Energy and indoor environment of Khf Stacken after passive house renovation with BIPV

Zack Norwood, Researcher, Göteborgs Universitet

Background

Million Program Building

- Built 1969
- Became Offices 1975
- Renovated to Co-housing 1980

Co-op bought building 2003

Kollektivhuset Stacken

Foto: Ola Höiden

Background

Foto: Ola Höiden

Deep Energy Retrofits

The “million program” needs to be renovated

Government’s Goal - Sweden carbon dioxide neutral 2045

Stacken’s goal - Renovate without rent increases

Foto: Ola Höiden

Deep Energy Retrofits

Profitable Strategy:

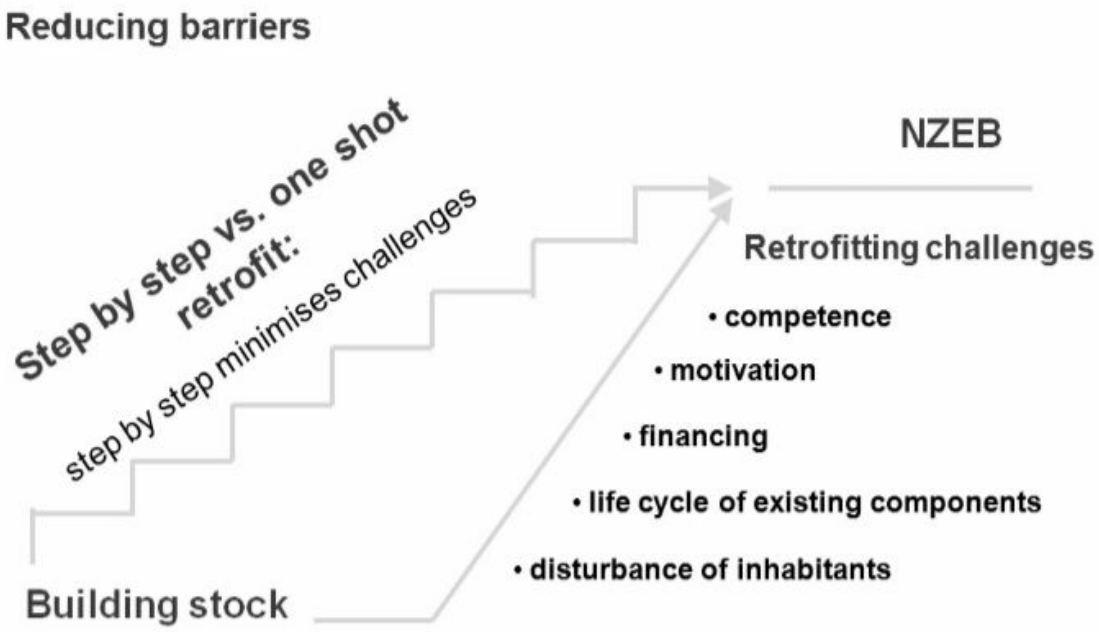
- Insulate and replace windows
- solar modules as facade elements

Sweden's building stock could produce more energy than it uses!

Foto: Ola Höiden

Deep Energy Retrofits

Step by step retrofits



Passive House Institute

EuroPHit

A long lasting energy focus

2008 - Energy group is formed

2009 - Energy convention
knowledge - discussion

Efficiency Decisions:
- New HRV ventilation
- Direct district heating

2013 - Attic insulation
- New radiator thermostats

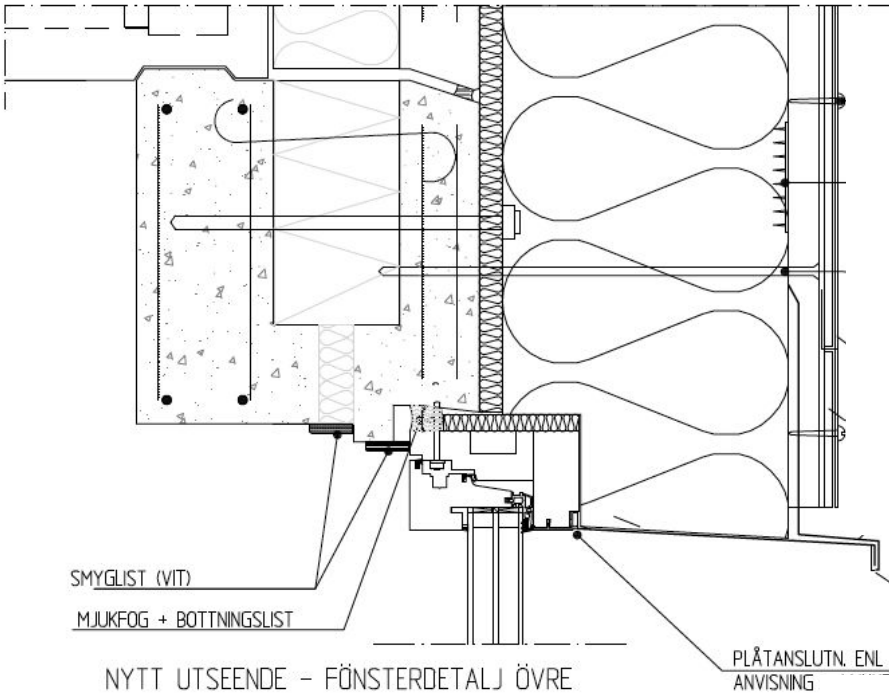
2014 - Energy calcs Passive House

2015 - Financing and permits

2016 - Budget approved
- Construction starts

Summer 2016

Summer 2017
Foto: Annika Söderlund



The renovation process

Building permit:

- Antiquarian's statement
- Drone scanning of the facade
- Concrete structural tests

Request for Bids:

- Tricky contract process
- Detail drawings

What is a Passive House?

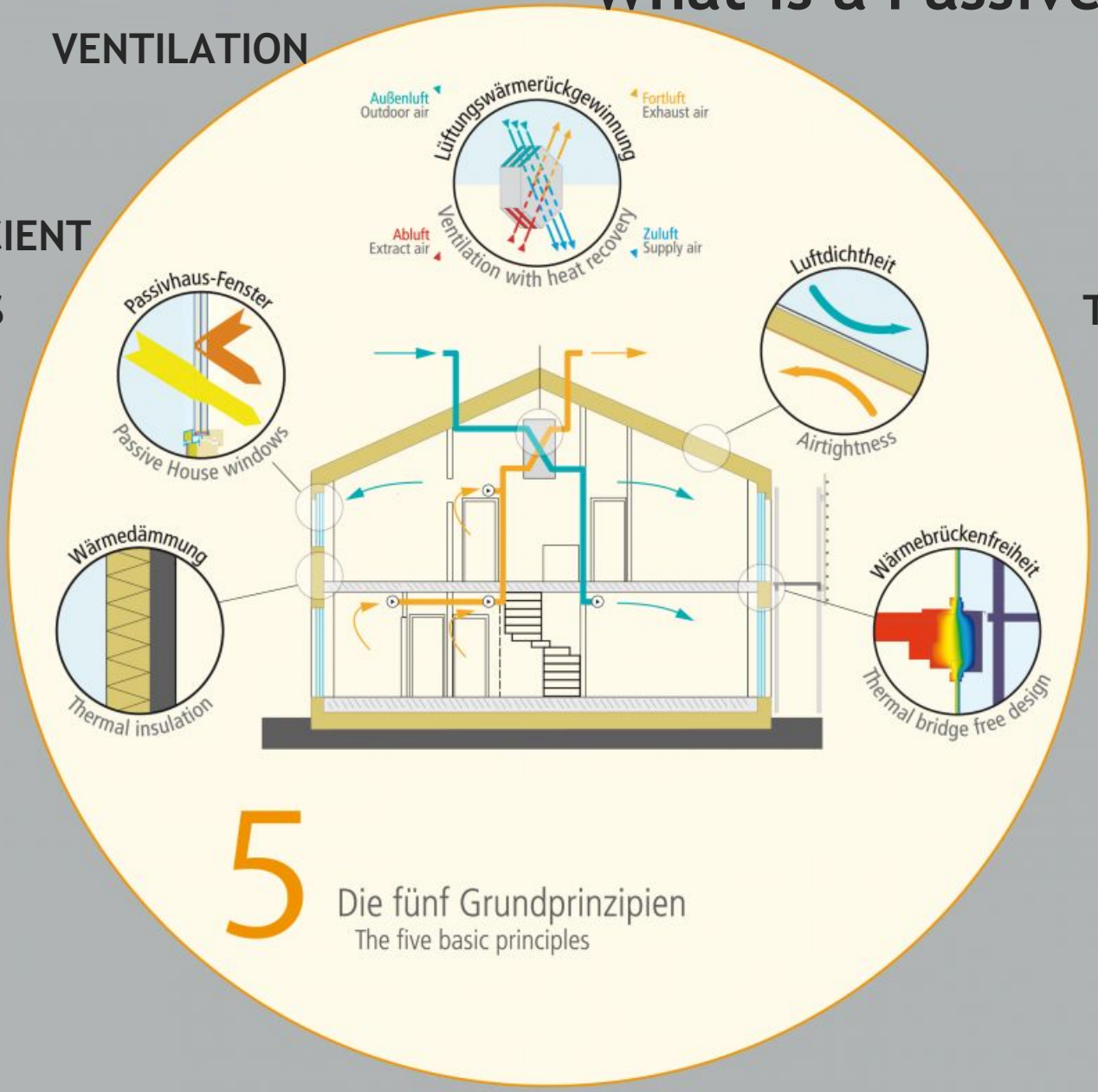
HEAT RECOVERY VENTILATION

ENERGY EFFICIENT WINDOWS

AIR TIGHTNESS

INSULATED THERMAL ENVELOPE

MINIMIZE THERMAL BRIDGES



Grafik | Graphic : © Passivhaus Institut | Passive House Institute

What is a Passive House?

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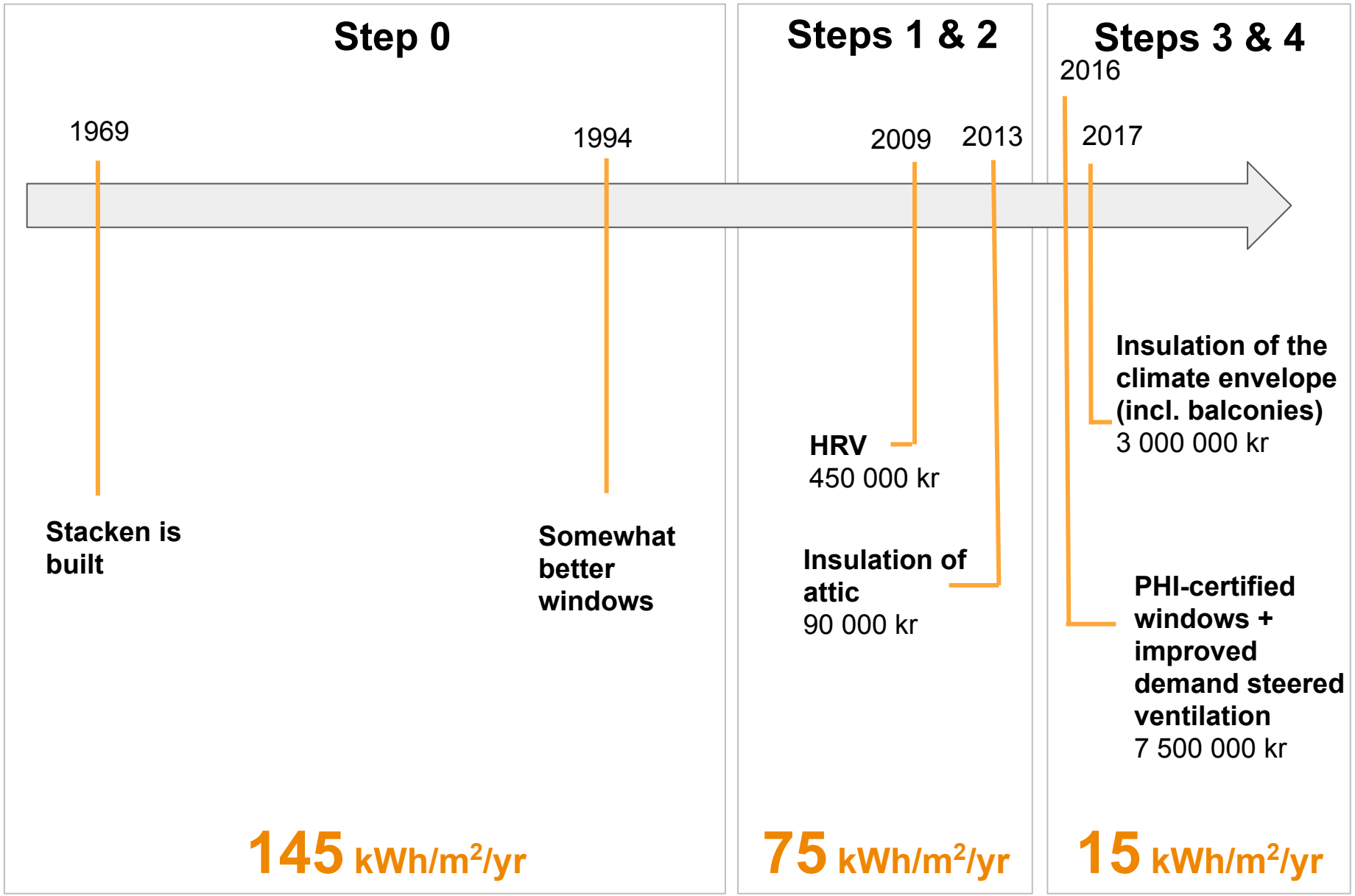
CRITERIA

1) **< 15 kWh/m^2/yr energy heating / cooling**
2) , or ≤ 10 W/m^2 power heating / cooling
3) ≤ 60 kWh/m^2/yr renewable primary energy
4) Air Tightness ≤ 0,6 ach/h at +/-50 Pa
5) High temperatures inside ≤ 10 %

Certified
Passive House
Passive House Institute

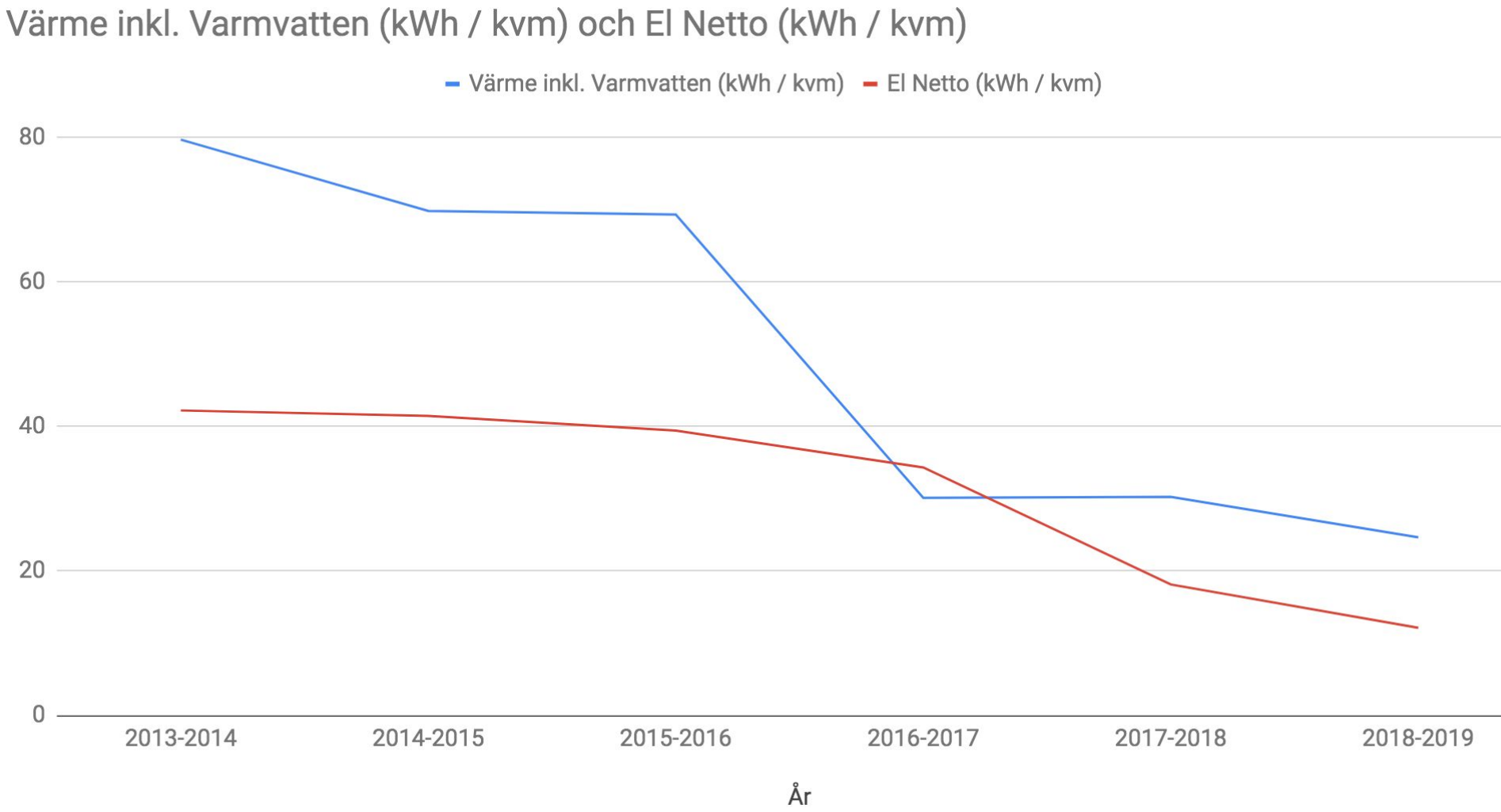
Stepwise Renovation



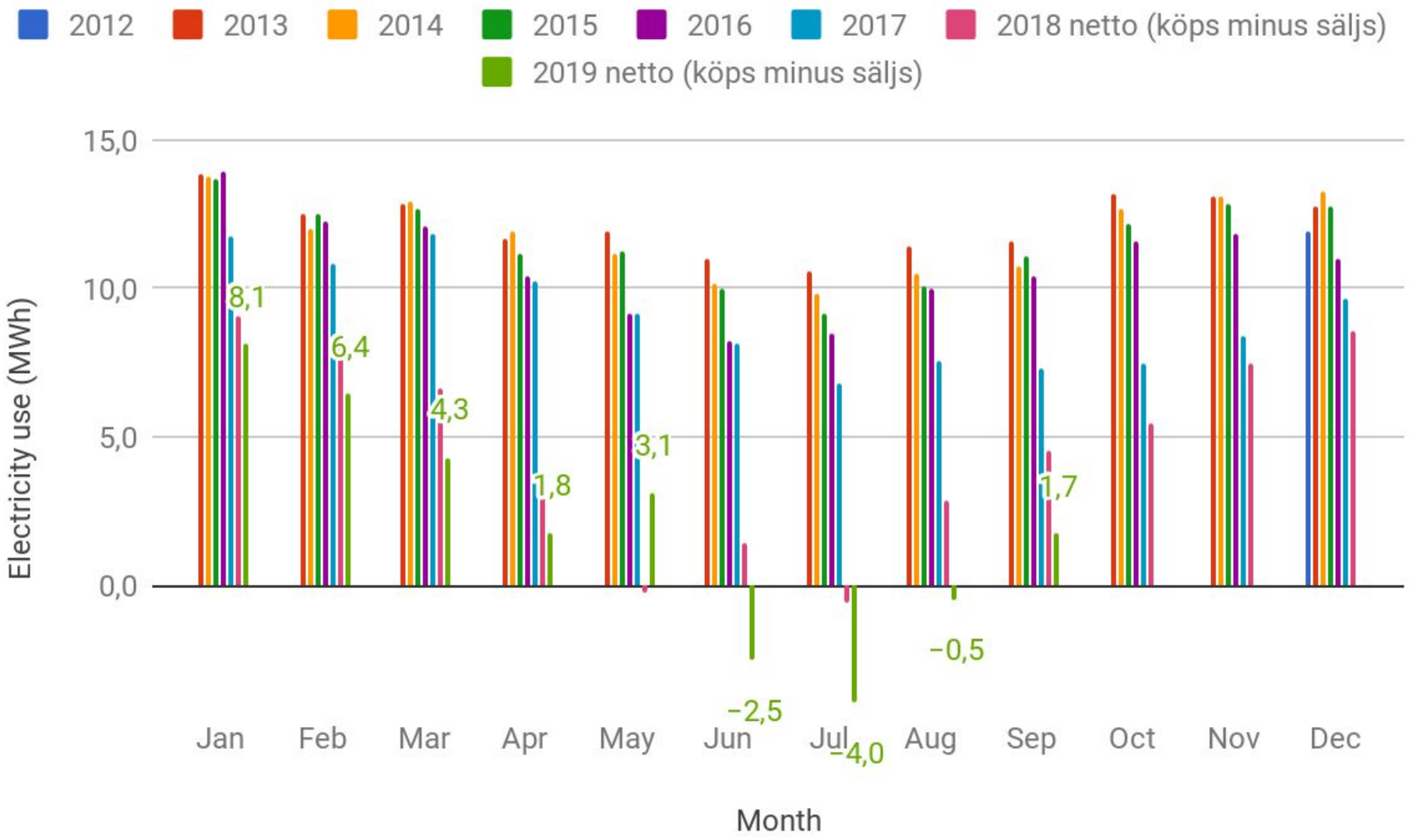
Stepwise Renovation

Steg 0 (1969, 1994)	Steg 1 (2009)	Steg 2 (2013)	Steg 3 (2016)	Steg 4 (2017)
Built in 1969, a (simple) triple-glazed window upgrade was implemented 25 years later.	Add a heat recovery ventilation (MVHR) unit; that since has been PHI-certified, with 85% heat recovery efficiency.	Insulate attic – 500mm cellulose insulation, resulting in a U-value of 0.079 W/(m2×K).	Install new PHI-certified windows [Uw-value ~ 0.7 W/(m2×K)] & sort out air tightness, upgrade MVHR control.	Insulate façade and include balconies into thermal envelope (adding 134m2 TFA and reducing thermal bridges); resulting U-value of external wall 0.102 W/(m2×K). Add BIPV to façade and roof
145 kWh/(m²×a) specific heating demand, 53W/m² specific heating load	**75 kWh/(m2×a)** specific heating demand, 33W/m2 specific heating load		**15 kWh/(m2×a)** specific heating demand, 11 W/m2 specific heating load	
	46,600 €	9,620 €	~300 000 €	~750 000 €

Historical Heating and Electricity Use



Electricity Use December 2012 - September 2019



Heat & Hot Water November 2012 - September 2019

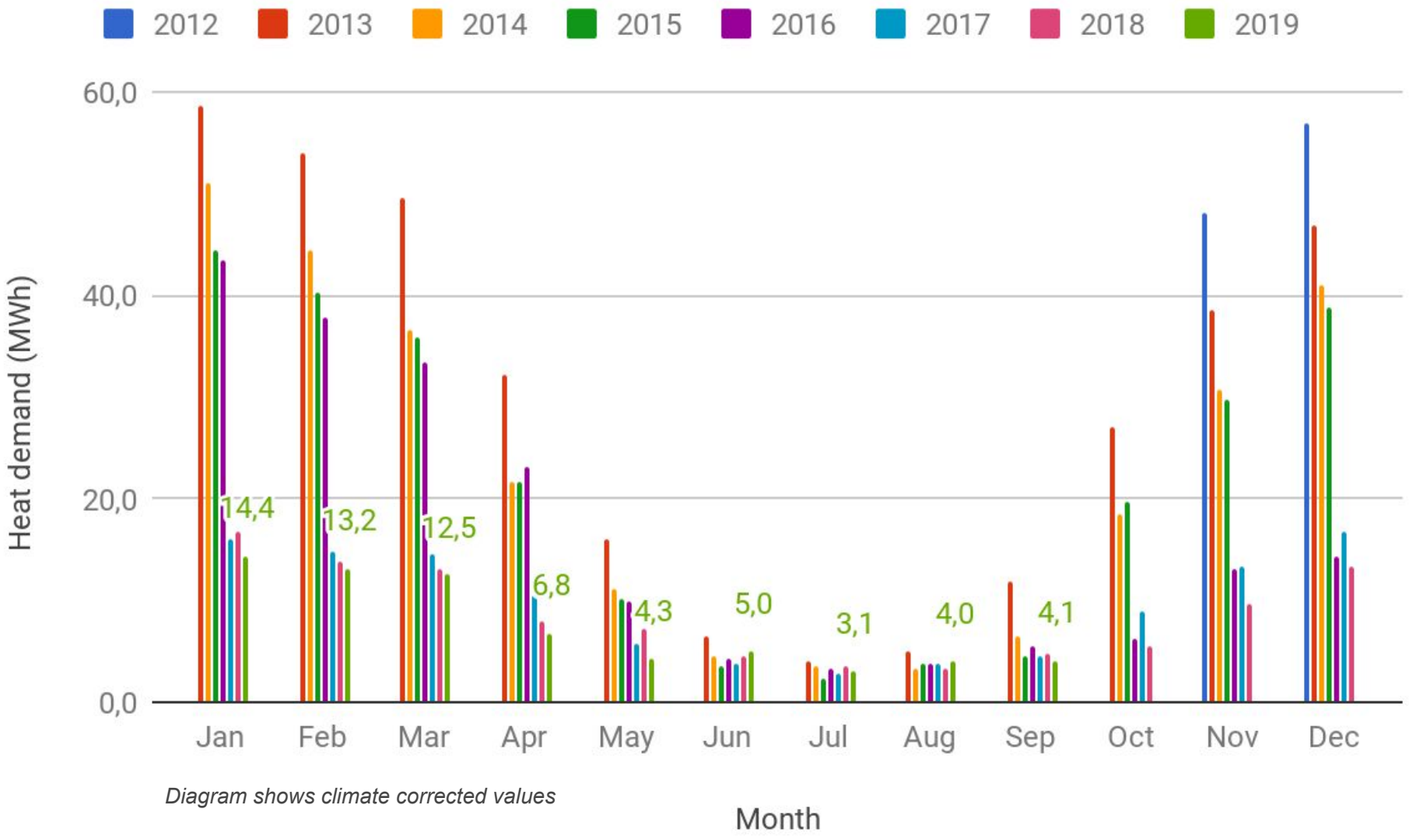


Diagram shows climate corrected values

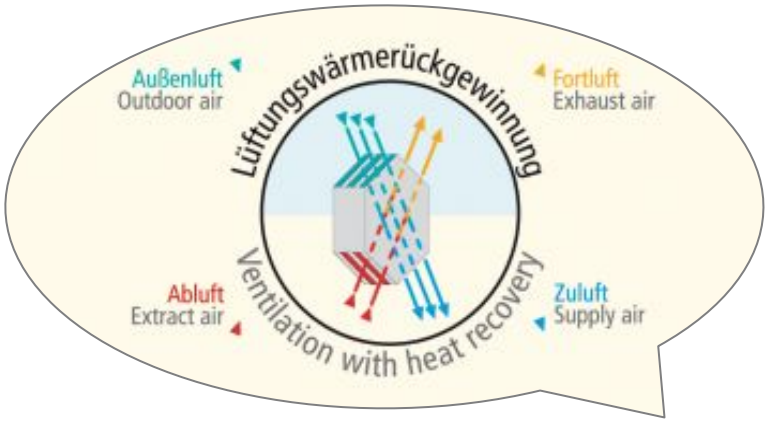
(Typical-year normalized)

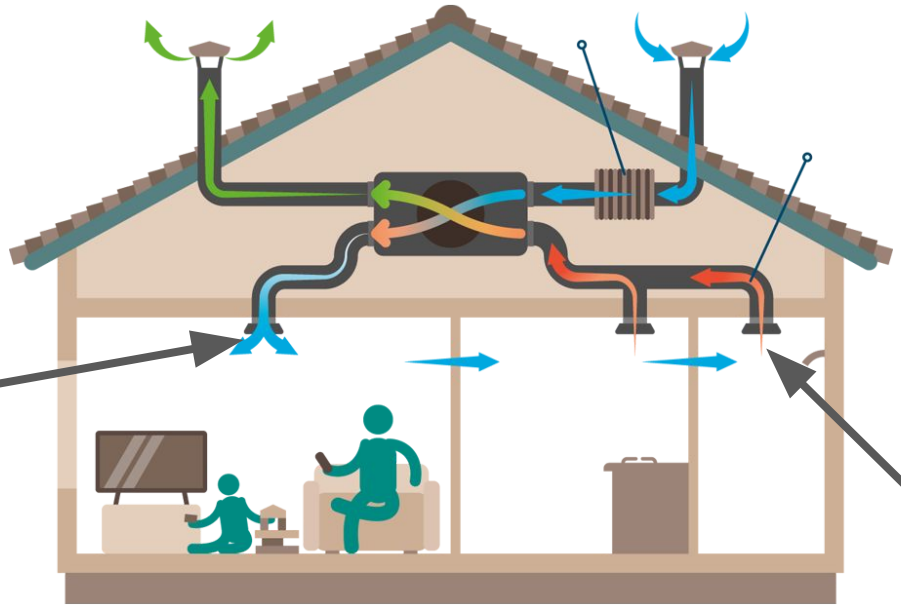
Demand Controlled Ventilation and HRV-system

HRV + Insulation of attic

=

50 % less heating energy use!





Non-active supply vents

Demand- controlled exhaust vents

https://www.energybuilding.se/ftx-system/

Control Strategy Ventilation

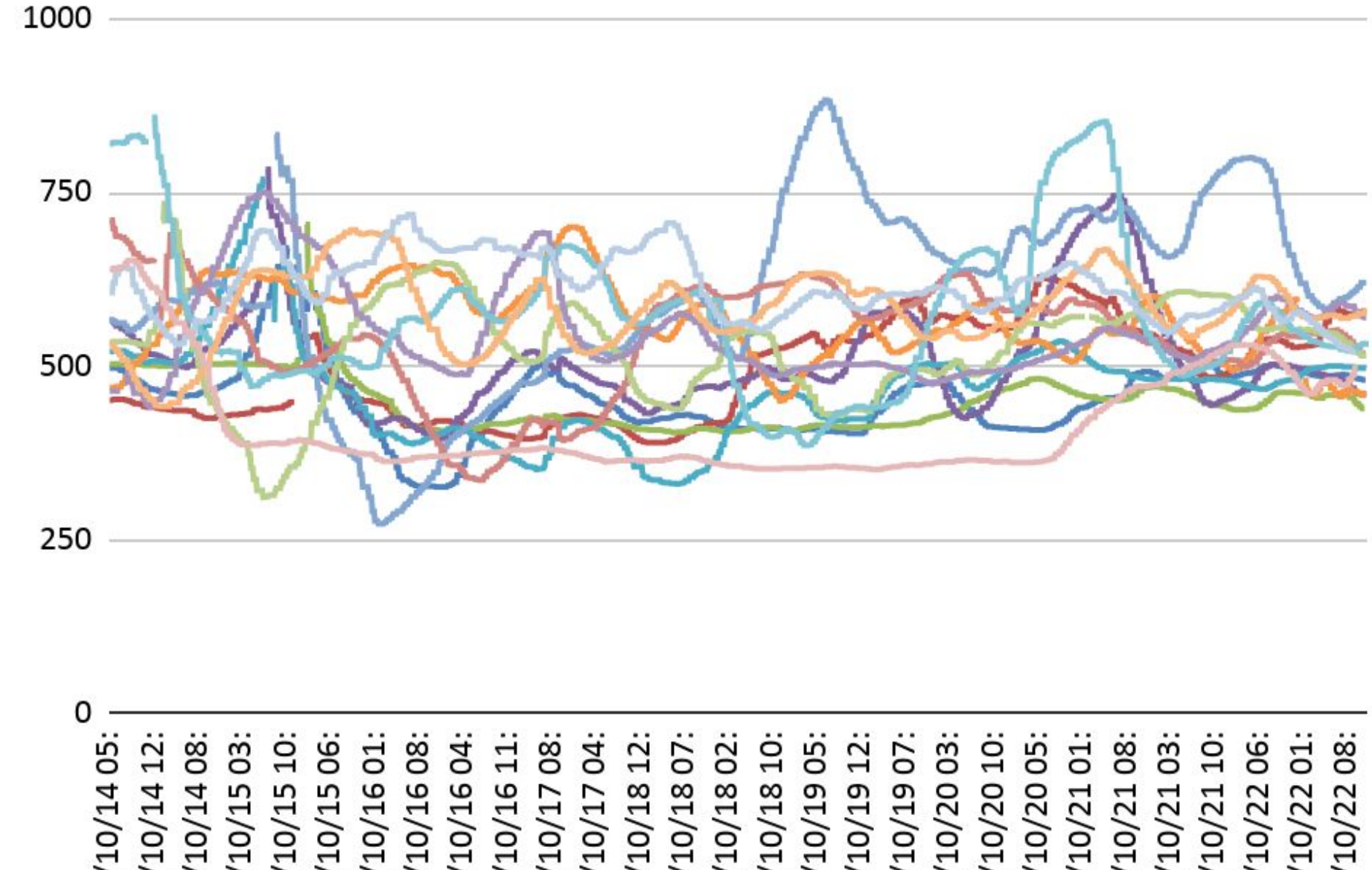
At HRV:

- Pressure controlled exhaust side (varying flow based on apartments need)
- Flow-slaved supply side (balanced supply and exhaust flow in the building)

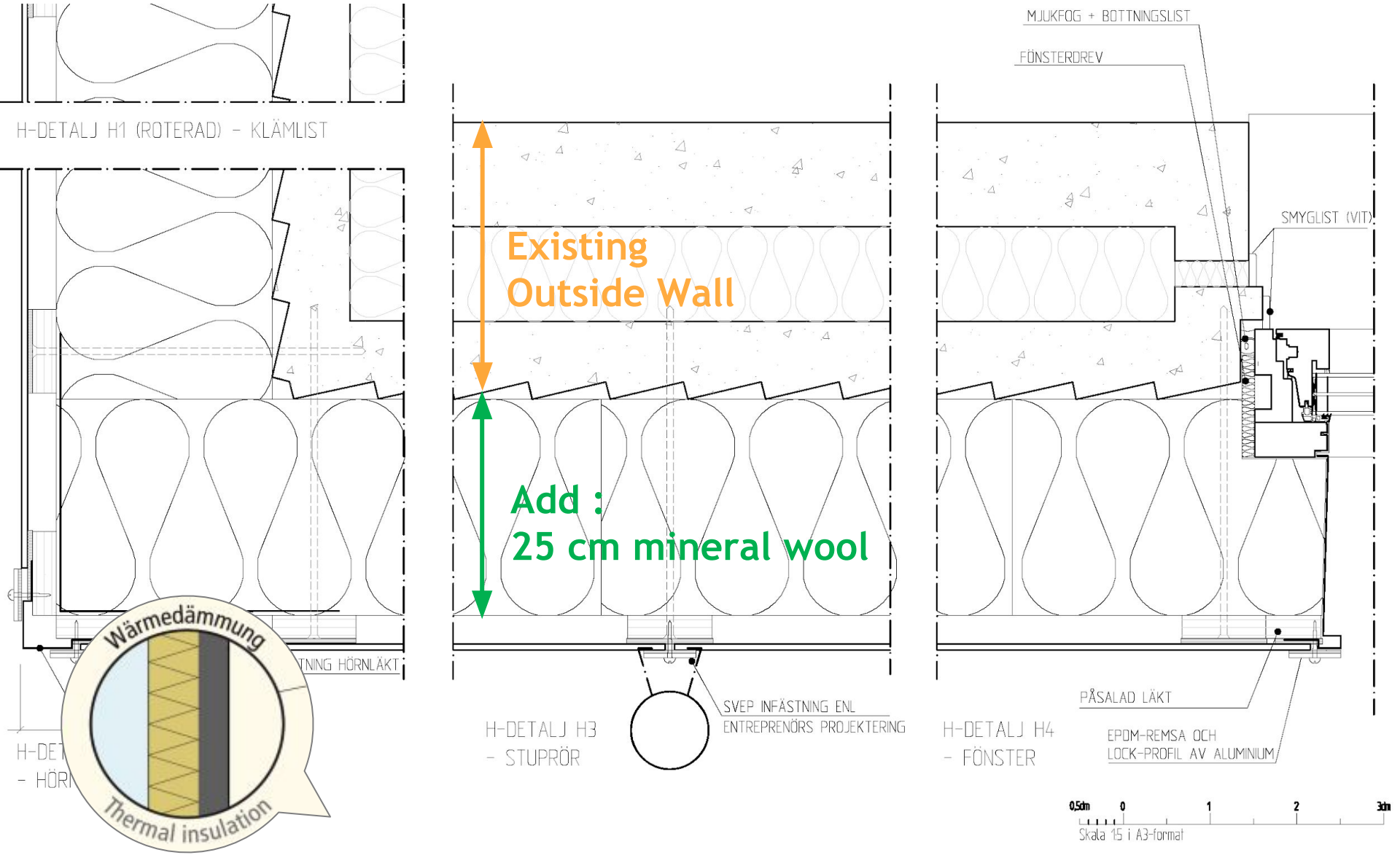
At Apartment:

- Exhaust forcing in bathroom with user control
- Exhaust forcing from kitchen with carbon dioxide above 1000 ppm
- Exhaust demand controlled starting from humidity above 37%
- Base flow of approx. 0.20-0.25 l/s per square meter
- Temporary local imbalance possible between exhaust and supply while maintaining balance in the building as a whole

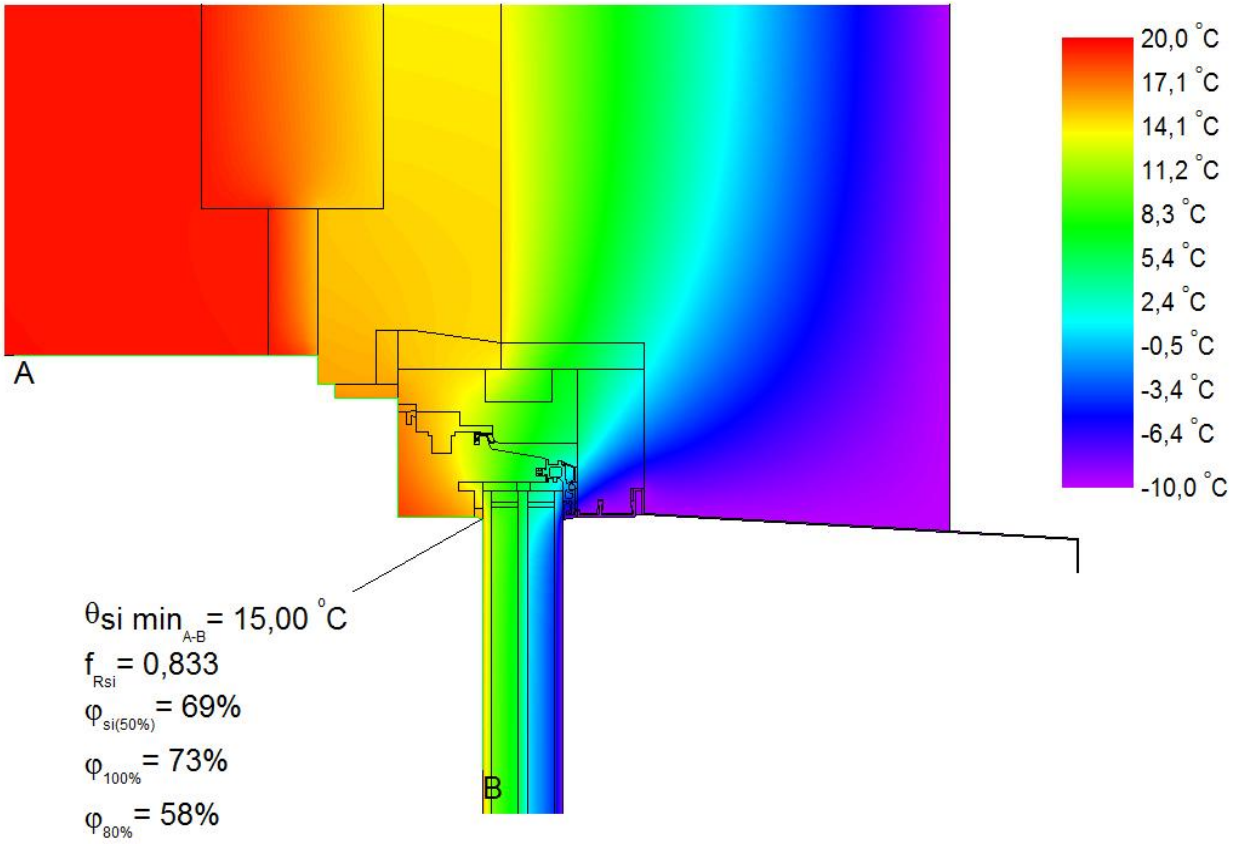
Carbon Dioxide concentration (ppm) in apartments during last week



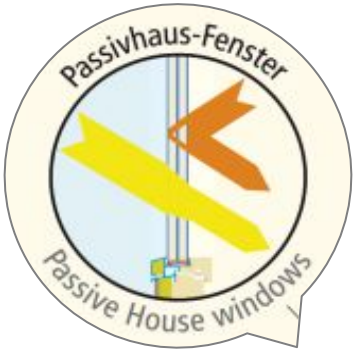
Insulation of the Climate Envelope



New PHI-certified Windows



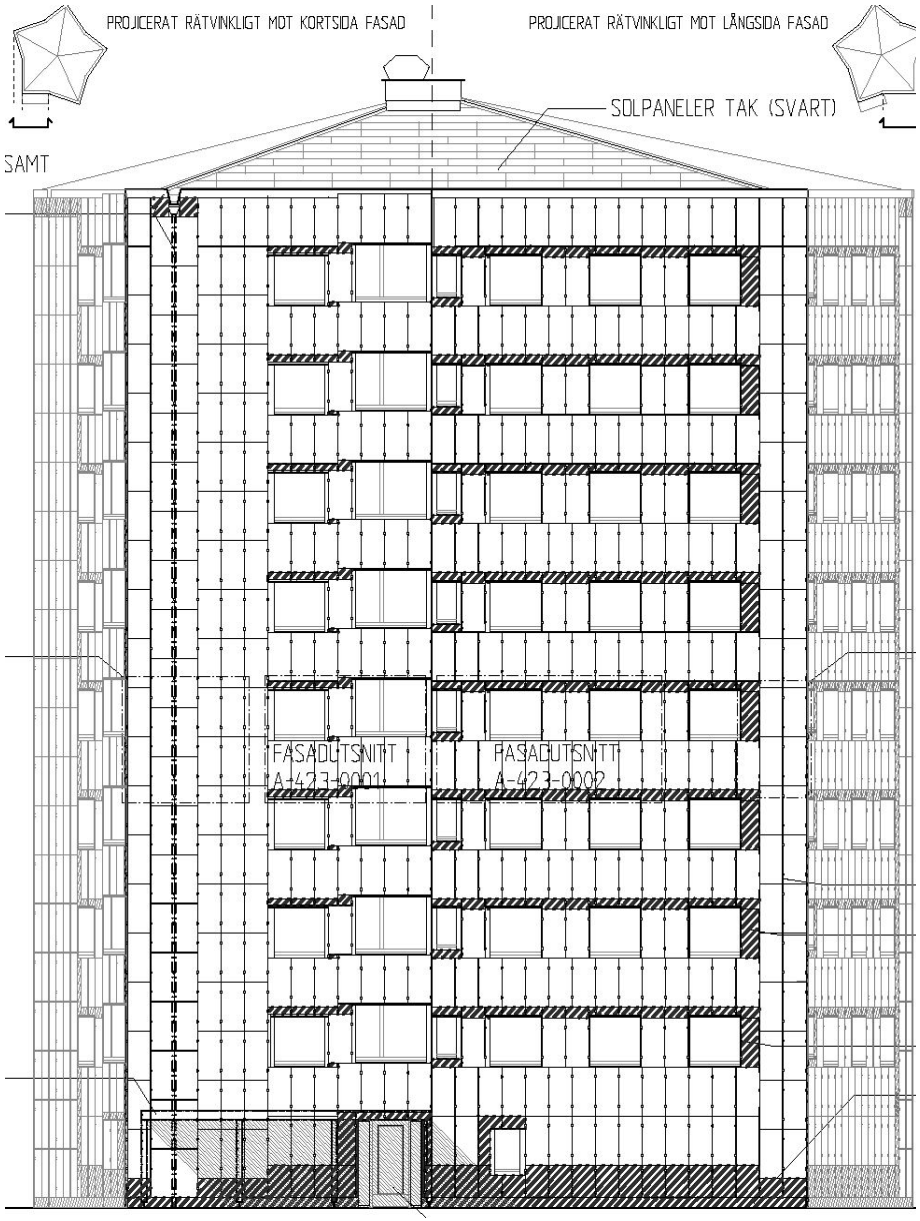
Psi(install) = 0.016 W/(m*K)

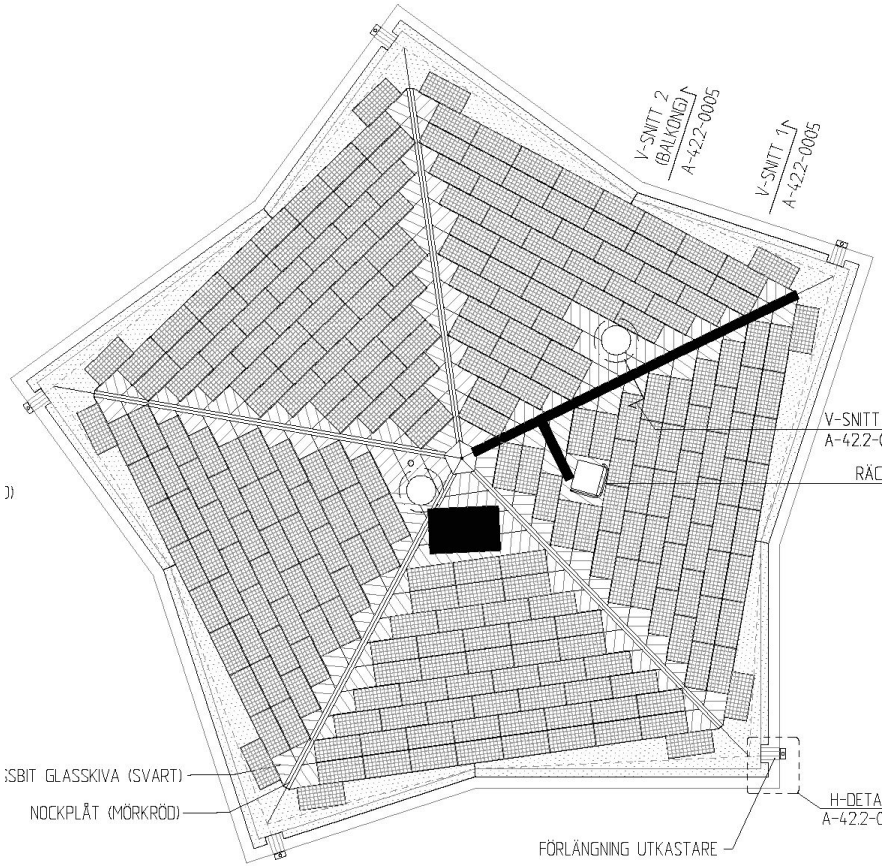


Optimization of Energy Use

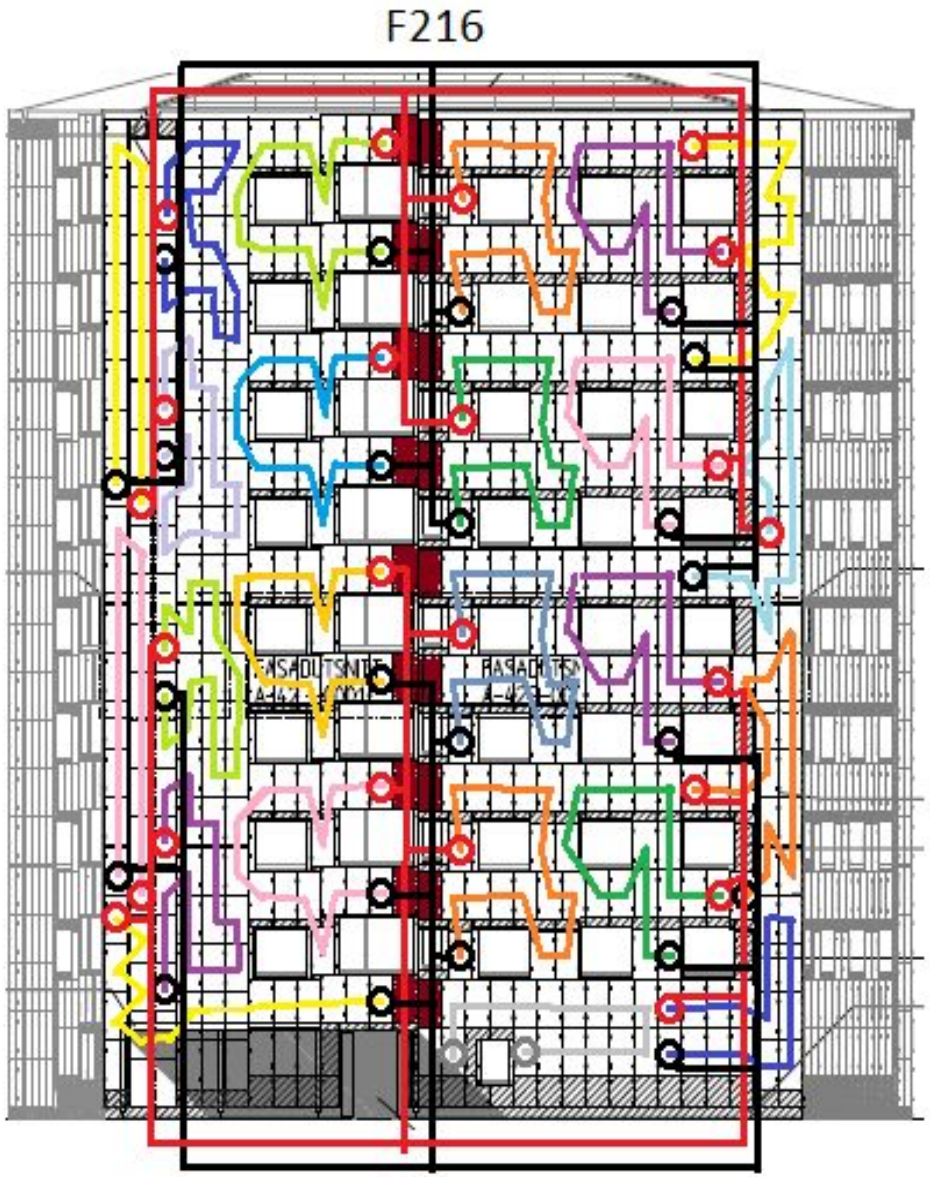
+ SENSORS

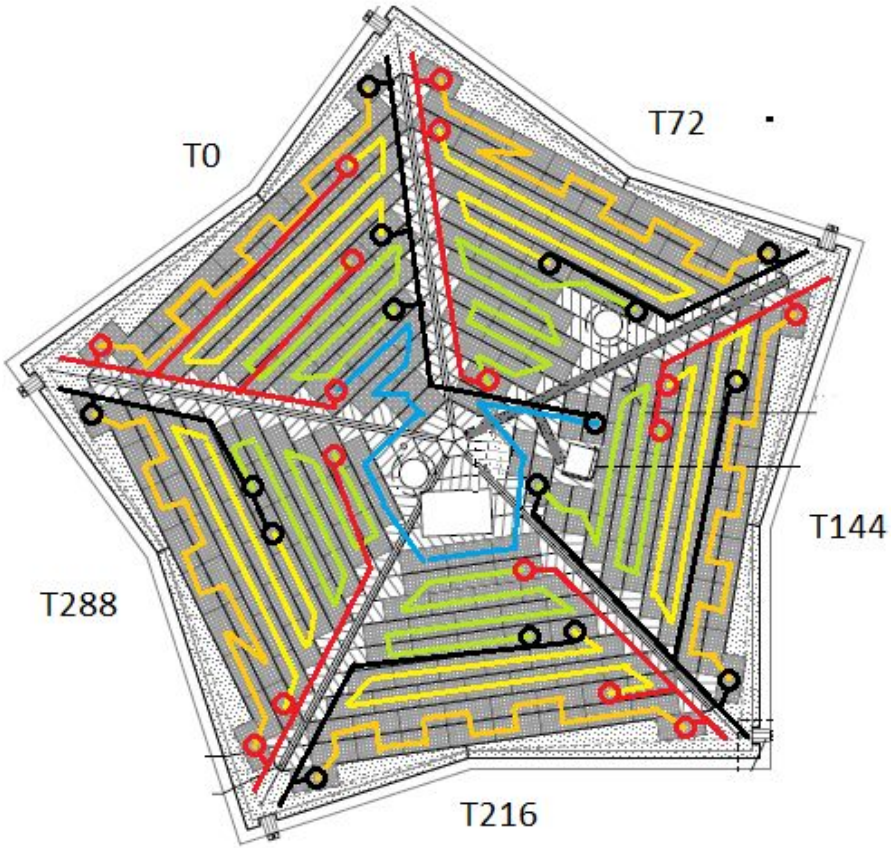
Solar PV


PROJICERAT RÄTVINKLIGT MOT KORTSIDA FASAD
PROJICERAT RÄTVINKLIGT MOT LÅNGSIDA FASAD
SOLPANELER TAK (SVART)
SAMT
FASADUTSNITT
A-423-0001
FASADUTSNITT
A-423-0002


V-SNITT 2
(BALKONG)
A-422-0005
V-SNITT 1
A-422-0005
V-SNITT
A-422-(
RÄC
SBIT GLASSKIVA (SVART)
NOCKPLÅT (MÖRKRÖD)
H-DETA
A-422-(
FÖRLÄNGNING UTKASTARE

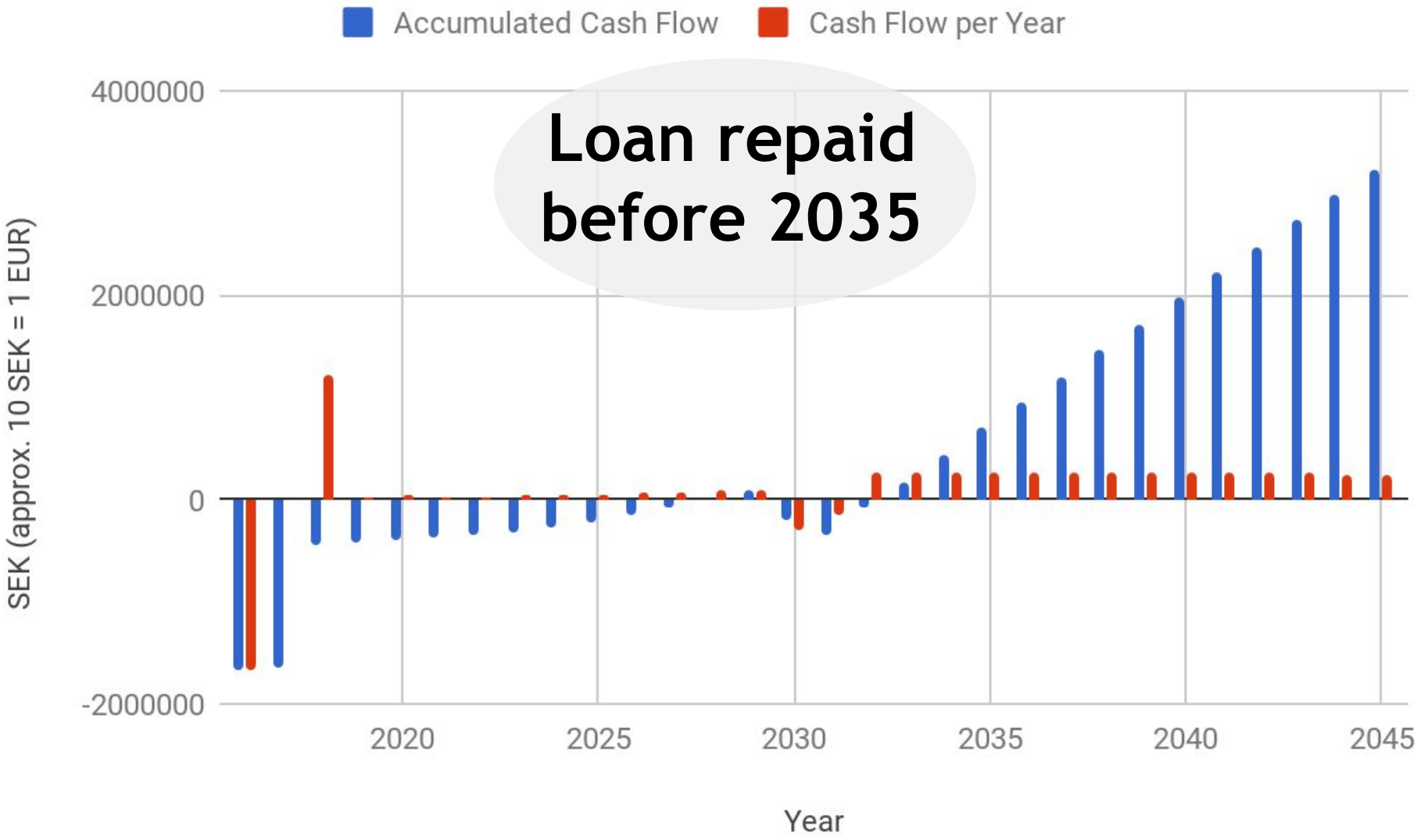
Solar PV





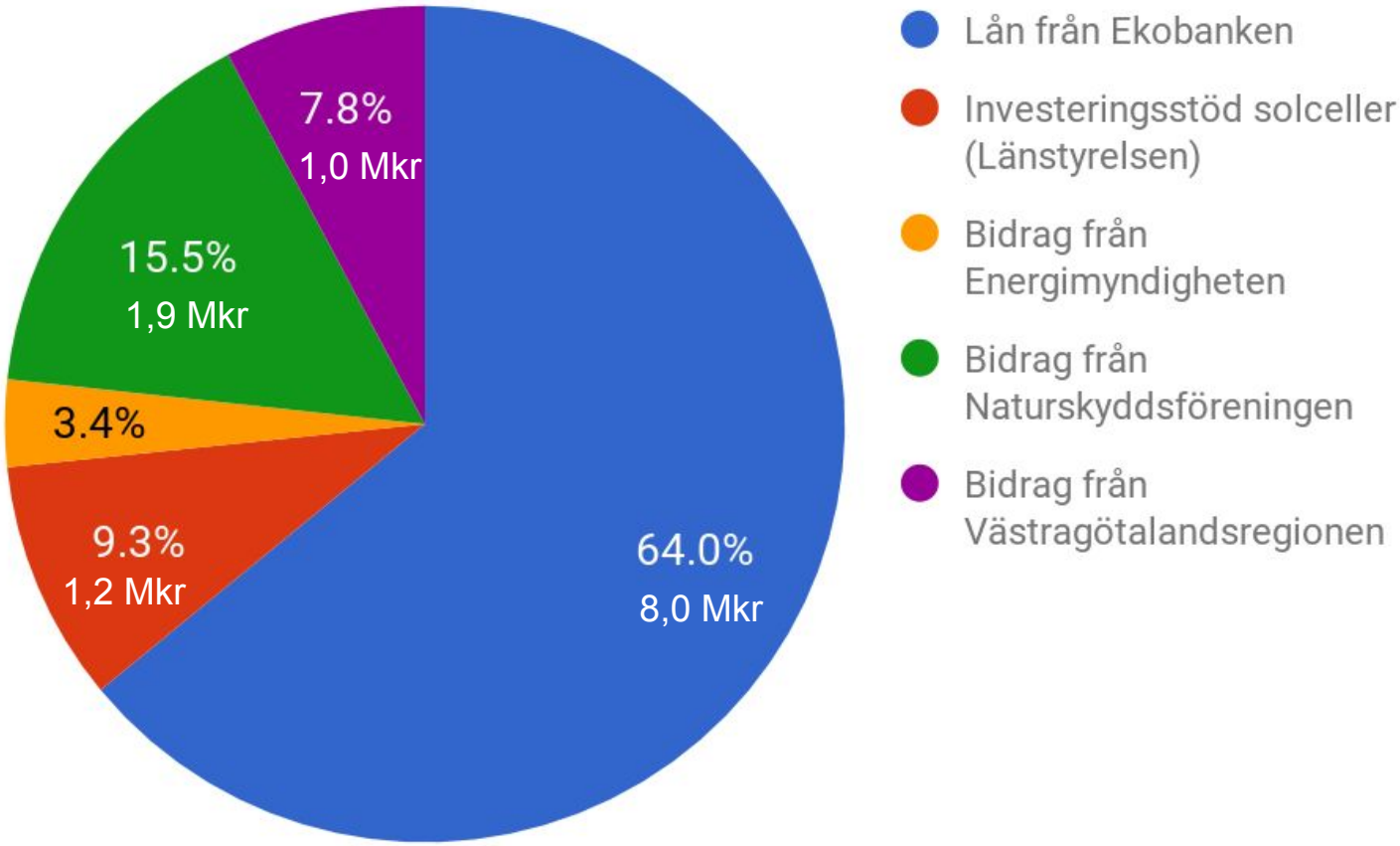
Stacken is a Passive House Plus

Cost Analysis



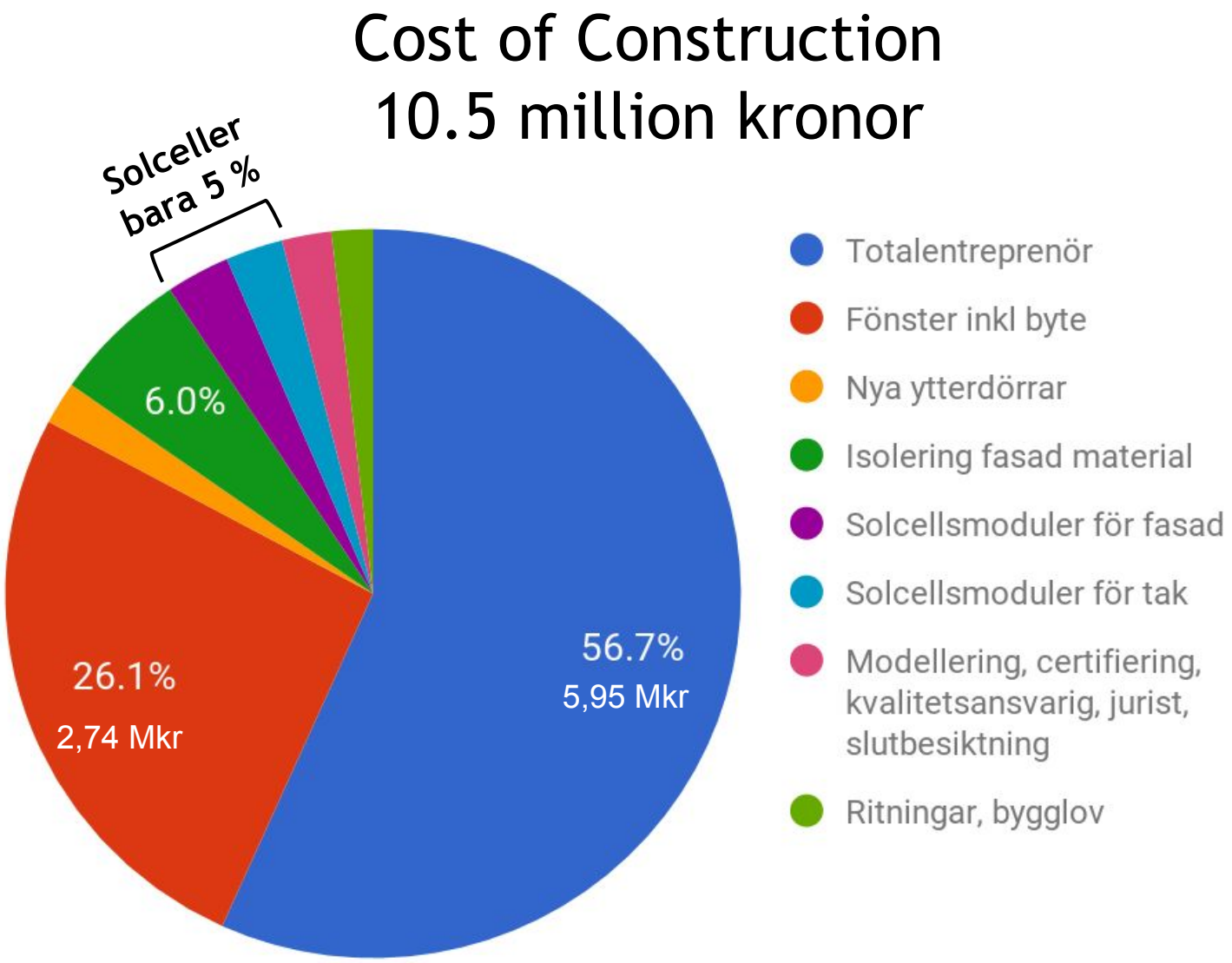
Cost Analysis

Financing, total 12.5 million kr



Steps 3 & 4 + kitchen, lighting, sensors

Cost Analysis



Steps 3 & 4, building measures

Cost Breakdown: Labor and Materials

- BIPV facade: 61 EUR/m² façade area.
- The total cost: 350 EUR/m^2 floor area (A_{temp})
- a-SI PV modules material cost: 18 EUR/m² sourced from a large canceled solar power plant project. Standard costs: 25 EUR/m².
- Installation Rockwool's REDAir FLEX mineral wool insulation system7-20 EUR/m² façade area.
- Material cost for the Redair flex system: 30 EUR/m² complete with all components

Inspired Research at Chalmers University and HSB Living Lab

Research leader: Zack Norwood, Johanneberg Science Park

Project leader: Dan-Eric Archer, Emulsionen

Project Members:

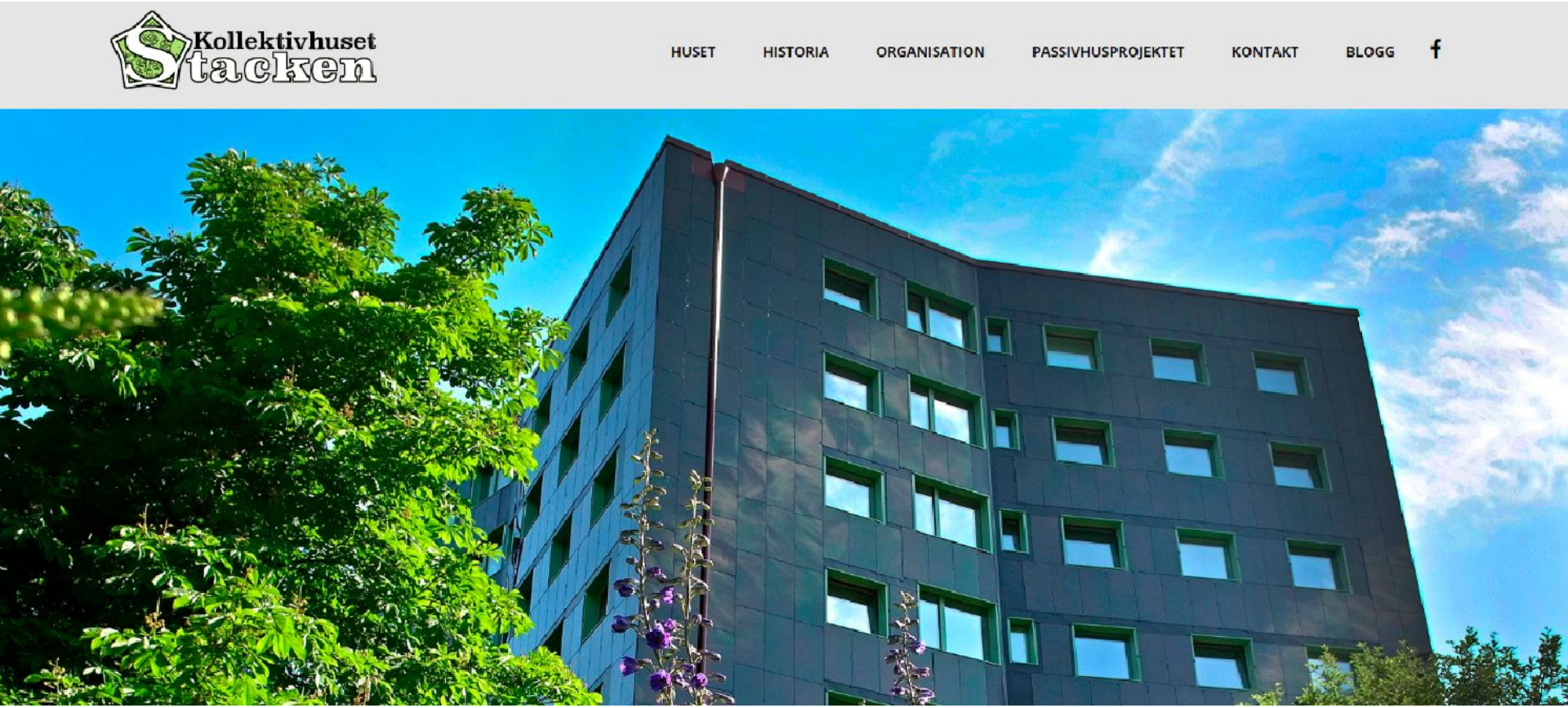
RISE: Anne Andersson, Francesco Sacco, Ricard Prat Ruiró, Peter Kovacs, Kaisa Svennberg

Chalmers: Shea Hagy, Quan Jin

Göteborg Energi: Filippa Borg

HSB: David Albinsson, Amanda Sandquist, Rickard Malm

More info and blog: www.stacken.org



Projektet är delvis finansierat genom försäljning av el märkt med “Bra miljöval”.

Kollektivhuset Stacken

Energimyndigheten

VÄSTRA GÖTALANDSREGIONEN

RADAR

HELHETSHUS

passivhusbyrån

i2 INNOVATIONS AND IDEAS

Naturskyddsföreningen

AVANCEZ 1829 CHALMERS

Questions?

Foto: Ola Höiden

Foto: Annika Söderlund

Foto: Annika Söderlund

Foto: Annika Söderlund

Foto: Annika Söderlund

Foto: Annika Söderlund

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Foto: Annika Söderlund

Foto: Annika Söderlund

What is a Passive House?

Dr Wolfgang Feist (Deutschland).

40% of energy that is used in the world is to heat and cool buildings.

Lessons

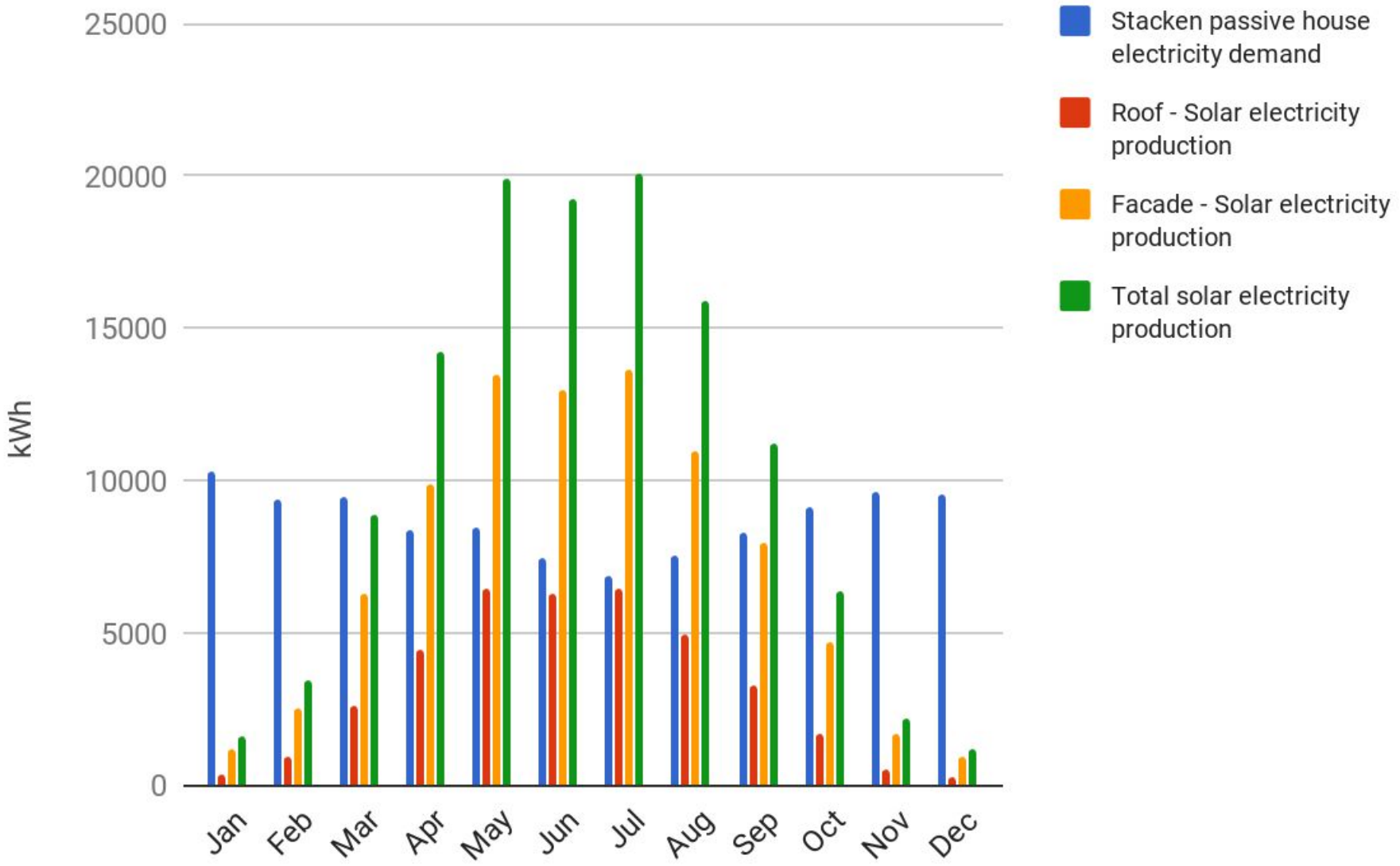
Utmaningar

- Stort projekt för ett litet kooperativ
- Förseningar
- Obekvämhet
- Oförutsedda övriga renoveringsbehov

Positivt

- Vi gjorde det!
- Stor medial uppmärksamhet & spridning
- Bättre inomhusklimat & inglasade balkonger
- Höjt taket för vad som är möjligt

Producerad solel versus el-användning (modell)



Passivhusprocessen 2014-2016

OLIKA STEG:

1) Energiberäkningar (2014)
2) Ritningar
3) Återbetalsningstid på under 30 år UTAN HYRESHÖJNINGAR (juni 2015)
4) Budget och start: 39 för, 6 emot, 1 nedlagd (mars 2016)

Vad är hemligheten?

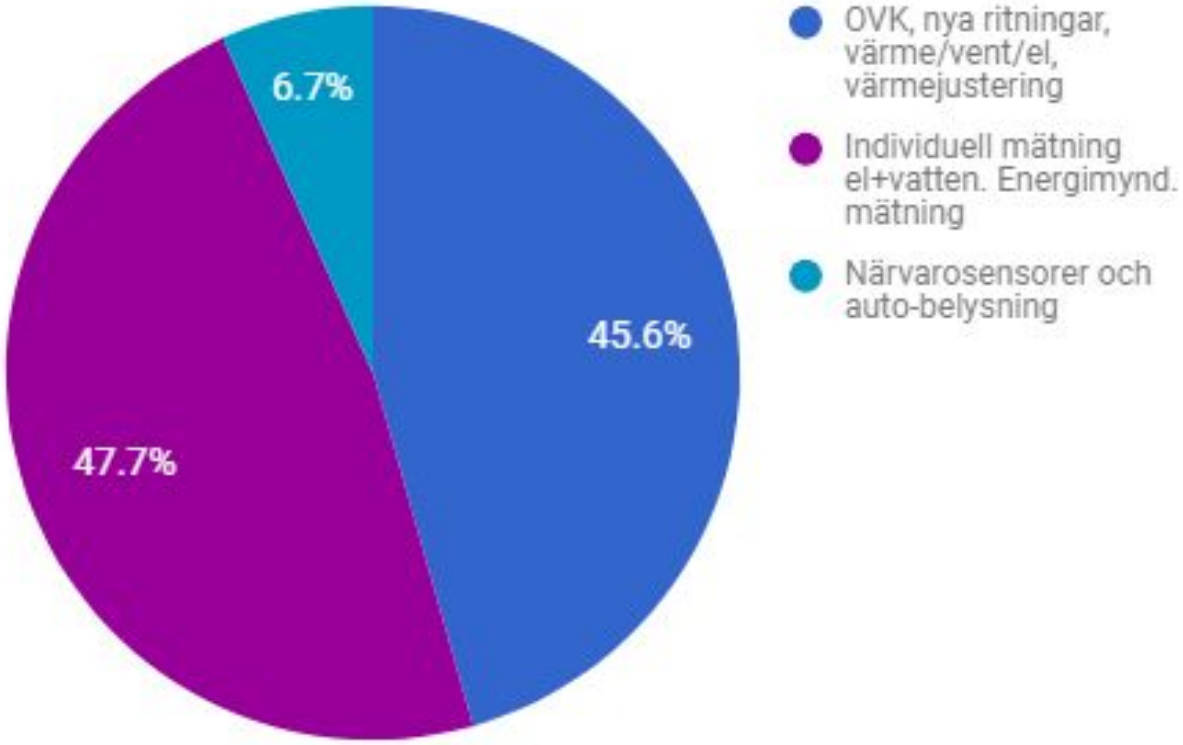
Hur lyckades vi med en stor klimatomställning av ett höghus utan hyreshöjningar?

Några nyckelfaktorer

- Engagemang
- Envishet
- Makt
- Kunskap
- Kollektivt agerande

- Pilotstöd och samarbeten

Investering per projektdel tot



Resurser om kooperativ och kollektivhus

Boihop - www.boihop.org
Verkar för att bogemenskaper och kollektivhus skall komma till stånd inom alla stadsdelar i Göteborg. Nu 2 projekt i Kålltorp och Högsbo.

Kollektivhus NU - www.kollektivhus.nu
Nationellt förening baserad på kollektivhus och fristående föreningar. Föreningen stöder existerande kollektivhus och grupper som arbetar för att skapa nya kollektivhus.

Föreningen för byggemenskaper - www.byggemenskap.se

Folkstaden och byggkooperativ - www.folkstaden.se

Bygga och bo i kooperativ hyresrätt

- En handbok för tillskapande av nya bostäder och kooperativa hyresrättsföreningar. (Gratis PDF att ladda ner.)

Fler exempel

Kollektivhuset Trädet (gammalt)
www.nyatradet.wixsite.com/tradet/kollektiv

Hogslätts Vänboende (nyligen klart)
www.hogslättsvänbo.se

Uddebo småhusby (under uppstart)
www.facebook.com/uddebosmahus/

Egnahemsfabriken på Tjörn
www.egnahemsfabriken.se

Grönbo ekoby (under uppstart)
www.ecoby.se