
(3) Efficiency improvements in air conditioning equipment and lighting
(4) Better lighting control
(5) Better air tightness and overnight ventilation
(6) Perimeter zone daylight harvesting
(7) Light-coloured external walls (mostly warmer climates)
……..

Move further to achieve zero carbon
(1) Best practice design
(2) On-site renewable energy
(3) Improved appliance efficiency
(4) Decarbonised grid electricity supply

Review of LETI Climate Emergency Design Guide

TRANSFORMING CONSTRUCTION NETWORK PLUS

Metrics and outcomes

Operational Energy

1 Design for and achieve the **energy use intensity** (EUI) targets:

- 35 kWh/m².yr — Residential
- 55 kWh/m².yr — Offices
- 65 kWh/m².yr — Schools

2 Design for and achieve the **space heating demand** target:

- 15 kWh/m².yr — All building types

3 Maximise **renewable energy generation** on-site:

- Small scale resi: Generate 100% of annual energy requirement on-site
- Medium and large scale resi: Cover 70% of roof area
- Offices: Generate the annual energy requirement for at least two floors of the development on-site
- Schools: Cover 70% of the roof area

Embodied Carbon

1 Meet upfront embodied carbon emission targets for building elements:

	Baseline	Best practice 2020	Best practice 2030
Domestic	800 kgCO₂/m²	<500 kgCO₂/m²	<300 kgCO₂/m²
		Equiv. to 40% reduction over baseline	Equiv. to 65% reduction over baseline
		30% materials from re-used sources	50% materials from re-used sources
		50% materials can be re-used at end of life	80% materials can be re-used at end of life
Non-domestic	1000 kgCO₂/m²	<600 kgCO₂/m²	<350 kgCO₂/m²
		Equiv. to 40% reduction over baseline	Equiv. to 65% reduction over baseline
		30% materials from re-used sources	50% materials from re-used sources
		50% materials can be re-used at end of life	80% materials can be re-used at end of life

2 Upfront embodied carbon emissions to be verified post-construction.

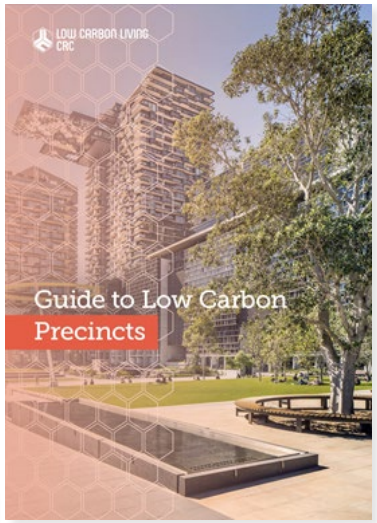
Forte, Melbourne

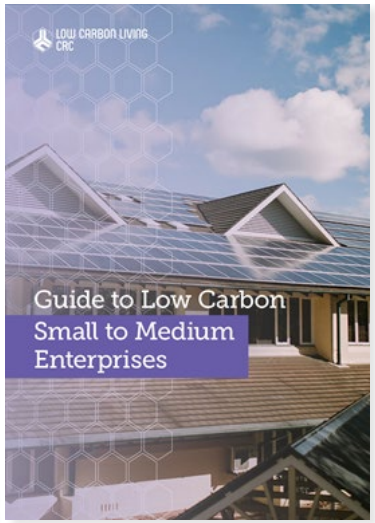
- World's *no longer* tallest timber building (9 storeys)
- Uses Cross Laminated Timber (CLT)
- Timber from certified sustainably managed forests
- Time savings and increased efficiencies
- Higher precision, design flexibility and customisation
- Reduced embodied carbon emissions (1400 tons or 345 cars off the road) compared to equivalent steel/concrete building
- Reduced impact of construction on local communities
- Aspiring to be the first 5 Star Green Star As Built Residential building

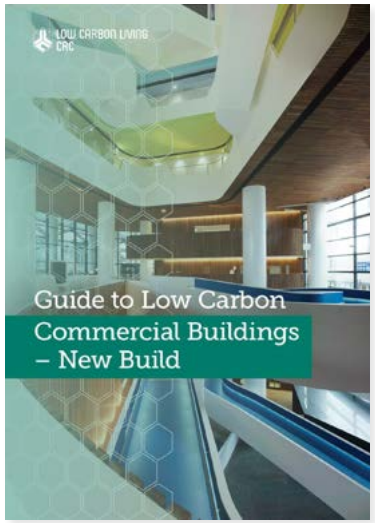
International House, Sydney

- Land Lease Headquarters
- Australia's first engineered timber office building at Barangaroo
- 6,850 sqm NLA across Six storeys
- Designed by Alec Tzannes and Jonathan Evans
- Uses Cross Laminated Timber (CLT) and glue laminated timber (Glulam)
- Production process with zero waste
- Timber sourced from certified sustainably managed forests (where?)
- Completion in 2017
- Committed A$1 bn to Design Make start-up for a prefab building component factory in Western Sydney

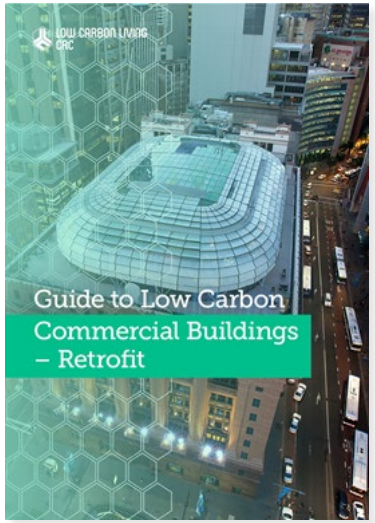
Next at UNSW

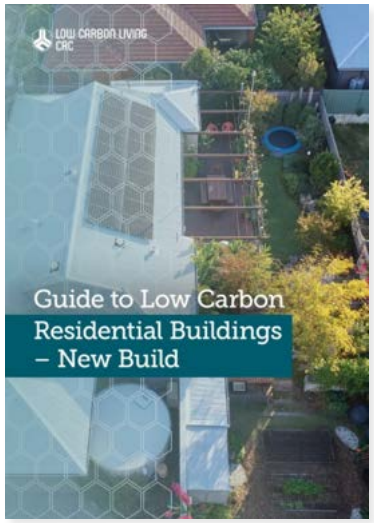

LOW CARBON LIVING CRC
Guide to Low Carbon
Precincts


LOW CARBON LIVING CRC
Guide to Low Carbon
Small to Medium
Enterprises


LOW CARBON LIVING CRC
Guide to Low Carbon
Commercial Buildings
– New Build

LOW CARBON LIVING CRC
Guide to Low Carbon
Residential Buildings
– Households


LOW CARBON LIVING CRC
Guide to Low Carbon
Commercial Buildings
– Retrofit


LOW CARBON LIVING CRC
Guide to Low Carbon
Residential Buildings
– New Build

OFFSITE CONSTRUCTION / PREFAB: THE STATE OF PAY IN AUSTRALIA

Dr Malay Dave

Sessional academic, University of New South Wales, Australia

Offsite construction / Prefab

The state of play in Australia

Dr Malay Dave

Contents

Promise vs reality of prefab

Collaborative research

Recent challenges and future directions

Key insights

Promise of prefab

Increased

- **thermal performance** (building envelope tightness)
- construction **quality** control
- work **safety**
- overall **productivity**
- overall **sustainability**
- applicability for **remote locations**

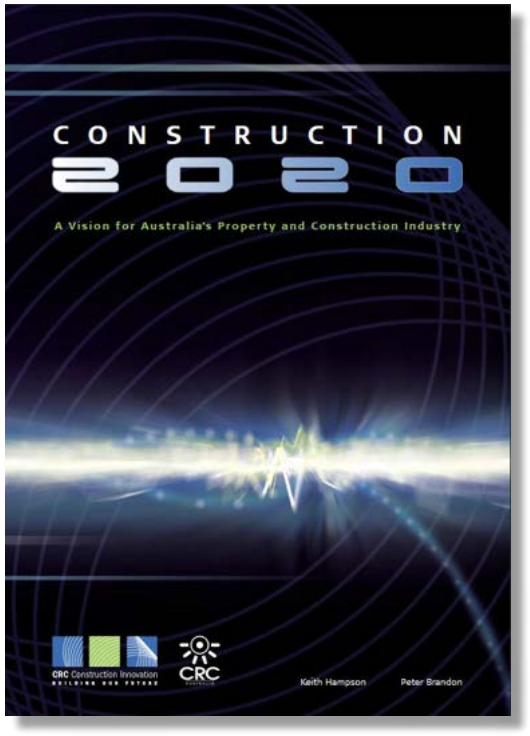
Decreased

- project schedules / **time**
- project budgets / **cost**
- construction **waste** (increased reuse and recycling)
- disturbances and **impacts** on the site and surrounding

Reality of prefab

- Recognised in Vision 2020 documents
  - UK: ConstructionSkills, 2008,
  - Australia: Hampson and Brandon, 2004

- Prefab remains in its infancy in Australia
- Still 3-5% of construction industry (A$150bn)
- 15% (A$180bn) by 2025?



Key barriers

- **Cost** vs value
- Market **size** is small and fragmented – economies of scale
- Market **culture**: Consumer preference and negative perception (Design quality)
- **Industry** awareness and skills
- Low investment in **R&D**
- Initial factory set-up **capital** intensive
- And many more

Collaborative research

Nova Deko: Existing design

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Aim:

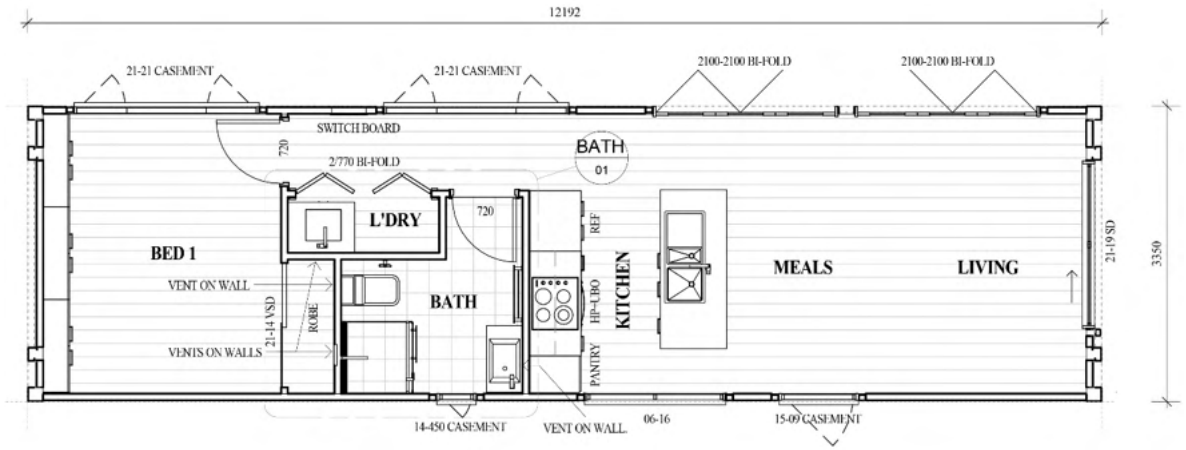
- High performance relocatable

Method:

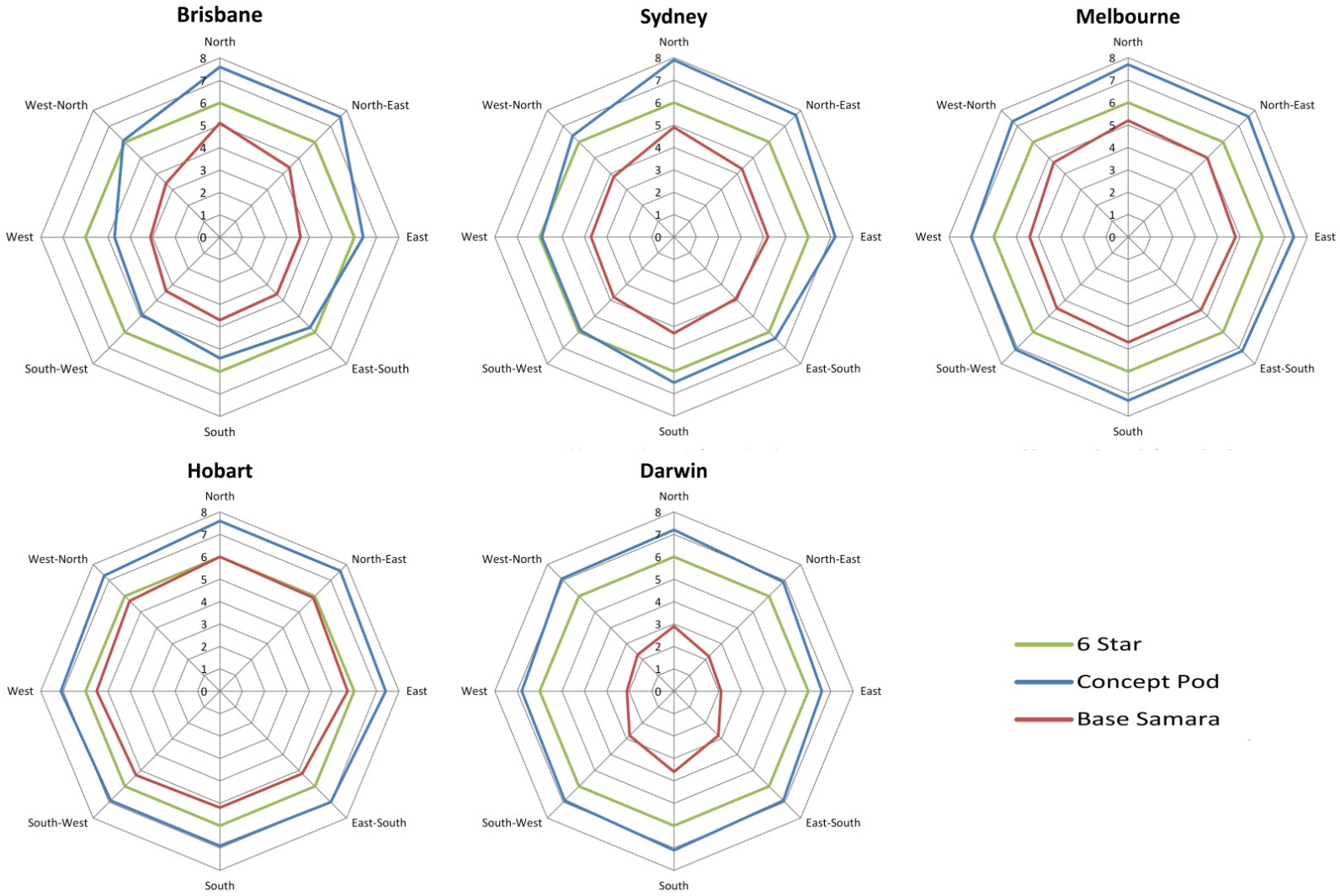
- Whole systems design
- AccuRate Sustainability
- Iterative optimisation / parametric study

Scope-Limitations:

- 5 key climates
- Shading, glazing and insulation



Orientation sensitivity analysis



Improved design & performance

Two overarching goals:

- Good Design
- High Performance

Approach:

- Desktop study: conceptPod to greenPod
- Onsite testing and monitoring
- Quality assurance during manufacturing

Outcome:

- Integrated design for efficiency (thermal, energy, water and waste)
- Mass customised product
- Advantages of prefab maximised
- Climate resilience

Thermal performance of final design

Location	North (Stars)	East (Stars)	South (Stars)	West (Stars)
Brisbane	8.6	7.8	6.9	6.3
Sydney	8.3	8.2	7.4	7.3
Melbourne	7.7	7.5	7.4	7.1
Hobart	8.2	8.1	7.7	7.9
Darwin	6.7	6.2	6.7	6.3

Recent challenges

Tektum

Strongbuild

ArchiBlox

Pressing ahead…

MODE Homes

Hickory Group

Future progress

Key insights

Greater collaboration between industry and academia

Greater emphasis on R&D

Affordability needs to go beyond first cost – Value

Sustainability needs to be embedded in systems

Importance of whole systems design

Project –> Product –> Process

THE TRANSFORMING CONSTRUCTION NETWORK PLUS

For general enquiries about the N+, please contact the network team:

enquiries.tcnetworkplus@ucl.ac.uk

Join our mailing list to hear about the latest N+ news, upcoming events, and funding opportunities:

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TRANSFORMING CONSTRUCTION NETWORK PLUS

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