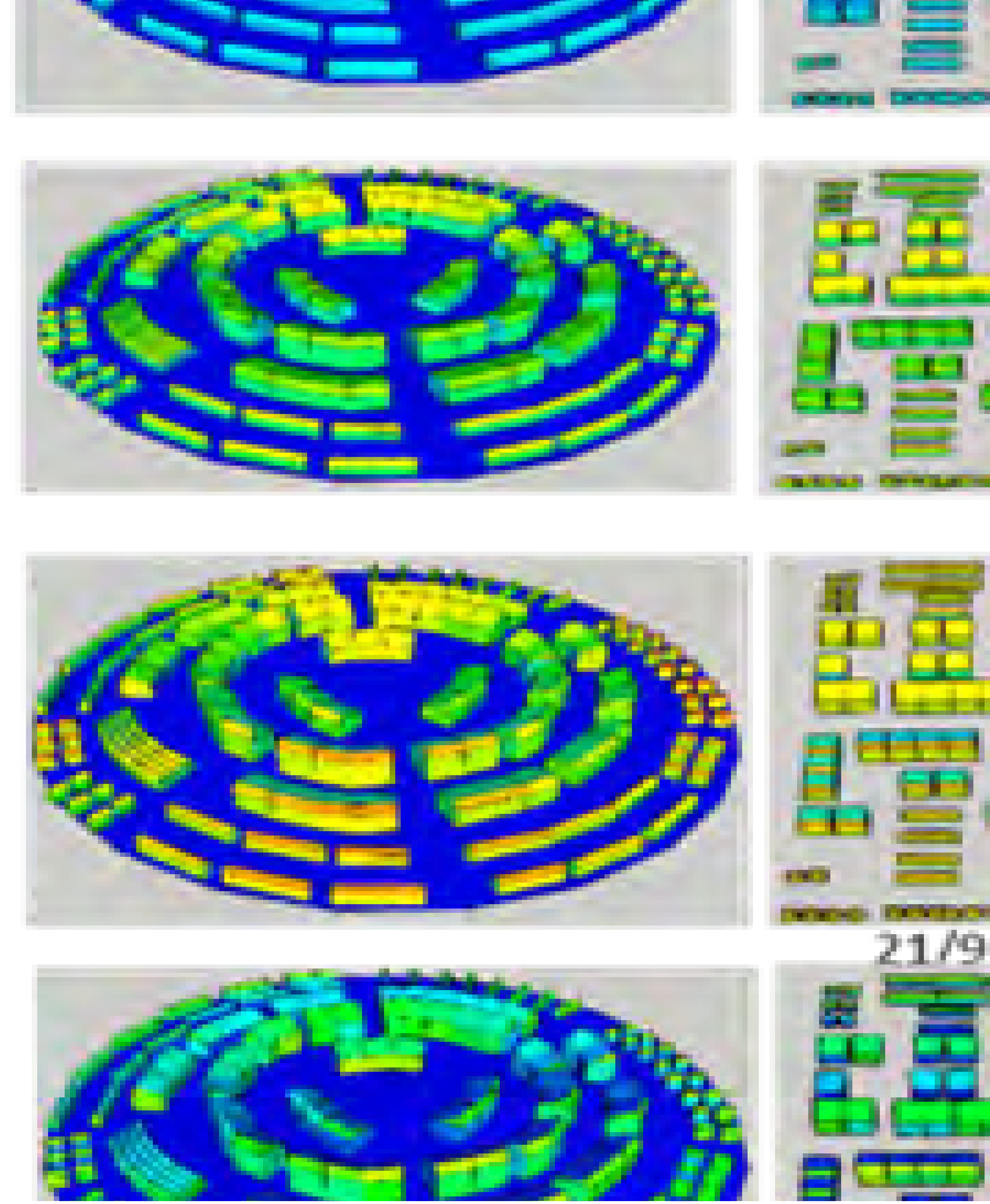


SEPTEMBER 23, 2022

SOLAR NEIGHBORHOODS: STRATEGIES AND APPLICATION CASE STUDIES

IEA SHC SEMINAR

IEA SHC Task 63
Solar Neighborhood Planning

Organized by
Caroline Hachem-Vermette, PhD (Subtask A Leader)
Maria Wall, PhD

Edited by
Caroline Hachem-Vermette, PhD
Maria Wall, PhD
Karly Do

University of Calgary
School of Architecture, Planning, and Landscape

The seminar was organized as part of IEA SHC Task 63(Solar Neighborhood Planning), Subtask A deliverables. It aimed to bring academic and professional knowledge, of designing sustainable communities with high life quality. In addition, it introduced and demonstrated the use of modeling tools in the design process to achieve specific performance goals, at urban and buildings levels.

International speakers from Australia, Switzerland, Italy, Norway, Denmark and Sweden presented alongside national speakers from various governmental research agencies and Canadian industry. The audience of the seminar included professionals such as architects and urban planners, city and municipality representatives, in addition to students and academic staff.

This public seminar presenting international case studies and demonstration projects of sustainable urban communities, brought international knowledge and expertise to local professionals such as architects and urban planners. Such knowledge can assist in changing the methods utilized in traditional planning of communities, to incorporate trade-offs of various environmental considerations.

The seminar was funded by SSHRC connection grant, and in-kind contribution of Lund University (Sweden), Norwegian University of Science and Technology (Trondheim, Norway), and SAPL (University of Calgary).

The seminar was conducted in hybrid mode (in person presentations and online via ZOOM).

ABOUT THE SEMINAR

CONTENTS

Dr. Maria Wall

Dr. Maria Wall is associate professor at the Division of Energy and Building Design, Lund University, Sweden. Energy aspects related to buildings have always fascinated her. She has a MSc in Architecture and a PhD in Engineering. Her research includes different aspects related to energy-efficient buildings as well as solar energy strategies. She is presently leader of the international research project IEA SHC Task 63 on Solar Neighborhood Planning (2019-2023), including both passive and active solar energy strategies. She was leader of the SHC Task 41 on Solar Energy and Architecture (2009-2012), and then leader for the SHC Task 51 on Solar Energy in Urban Planning (2013-2018).

She was the main initiator and developer, and was the Director of the 2-year Master's Programme in Energy-efficient and Environmental Building Design at Lund University, during 2012-2022. This programme is enrolling international students from different backgrounds, both in architecture and in engineering, since interdisciplinary teamwork is needed when designing sustainable buildings and neighbourhoods.

SPEAKERS

Dr. Caroline Hachem-Vermette

An architect by training and by profession, Dr. Caroline Hachem-Vermette has two master's degrees in architecture, and an additional master's, and PhD degrees in Building Engineering from Concordia University. Dr. Hachem-Vermette research program is highly multidisciplinary, involving such diverse disciplines as architecture, urban planning, and building engineering.

Her research area includes the investigations of multifunctional energy-efficient, resilient neighborhood patterns, solar potential and energy implications of building shapes, building envelope design, developing multifunctional facades for multistory buildings, and others. Her research is multidisciplinary, it plays a bridging role between building engineering and architectural and urban design. Her current research program aims at developing concepts and strategies for the design of sustainable and climate resilient, self-sufficient, smart communities and urban developments. A part of this research program concentrates on the design of urban green infrastructure that aims at improving the health and wellbeing of urban inhabitants, especially in times of stresses (including pandemics).

She is currently leading a subtask on developing strategies for net-zero energy solar communities, within the International Agency Energy Task (IEA) 63- Planning Solar Neighborhoods. She was also an expert on 2 others IEA SHC tasks on solar energy in architecture and urban planning. She is widely published on the topic of energy efficiency and solar energy, including a book (with Springer) on designing solar buildings and neighborhoods. Dr. Hachem-Vermette is a recipient of a number of awards including the 2019 Peak Scholar Award, 2016 sustainability award, e-sim/ IBPSA award for innovation in modelling, and Hangai prize for young researchers.

SPEAKERS

Dr. Olaf Bruun Jørgensen

Dr. Olaf Bruun Jørgensen has more than 30 years of experience in energy engineering. He has over 20 years' experience as project leader and strong expertise in sustainable and energy efficient R&D projects. He has specialized in optimization, design and implementation of active and passive solar energy systems in buildings.

Moreover, Olaf has extensive experience with the use of the Integrated Energy Design process which ensures a positive relation between form function, architecture, and sustainability through a close dialogue with all stakeholders involved in the construction project.

Previous projects include social housing, eco-housing and urban planning projects in Denmark and Europe. His experiences include working with national regulations and international frameworks (namely the SDGs). His clients include private and public organisations.

Alejandro Pacheco Diéguez

Alejandro Pacheco Diéguez has been working since 2014 as an architect specialized in digital tools applied to environmental design.

Alejandro's background includes optimization of building design and urban planning for environmental aspects such as energy use, daylighting, microclimate or environmental impact. Since 2019, he focuses on the development of accessible digital tools to evaluate various environmental performance aspects during building design in the early stages.

Dr. Mark Snow

Dr. Mark Snow is a leading international expert on Building integrated PV with over 20 years of expertise. He has produced best practice BIPV guidelines for the Australian Government, developed solar design knowledge products for the Australian Institute of Architects and provided comprehensive state of the art reports for international governments on urban solar applications - including on PV as a building material for the recently completed Australian Cooperative Research Centre (CRC) for Low Carbon Living.

Dr. Snow has also worked extensively as an Australian representative on numerous International Energy Agency (IEA) tasks on Solar Energy programs including Solar Heating and Cooling Task 63 on Solar Neighbourhood Planning as well as co-authoring an internationally acclaimed book on designing with Solar Power.

Dr. Gabriele Lobaccaro

Dr. Gabriele Lobaccaro is Associate Professor and Coordinator of Building and Technology Research Group at the Department of Civil and Environmental Engineering, Faculty of Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway. He is co-leader of Subtask D on “Case studies” in the IEA SHC Task 63 “Solar Neighborhood Planning”.

His research focuses on solar energy design and digitalization, environmental analysis, energy and building technology, sustainable and resilient built environment.

Gabriele is currently the project manager and primary investigator of the research project NFR-FRIPRO FRINATEK – HELIOS - enHancing optimal ExpLoitatIOn of Solar energy in Nordic cities through digitalization of built environment. The project is supported by the Research Council of Norway (project. No. 324243).

Dr. Mattia Manni

Dr. Mattia Manni is a Postdoc Fellow at the Department of Civil and Environmental Engineering, Faculty of Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway. He is co-leader of Subtask D “Case studies” in the IEA SHC Task 63 “Solar Neighborhood Planning”.

His research core concerns solar energy digitalization, combining experimental monitoring activities with numerical solar and energy analyses.

Mattia is currently leading the WP1 - Modelling and simulation and WP2 - Experiment and monitoring of the research project HELIOS - enHancing optimal ExpLoitatIOn of Solar energy in Nordic cities through digitalization of built environment. The project is supported by the Research Council of Norway (project. No. 324243).

Dr. Gilles Desthieux

Dr. Gilles Desthieux is an associate professor at the Geneva Institute of Landscape, Engineering and Architecture (HES-hepia) and a senior consultant in urban energy planning in the company Amstein+Walthert Genève.

He holds an MA in environmental engineering and sciences and a PhD from the Swiss Federal Institute of Technology Lausanne (EPFL). His expertise deals with integrated urban and energy planning, development of GIS tools for energy mapping and planning, 3D urban modeling for environmental assessment – solar energy.

Dr. Silvia Croce

Dr. Silvia Croce is a Post-Doc researcher at the Institute for Renewable Energy, Eurac Research (Italy). She is a building engineer - architect by training, and holds a PhD in Engineering at the University of Padova.

Her research work aims at gaining insights into solutions for an integrated design of the urban built and natural environment, with focus on outdoor microclimate, thermal comfort, energy savings and renewable energy production. At the same time, it intends to raise awareness on the interlinkages of those topics and to activate different actors in developing integrated and systemic solutions.

She is co-leading the H2020 project JUSTNature, and active in several European projects. She was actively involved in IEA SHC Task 51 “Solar energy in urban planning”, and currently is co-leading sub-task B “Economic strategies and stakeholder engagement” of IEA SHC Task 63 “Solar neighborhoods planning”.

Dr. Lucio Mesquita

Dr. Lucio Mesquita is a Senior Research Engineer at CanmetENERGY-Ottawa/ Natural Resources Canada. He has over 30 years of experience and skills in the research, design, and testing of solar thermal and thermal storage products and systems for heating and cooling applications in industrial, commercial and residential markets in several countries including Canada, Brazil, China, and the United States. He also has experience with sorption process through his doctoral research on the development of liquid-desiccant components and systems.

Dr. Mesquita work is currently focused on sustainable community energy systems and thermal storage technologies. He holds a PhD in Mechanical Engineering from Queen's University and a Bachelor of Science in Mechanical Engineering from the Federal University of Minas Gerais (UFMG–Brazil).

Dr. Mesquita is actively involved with International Energy Agency Technical Collaboration Programmes on Solar Heating and Cooling, District Heating and Cooling, and Energy Storage.

Dr. Andreas K. Athienitis

Dr. Andreas K. Athienitis is a Professor of Building Engineering and Director of the Centre for Zero Energy Building Studies that he founded at Concordia University.

He obtained a PhD in Mechanical Engineering from the University of Waterloo (1985). He holds the NSERC/Hydro Québec Industrial Research Chair "Optimized Operation and Energy Efficiency: Towards High Performance Buildings" and a Concordia University Research Chair in Solar Energy. He is internationally recognized and a leader in smart net-zero energy solar buildings - a Fellow of the Canadian Academy of Engineering, Fellow of IBPSA and Fellow of ASHRAE. He led as Principal Investigator the NSERC Smart Net-zero Energy Buildings Strategic Research Network and the NSERC Solar Buildings Research Network with over 30 researchers from 15 Canadian Universities and about 30 industry and public sector partners.

He was profiled as one of 25 top innovators in Québec by Actualité Magazine. He has published over 300 refereed papers, including eight that received best paper awards, and several books. He played a leading role in the conception and realization of several award-winning innovative buildings such as the Varennes net-zero energy Library, EcoTerra House and his own award-winning solar home. He currently co-chairs the Canadian Academy of Engineering Roadmap to Resilient, Ultra-Low Energy Built Environment with Deep Integration of Renewables.

Milfred Hammerbacher

Milfred Hammerbacher has lived and managed businesses in four countries with 30 plus years of photovoltaic and energy experience.

As co- founder and CEO of S2E Technologies, Inc, his team built the largest solar factory in Canada at the time, partnered with Samsung to build the largest solar farms in Canada at the time, and developed or supplied over 800MW's of solar projects operating today. 9 years ago, the company began a transition into sustainable community and Building development, with projects in London, Ontario and Punta De Mita, Mexico.

Introduction to the IEA SHC Task 63 Seminar

Caroline Hachem-Vermette

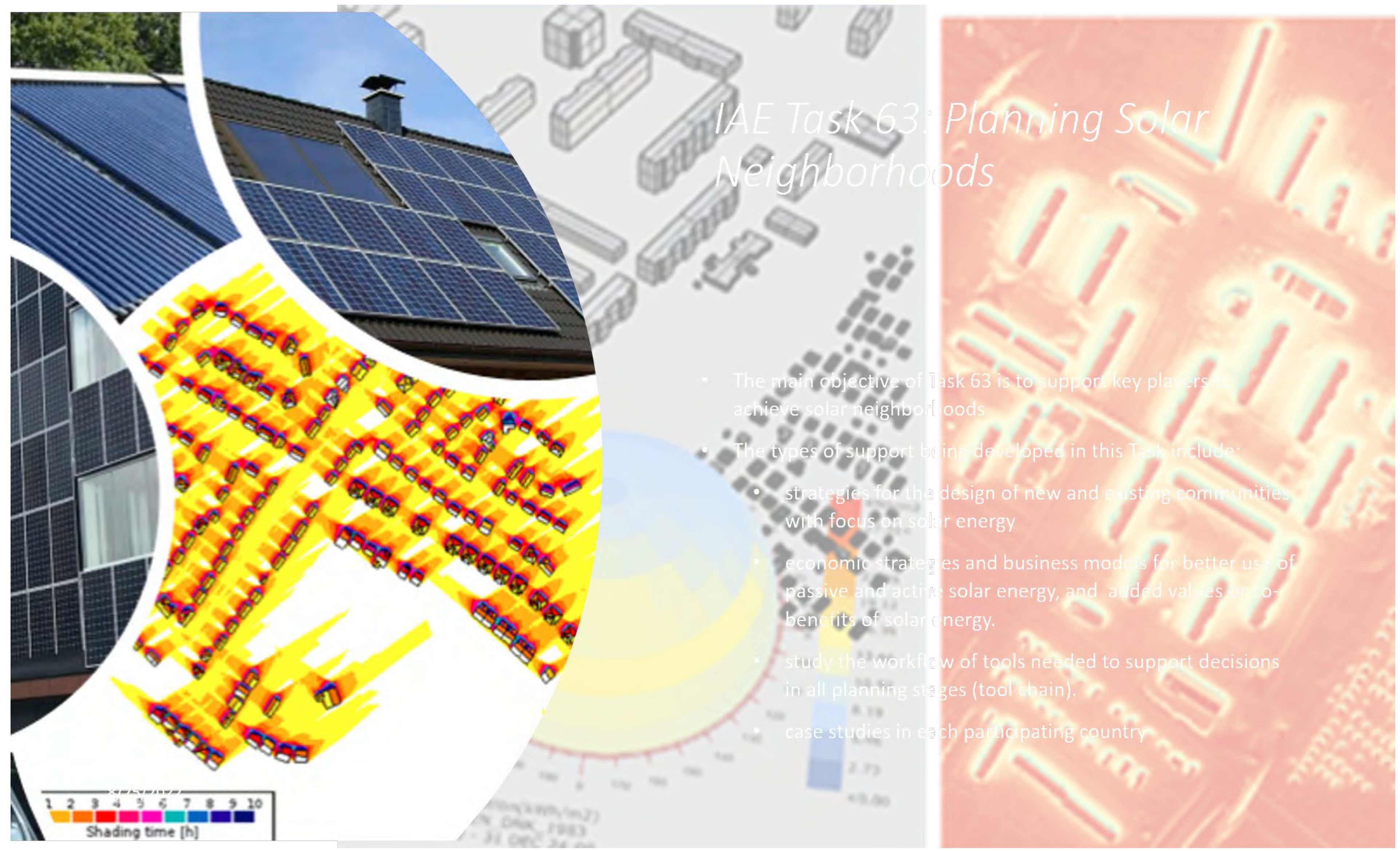
The presentation identifies the objectives of the IEA SHC Task 63 Seminar (namely, to bring together international perspectives in planning solar neighborhoods and highlighting the main considerations in designing sustainable and environmentally oriented communities), provides a schedule for the day, and introduces the speakers presenting at the seminar.

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Organized by: Caroline Hachem-Vermette, PhD,
Associate Prof, University of Calgary
Solar Energy and Community Design Lab (SECDL)
IEA SHC Task 63, Subtask A Leader

UNIVERSITY OF CALGARY
Solar Energy and Community Design Lab (SECDL)

Objectives



This seminar aims at:

- Bringing together international and national perspectives in planning solar neighborhoods
- Highlighting main considerations in designing sustainable and environmentally oriented communities.

The seminar

MORNING

08:30 - 08:45 **REGISTRATION**

08:45 - 09:00 **MARIA WALL**
CAROLINE HACHEM-VERMETTE
WELCOME NOTES

09:00 - 09:30 **OLAF BRUUN JØRGENSEN (DENMARK)**
SOLAR DAYLIGHT IN URBAN PLANNING (ZOOM)

09:30 - 10:00 **GABRIELE LOBACCARO**
MATTIA MANNI (NORWAY)
SOLAR DIGITIZATION TECHNIQUES TO ENHANCE OPTIMAL EXPLOITATION OF SOLAR ENERGY IN THE NORDICS

10:00 - 10:15 **COFFEE BREAK**

10:15 - 10:45 **MARK SNOW (AUSTRALIA)**
AUSTRALIAN INSIGHTS AND CASE STUDY EXAMPLES FOR SOLAR NEIGHBORHOOD PLANNING

10:45 - 11:15 **ALEJANDRO PACHECO DIÉGUEZ (SWEDEN)**
SOLAR ENERGY AND DAYLIGHTING IN SWEDISH CASE STUDIES

11:15 - 11:45 **GILLES DESTHIEUX (SWITZERLAND)**
HOW TO BOOST MAJOR SOLAR PROJECTS IN BUILDING ENVIRONMENT: THE EXAMPLE OF A VILLAGE IN GENEVA, SWITZERLAND

AFTERNOON

11:45 - 13:00 **LUNCH**

13:00 - 13:30 **SILVIA CROCE, EURAC RESEARCH (ITALY)**
SUSTAINABLE AND CLIMATE RESILIENT SOLAR NEIGHBORHOODS

13:30 - 14:00 **LUCIO MESQUITA, NRCAN (CANADA)**
SOLAR-DRIVEN LOW-CARBON COMMUNITIES: DRAKE LANDING AND BEYOND (ZOOM)

14:00 - 15:00 **ANDREAS ATHIENITIS (CONCORDIA UNIVERSITY, CANADA)**
BIPV, BUILDING-GRID INTERACTION AND DYNAMIC PRICING OF ELECTRICITY (ZOOM)

15:00 - 15:15 **COFFEE BREAK**

15:15 - 15:45 **MILFRED HAMMERBACHER (S2E, LONDON ONTARIO)**
SOLAR: A KEY INGREDIENT OF HOLISTIC APPROACH TO SUSTAINABLE COMMUNITY DESIGN - LONDON, ONTARIO CASE STUDIES (ZOOM)

15:45 - 16:00 **CONCLUDING REMARKS**

All times are reported in Calgary local time (+8H CEST)

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Solar Energy and Community Design Lab (SECDL)
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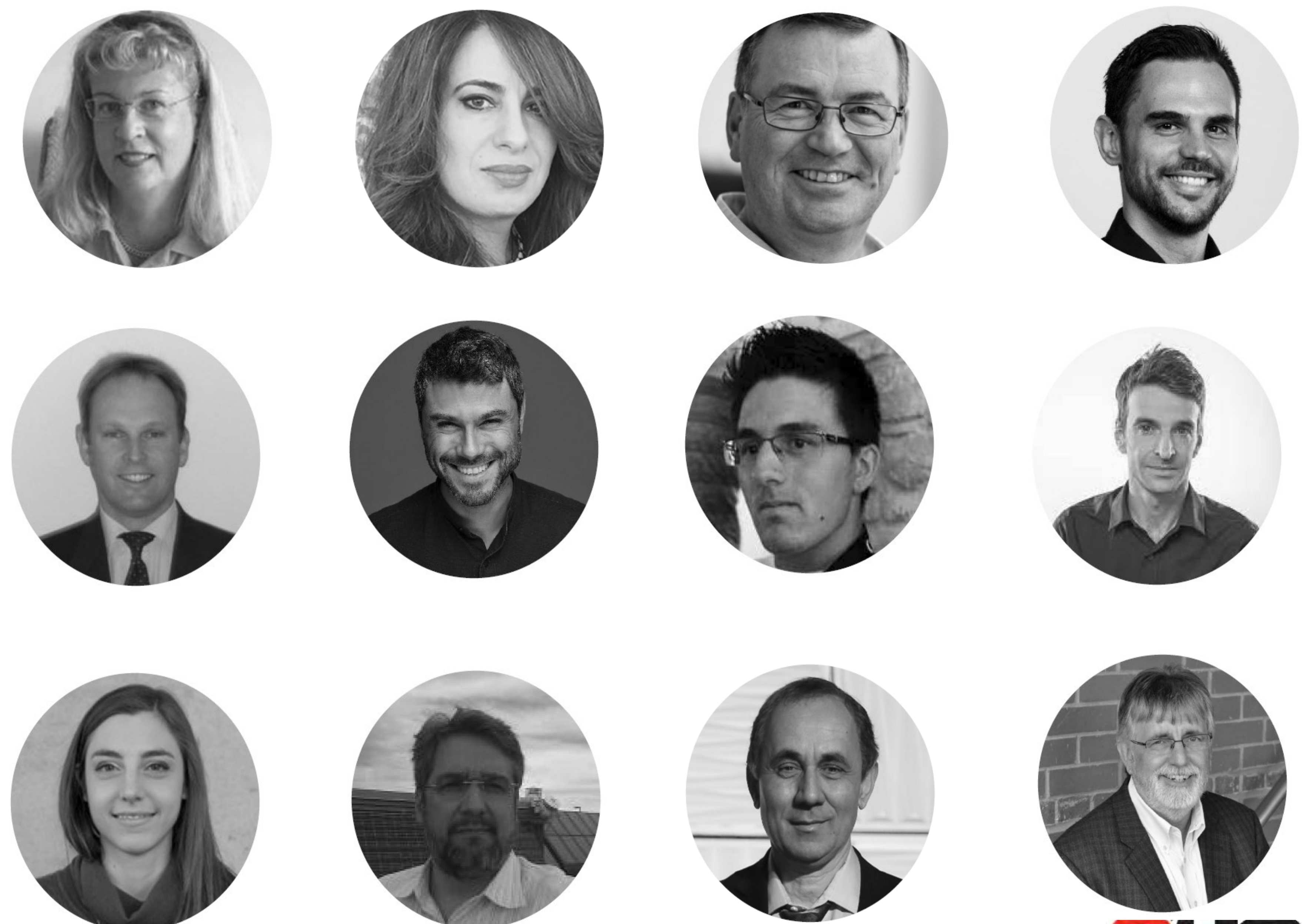
Seminar

UNIVERSITY OF CALGARY
Solar Energy and Community Design Lab (SECDL)



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Enjoy the seminar!

Many thanks to the sponsors of the seminar:

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UNIVERSITY OF CALGARY Solar Energy and Community Design Lab (SECDL)

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IEA Solar Heating and Cooling Programme (group 4230381)

Introduction to IEA SHC Task 63: Solar Neighborhood Planning

Maria Wall

The presentation first defines the concept of neighborhood and identifies the contribution of solar energy to renewable energy production, food production, and daily life. The primary purpose of the presentation is to outline the objective and scope of the IEA SHC Task 63, and to identify the four subtasks and their main objectives.

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IEA SHC Task 63
Solar Neighborhood Planning

Maria Wall, Task Manager
Seminar, September 23, 2022

Definition - neighborhood

A neighborhood is defined as a group of buildings, a district/precinct. It is a spatially defined specific geographic area, often including different types of buildings and functions, open space and infrastructure.

A neighborhood can be part of a larger city or a smaller village. It can be part of an urban area, a rural development or represent an isolated community.

- Connected to a district heating/cooling network or outside, giving different boundary conditions

Solar Contributions

- **Passive solar energy**: indoors and outdoors to reduce heating demand and improve thermal comfort and health
- **Daylighting** buildings and outdoor areas, to reduce electricity for lighting and improve visual comfort and health
- **Local renewable energy production** using Photovoltaics (electricity) and Solar Thermal Systems, to help create energy/resource self-sufficient environments and not rely on energy imports, and to create resilience to energy price fluctuations
- **Local food production** and use of **green areas** for improved air quality and reducing storm water (roofs, facades, outdoor areas)

Task 63: Solar Neighborhood Planning: 2019- 2023

Objective

The main objective is to support key players to achieve solar neighborhoods that facilitate long-term solar access for energy production and for daylighting buildings and outdoor environments – resulting in sustainable and healthy environments.

Scope

The scope of the Task includes solar energy aspects related to

1. New neighborhood development
2. Existing neighborhood renovation and development

Solar energy aspects include active solar systems (solar thermal and photovoltaics) and passive strategies. Passive solar strategies include passive solar heating and cooling, daylighting, and thermal/visual comfort in indoor and outdoor environments.

The role of solar aspects related to energy, environment, economy and inhabitants' comfort and health is in focus

Subtasks and leaderships

A. Solar Planning Strategies and Concepts

Leader: Caroline Hachem-Vermette, University of Calgary, Canada

B. Economic Strategies and Stakeholder Engagement

Leader: Silvia Croce & Daniele Vettorato, EURAC Research, Italy

C. Solar Planning Tools

Leader: Jouri Kanters, Lund University, Sweden &

Martin Thebault, University Savoie Mont-Blanc – INES, France

D. Case Studies

Leader: Gabriele Lobaccaro & Mattia Manni,

Norwegian University of Science and Technology NTNU, Norway, jointly with all leaders

Project leader (Task Manager): Maria Wall, Lund University, Sweden

Participating countries

- Australia
- Canada
- China
- Denmark
- France
- Italy
- Norway
- Sweden
- Switzerland

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Thank you!

For more information, see

Task 63: Solar Neighborhood Planning (2019-2023): https://task63.iea-shc.org/

Publications: https://task63.iea-shc.org/publications

- *Identification of existing tools and workflows for solar neighborhood planning*
- *Surface uses in solar neighborhoods*

Finalized projects:

Task 51: Solar Energy in Urban Planning (2013-2018): https://task51.iea-shc.org/

Task 41: Solar Energy and Architecture (2009-2012): https://task41.iea-shc.org/

LUND UNIVERSITY

Maria Wall / Energy and Building Design, Lund University
Funded by the Swedish Energy Agency

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Solar Daylight in Urban Planning

Olaf Bruun Jørgensen

The presentation first introduces Danish Energy Managementand gives an overview of the scope fo their work. This is followed by an introduction to solar planning in urban areas, and the benefits of daylighting and solar utilization. The majority of the presentation is focused on several case studies that exemplify the use of daylighting, including Gehry City Harbour (Sonderborg), FredericiaC, New Urban Quarters (Arslev), and Carlsberg.

Olaf Bruun Jørgensen

Project Manager

Sustainable Building Design

& Urban Development

Tel.: +45 20 99 23 07, e-mail: obj@dem.dk

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Danish Management Group

DANISH MANAGEMENT
DM
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WARM NORDIC

DANISH DESIGN RESTAURANTS

deep
Danish Energy Efficiency Partners

Dansk Ejendoms Management
En del af Danish Management Group

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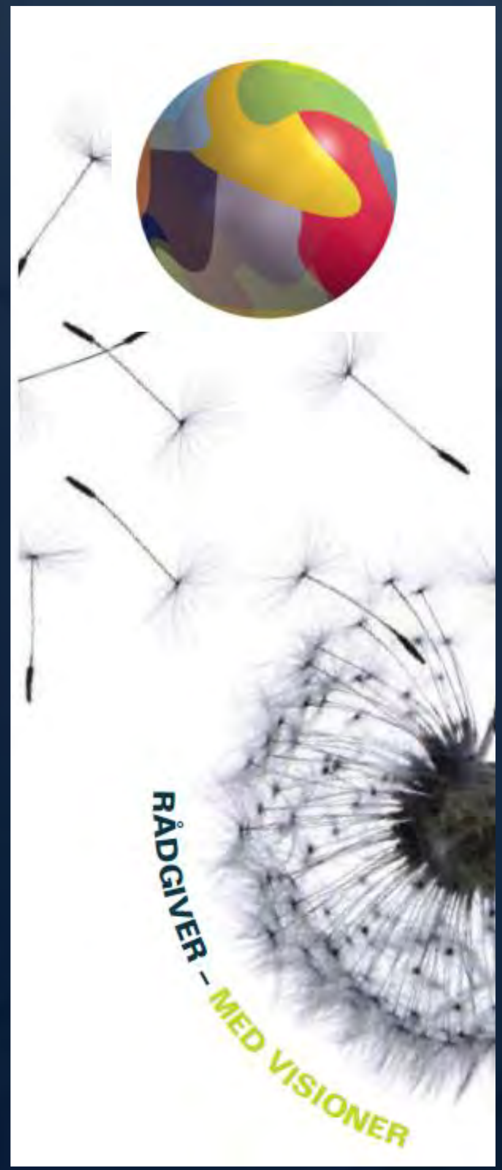
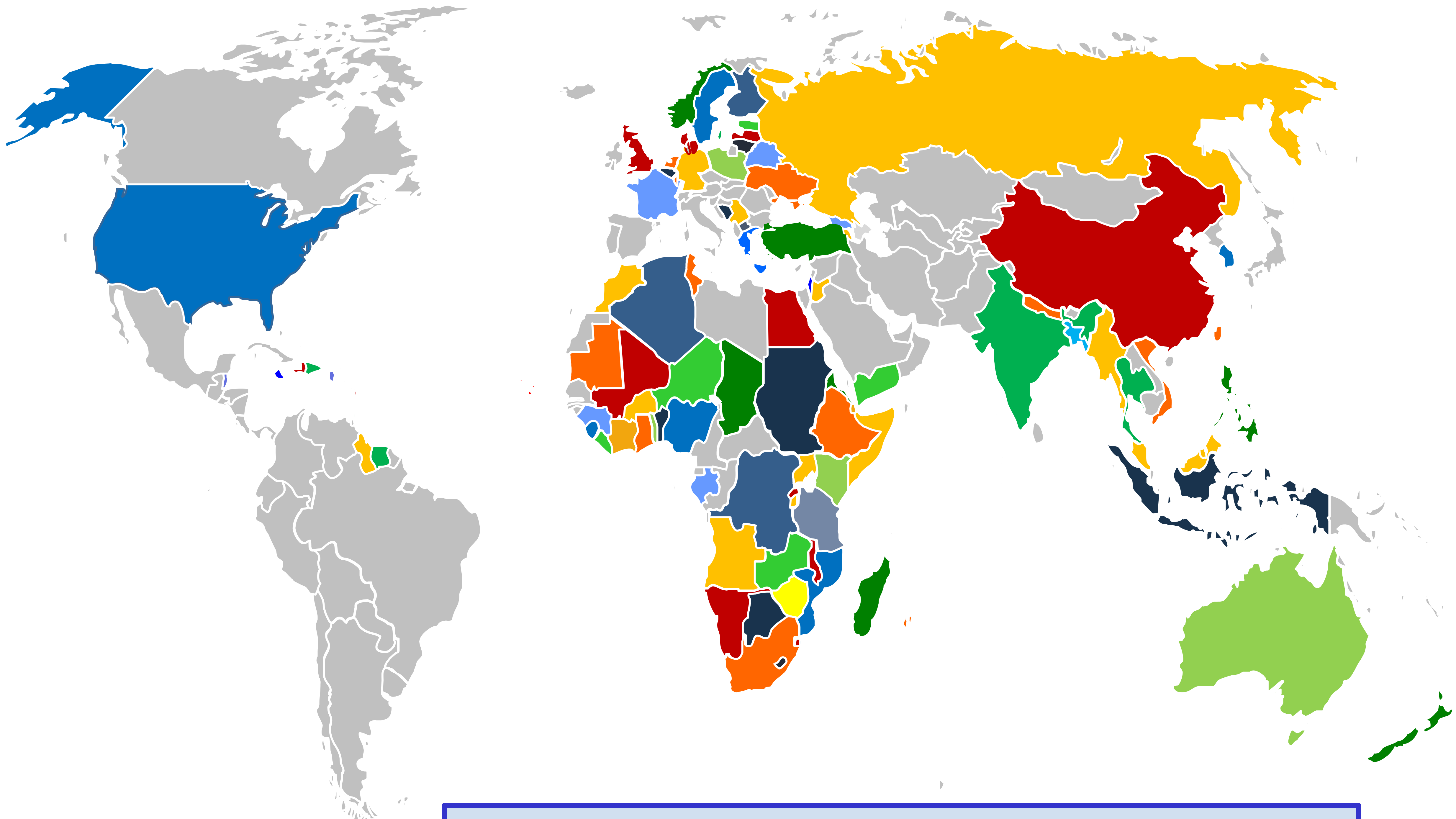
Danish Energy Management

- DEM - Danish Energy Management A/S was founded in 1986
- ESB - Esbensen Consulting Engineers A/S was founded in 1947
- DEM and ESB were merged in 2012
- DEM has approx. **70 experts**
- Headquater in Århus, Denmark





DEM has delivered projects in 97 countries Worldwide

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Sustainability & Energy management

Sustainable building design and urban development

Energy renovation

Client consultancy

Sustainable development goals

Research & Development

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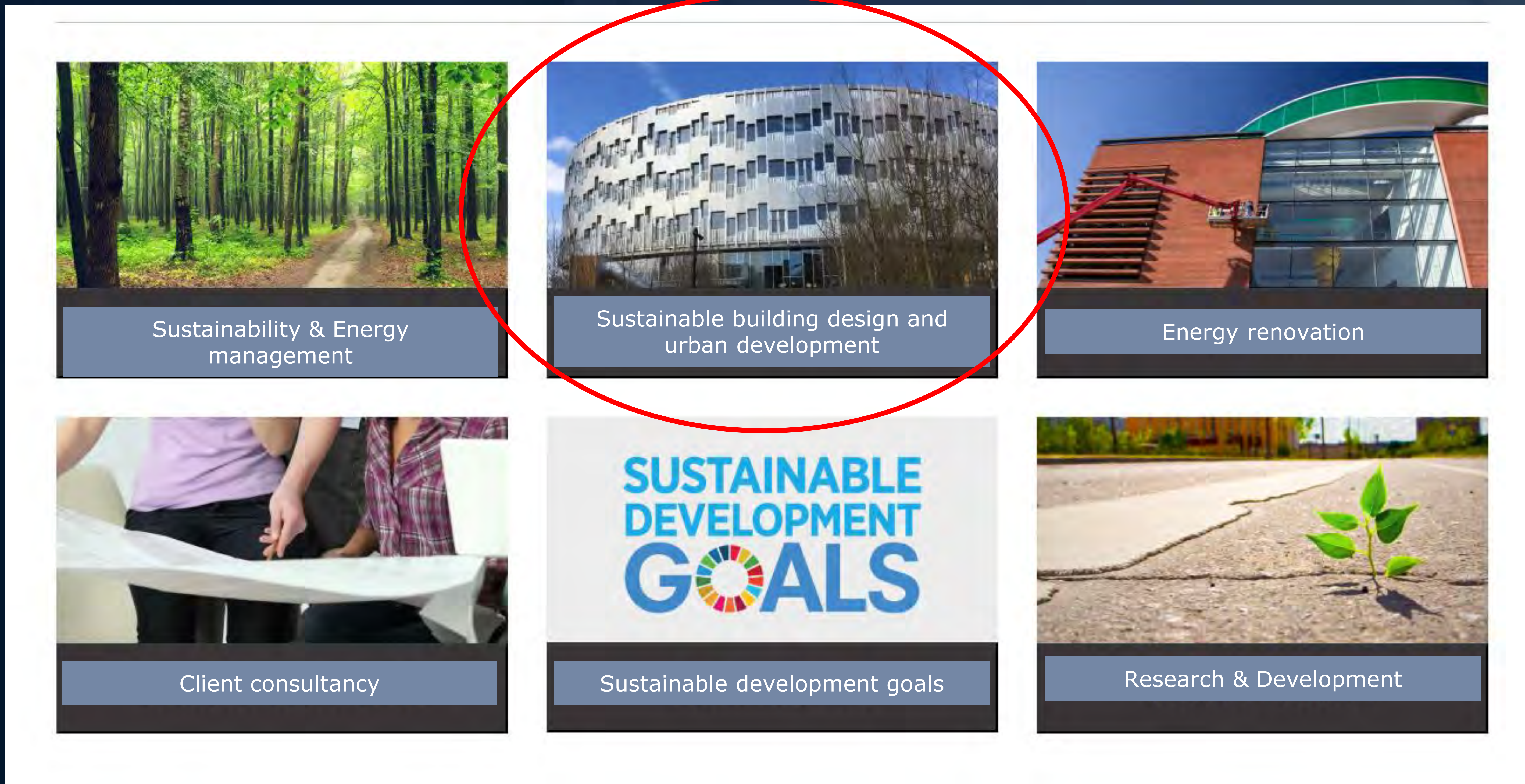

Main services

- Energy supply systems
- Technical installations (HVAC)
- Electrical installations
- Indoor climate
- Sustainability
- Renewable energy
- Sustainable master plan design
- Low/zero/plus energy buildings

Key aspects for solar energy in urban areas

In urban planning projects DEM analyses and optimizes **location and geometry** of buildings through an Integrated Design Process in order to **ensure good solar and daylight access** for the buildings in the area.

In sustainable urban planning, this is essential for outdoor areas as well as for indoor climate and local energy production, in the very beginning of the planning phase.

Our focus areas are:

- Daylight
- Utilization of solar energy
- Solar access and shading conditions in urban spaces

Daylight – What and Why?

- Most energy effective light source (reduction of energy demand)
- Maximum lighting comfort
- Almost impossible to change daylight conditions without signifant changes in the site plan

Special attention in order to ensure good daylight conditions:

- Hight of opposite building
- Street with (distance to oppposite building)
- Colour of facade (reflectance) of opposite building
- Window size, placing and type
- Space depth and room hight

Shadows and solar utilization – Why important?

Shadow analysis

- Direct solar is necessary to create urban life
  As a minimum, one urban space with direct solar in the morning, noon and afternoon must be available

Passive Solar

- Utilization of passive solar is free and reduces the energy demand

Active Solar

- What is the potential for local “free” energy production?

DK examples of new urban areas

Gehry City Harbour Sonderborg

- Daylight
- Utilization of solar
- Solar access and shading in urban spaces

FredericiaC

- Daylight
- Utilization of solar
- Solar access and shading I urban spaces

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DK examples of new urban areas

New Urban Quarters, Årslev

- Daylight
- Utilization of solar
- Wind

Carlsberg

- Utilization of solar

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Gehry City Harbour Sonderborg

Participants:

- Sønderborg Harbour Company
- Project Zero
- Municipality of Sonderborg
- Gehry Partners, LLP
- Juul & Frost architects
- Danish Energy Management

Area:	50.000 m^2
Floor area	52.400 m^2

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Sonderborg Harbour – Gehry proposal – Is it sustainable ?

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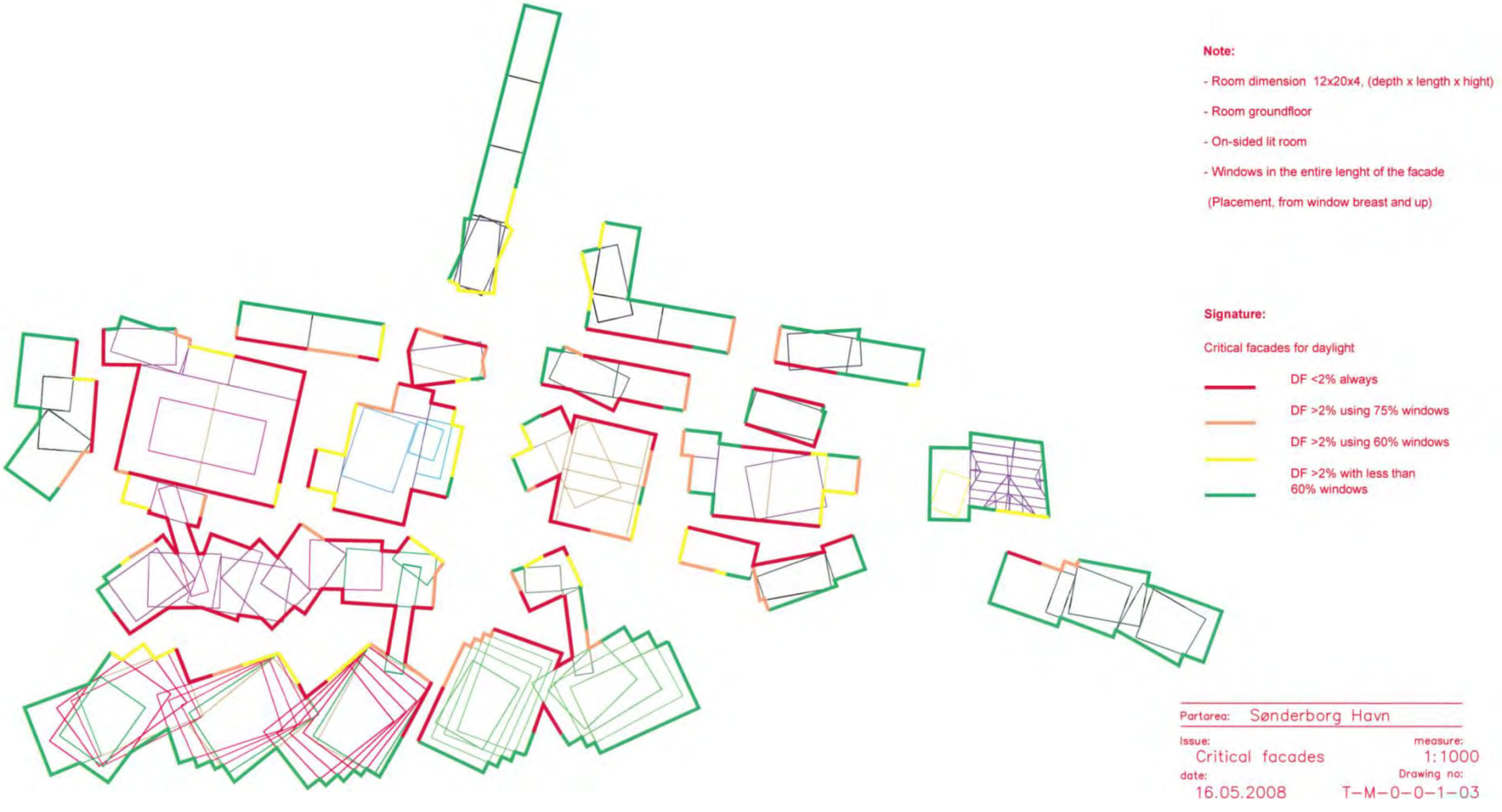
Sonderborg Harbour - Daylight

- Daylight factor > 2 % for work places
- The higher the daylight factor, the lower the need for artificial lighting and use of electricity

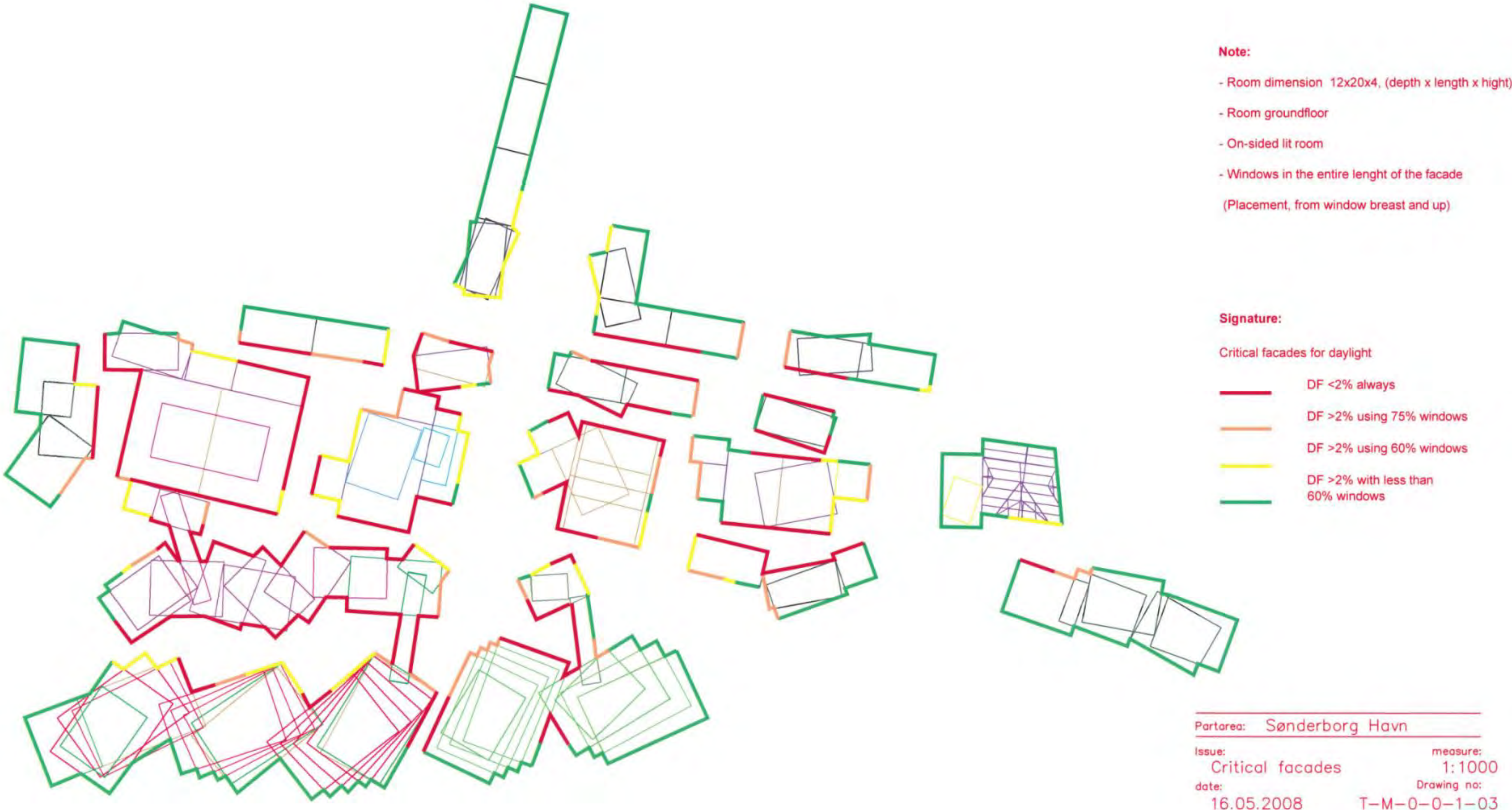
Analysis is based on the Wall to Window Ratio factor.
Developed as a part af business PhD by Anne Iversen



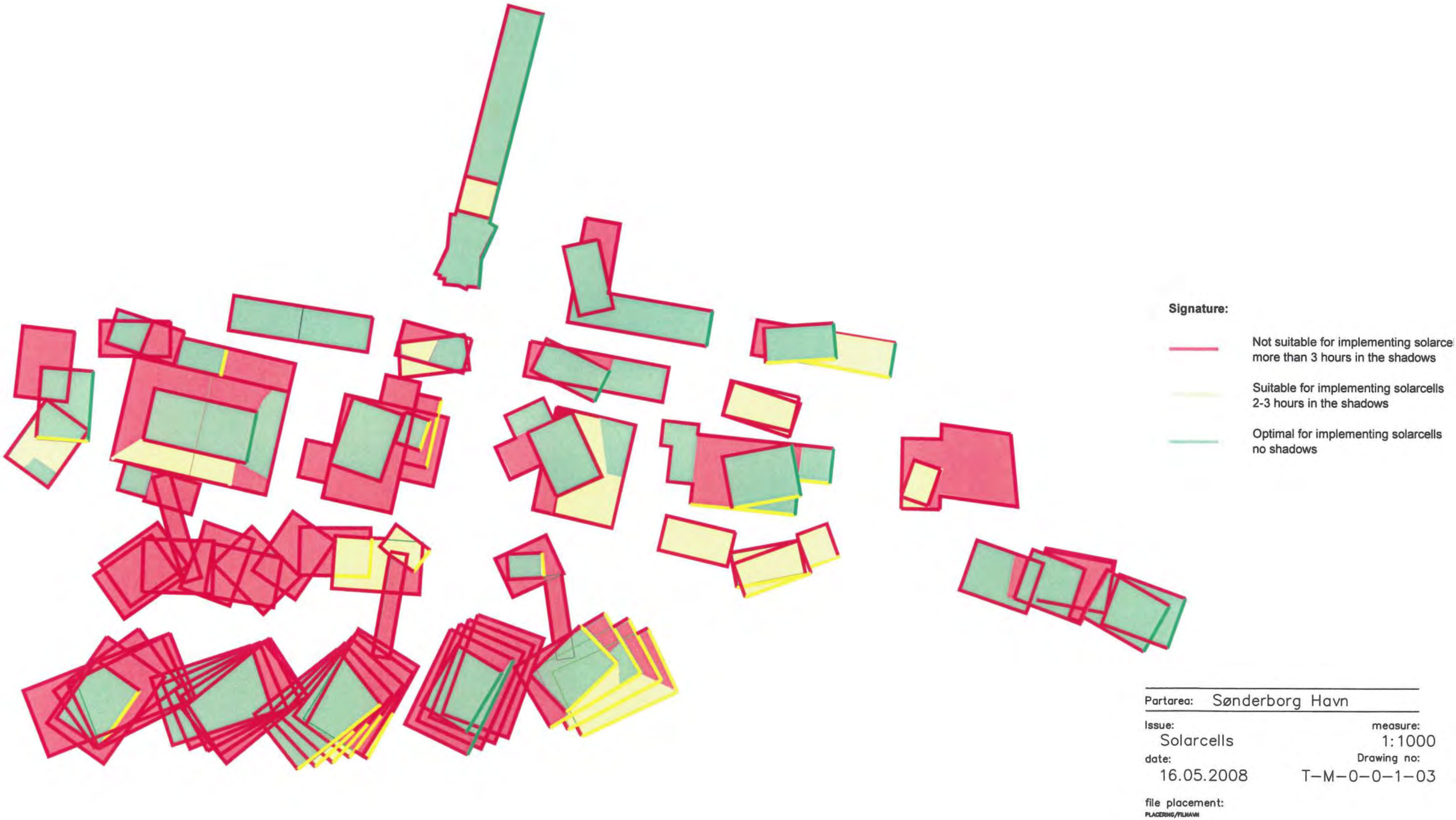
Sonderborg Harbour – Daylight - Fair

- Daylight factor > 2 % for work places
- The higher the daylight factor, the lower the need for artificial lighting and use of electricity

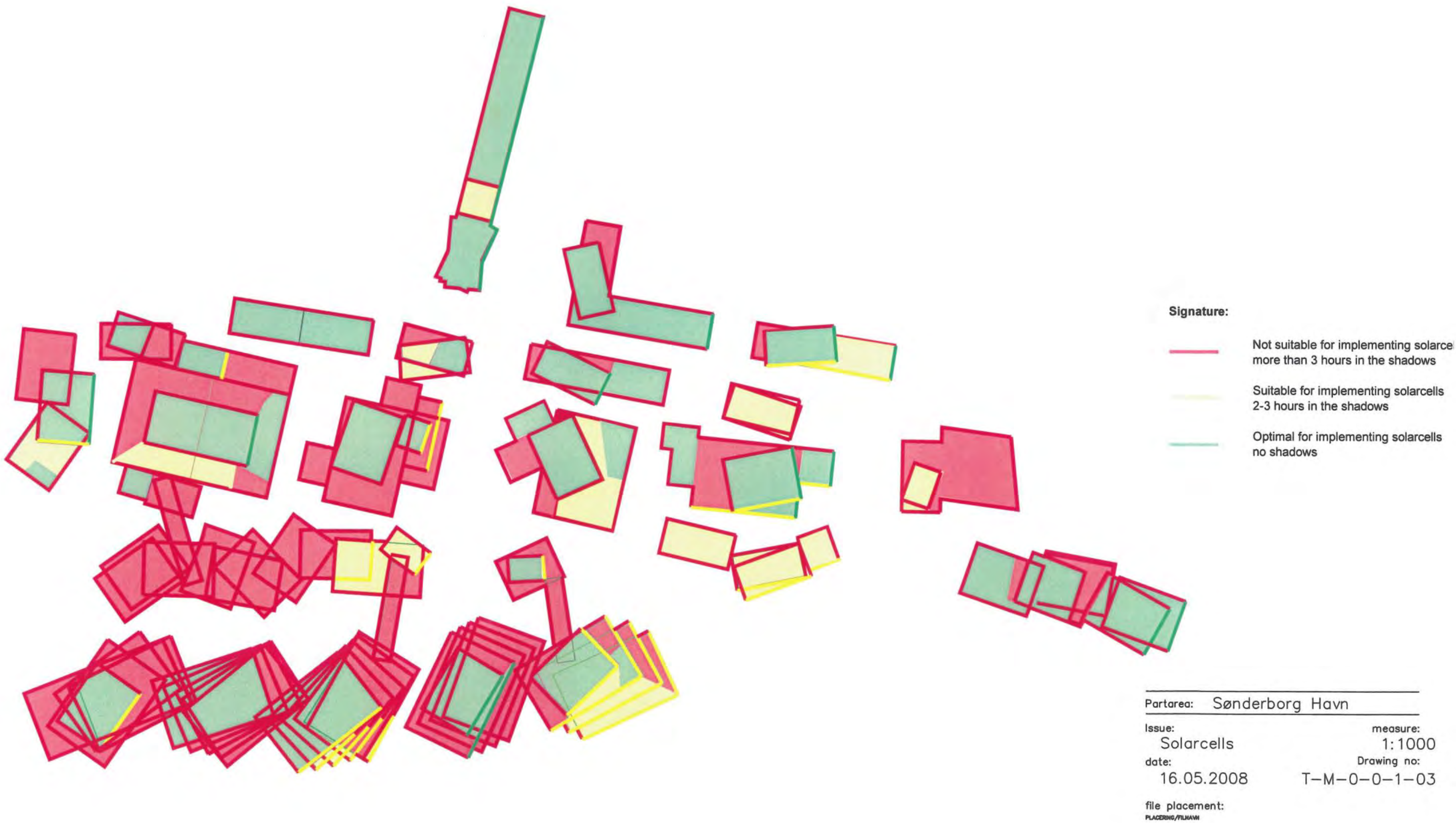
Analysis is based on the Wall to Window Ratio factor.
Developed as a part af business PhD by Anne Iversen



Sonderborg Havn – Solar access



Sonderborg Havn – Solar access – Too little



Sonderborg Havn – Solar access and shading – Equinox

- Left square - No solar
- On main square – Only solar in the middle of the day
- Theatre square – Solar from the middle of the day

Insufficient solar and daylight conditions in first Gehry proposal

Sonderborg Harbour

- Create life/light in urban spaces
  - Ensure direct solar in different places morning, noon and afternoon

- Design for increased solar utilization
  - Solar access
  - Daylight

Design workshop with architect

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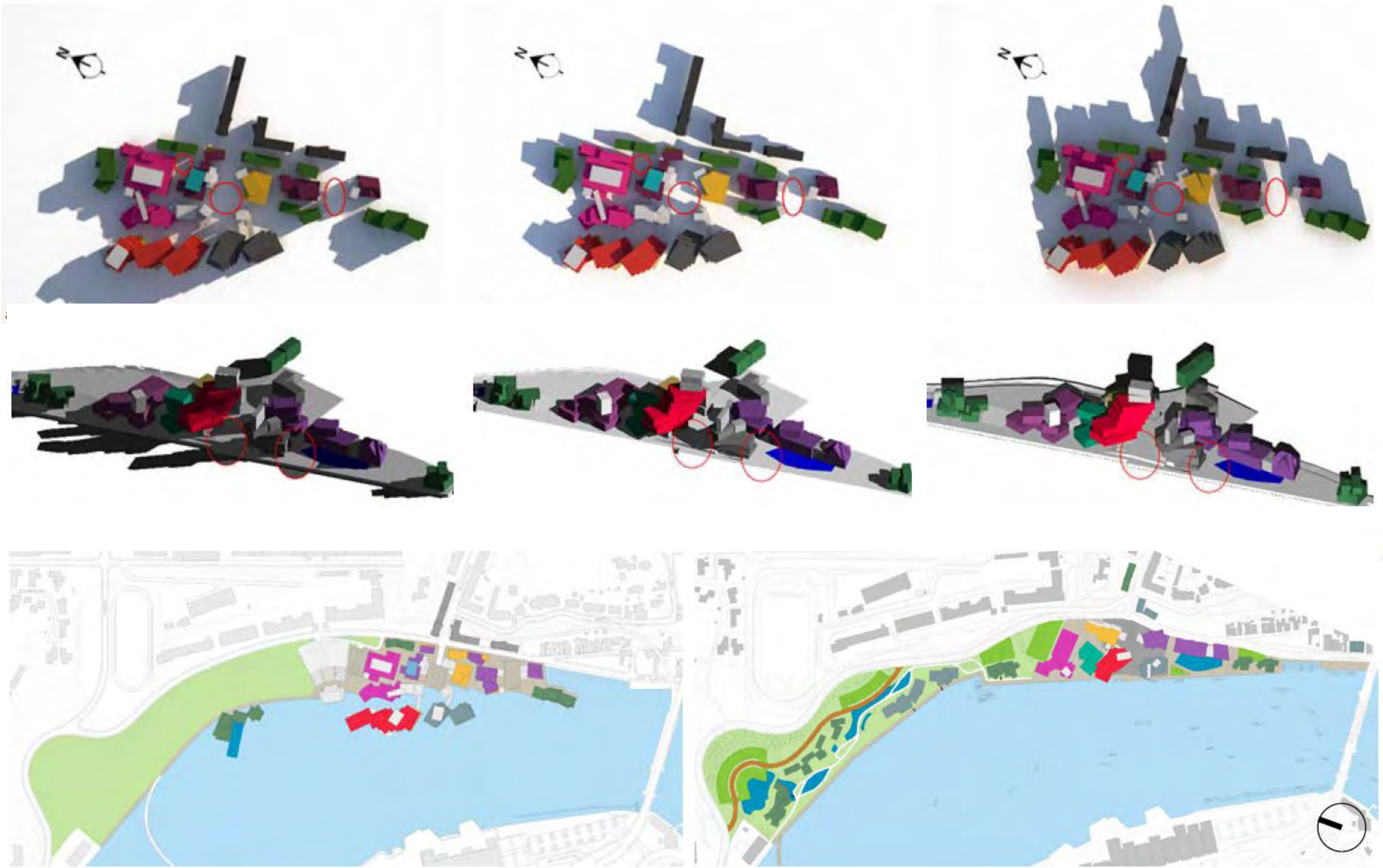
Sonderborg Harbour

- Create life/light in urban spaces
  - Ensure direct solar in different places morning, noon and afternoon

- Design for increased solar utilization
  - Solar access
  - Daylight

Design workshop with architect

Sonderborg Havn – Sollar access and shading - Equinox



Sonderborg Havn – photos & visualisations

http://www.byenshavn.dk

Figure 7 - Apartment building at City Harbor Sonderborg. (Source: © www.arkark.dk)

Figure 8 - Visualisation from hotel project at City Harbor Sonderborg (Source: © Henning Larsen Architects)

Figure 9 - Office building at City Harbor Sonderborg (Source: www.google.com)

Fredericia C

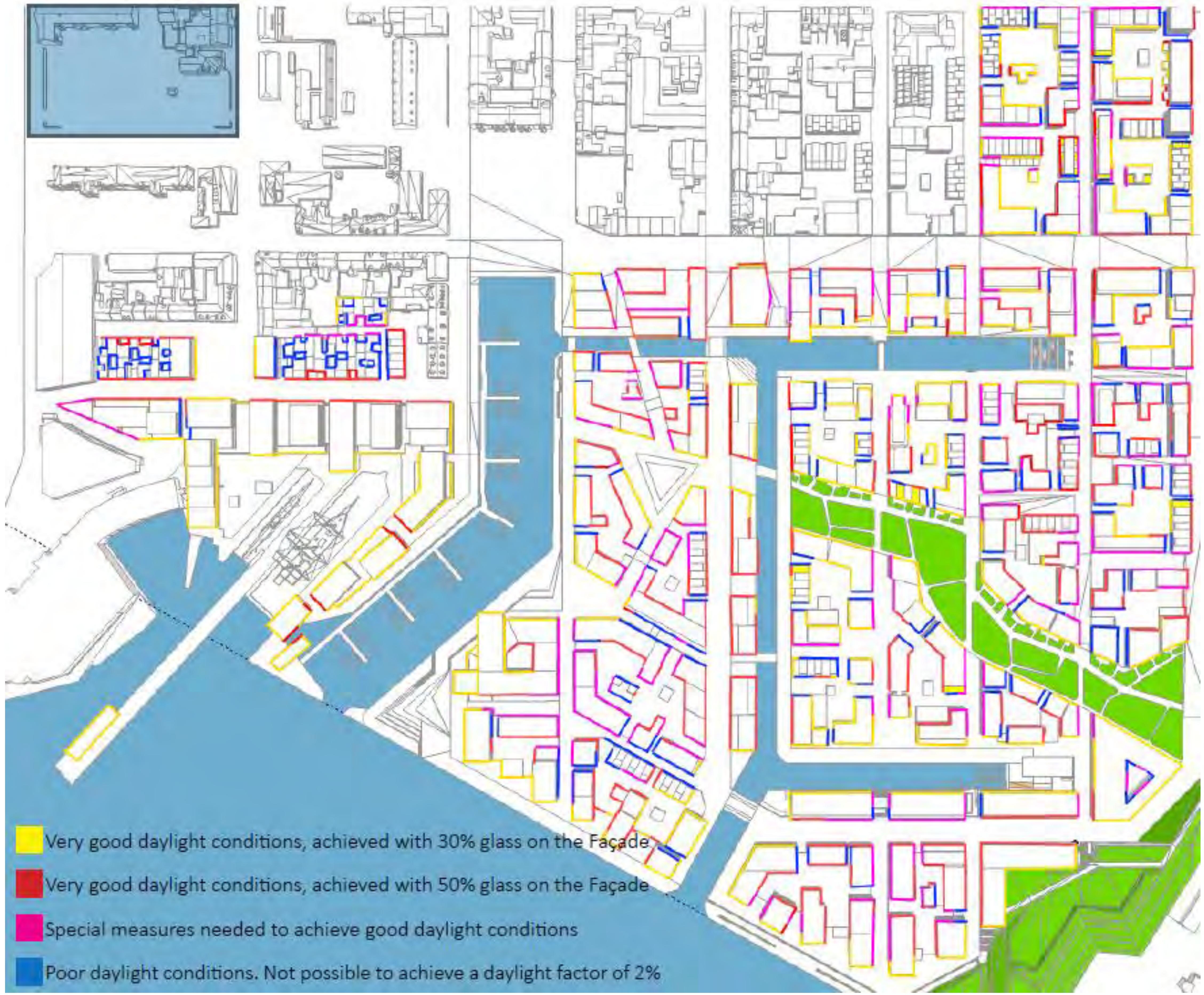
Participants:

- FredericiaC P/S
- Municipality of Fredericia
- Realdania
- KCAP Architects Planners
- Vandkunsten
- Danish Energy Management

Area: 204.000 m²

Floor area: 265.580 m²

FredericiaC - Daylight



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FredericiaC - Daylight - Final development plan

Housing

- Most housings will have very good daylight conditions. In critical areas apartments could be in 2 storeys

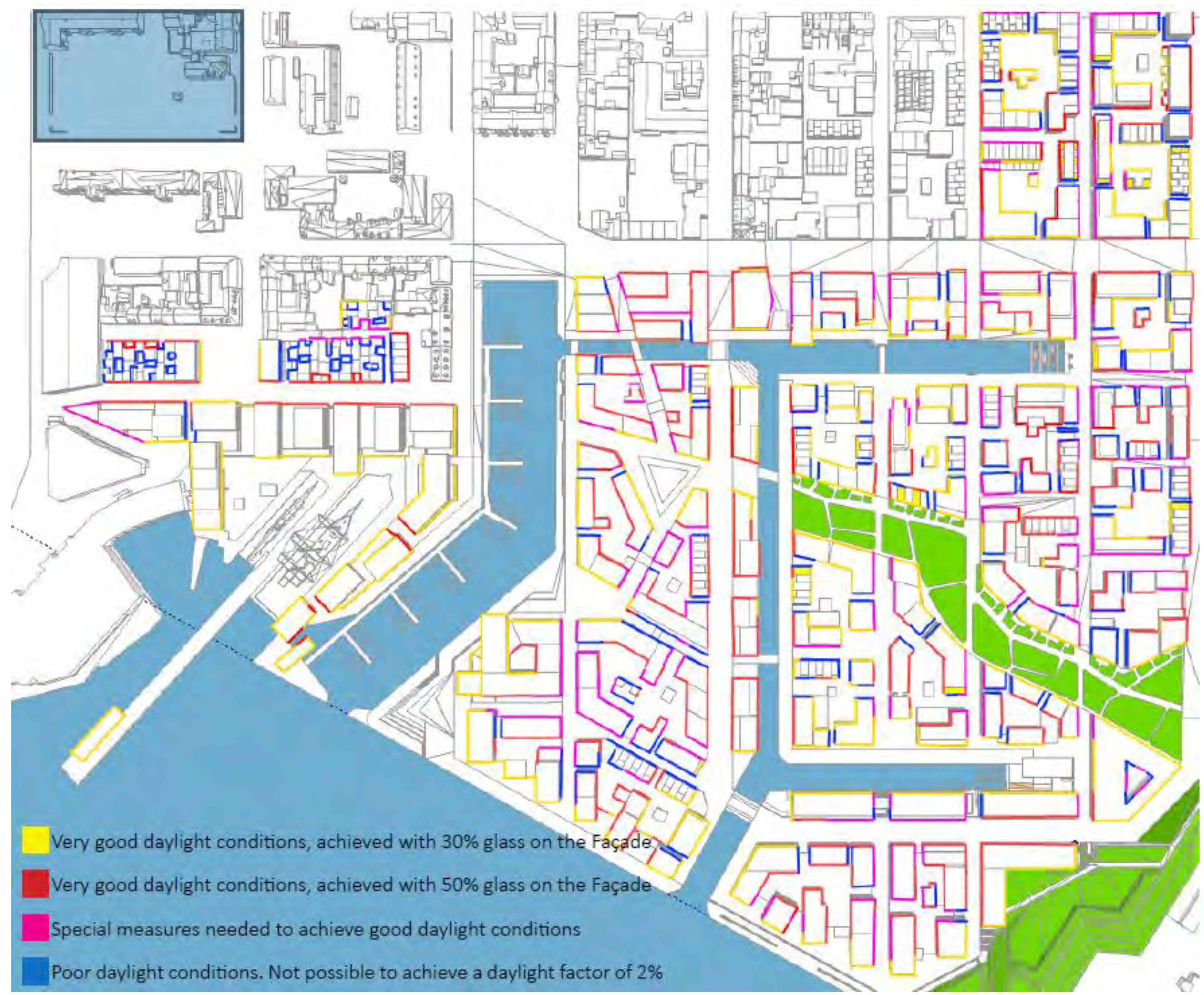
Offices

- Good daylight conditions everywhere

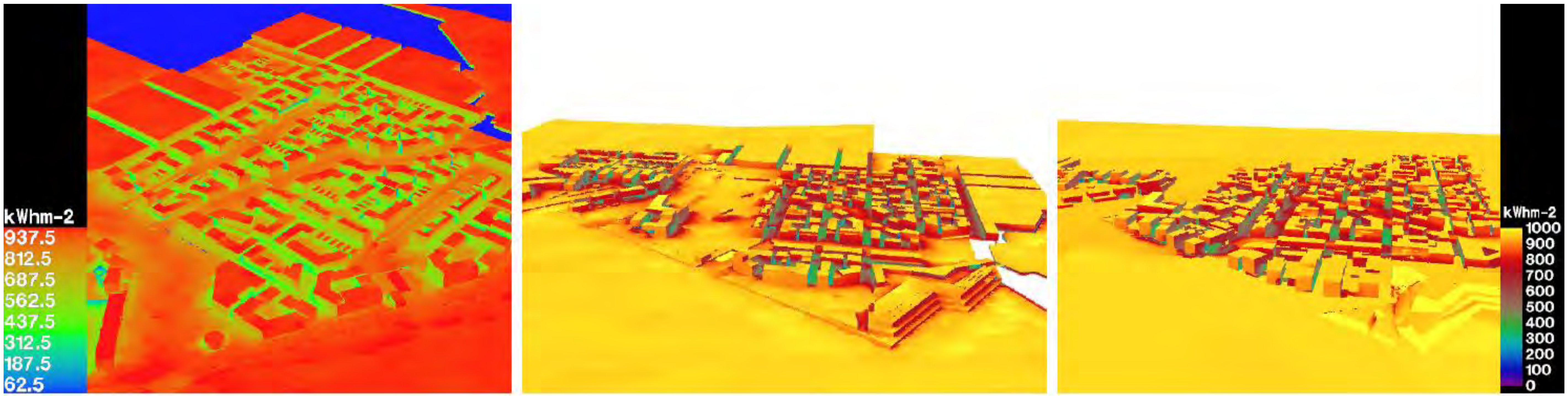
Hotels, retail and culture

- Good daylight conditions everywhere

Analyses made for ground floor



FredericiaC – Solar access



Available roof area for PV

In final masterplan 95 % of roof surface may be used for PV

I.e. 65.000 m² PV corresponding to an annual production of electricity of 8.750 MWh ≈ the electricity demand in 2.000 homes

FredericiaC - Solar access and shading – Final masterplan

Shading analyses at equinox (22/3, 22/9), kl. 9.00, 12.00 og 15.00

Most urban spaces have good direct solar access

FredericiaC – Visualization of part of FredericiaC

http://www.fredericiac.dk/

New Urban Quarters, Årslev

Participants:

- Municipality of Midtfyn
- Vandkunsten
- Danish Energy Management
- Raw Mobility
- Bactocon

Area: ca. 200.000 m^2

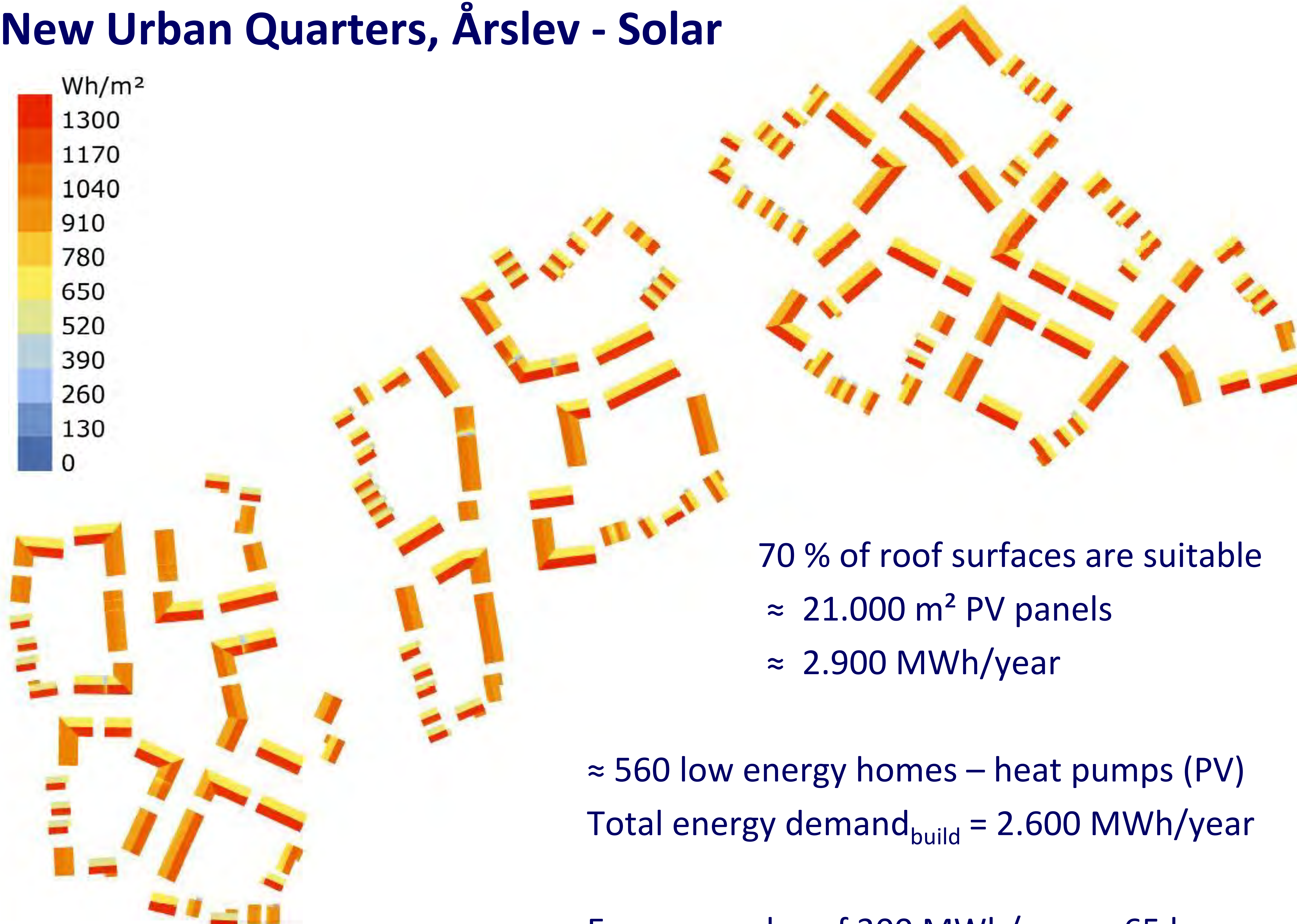
Floor area: up to 60.000 m^2

Time schedule:

2018 - 2050


Stationsvej
Portalen
Portalbroen
Vindingeå
Vindinge Ådal
børnenes dyremark
udlagt til parkering
eng
blå-grøn landskabskile
regnvandssø
bro
trug
Gård 1.1
Gård 1.2
Gård 1.3
Gård 1.4
Gård 1.5
bydelsplads
klynge 1
BAKKEDRAGET
ressourceplads
Gård 2.1
Gård 2.2
Gård 2.3
Gård 2.4
klynge 2
Å-DALEN
grussti
græsland
Ringsted Å
Nybyvej
eksisterende allé
ny skov
Ringstedskov
Gård 3.1
Gård3.2
Gård 3.3
Gård 3.4
Gård 3.5
Gård 3.6
klynge 2
SKOVBRYNET
hestefold
0 20 40 60 80 100 m
N

New Urban Quarters, Årslev - Solar



70 % of roof surfaces are suitable

≈ 21.000 m² PV panels

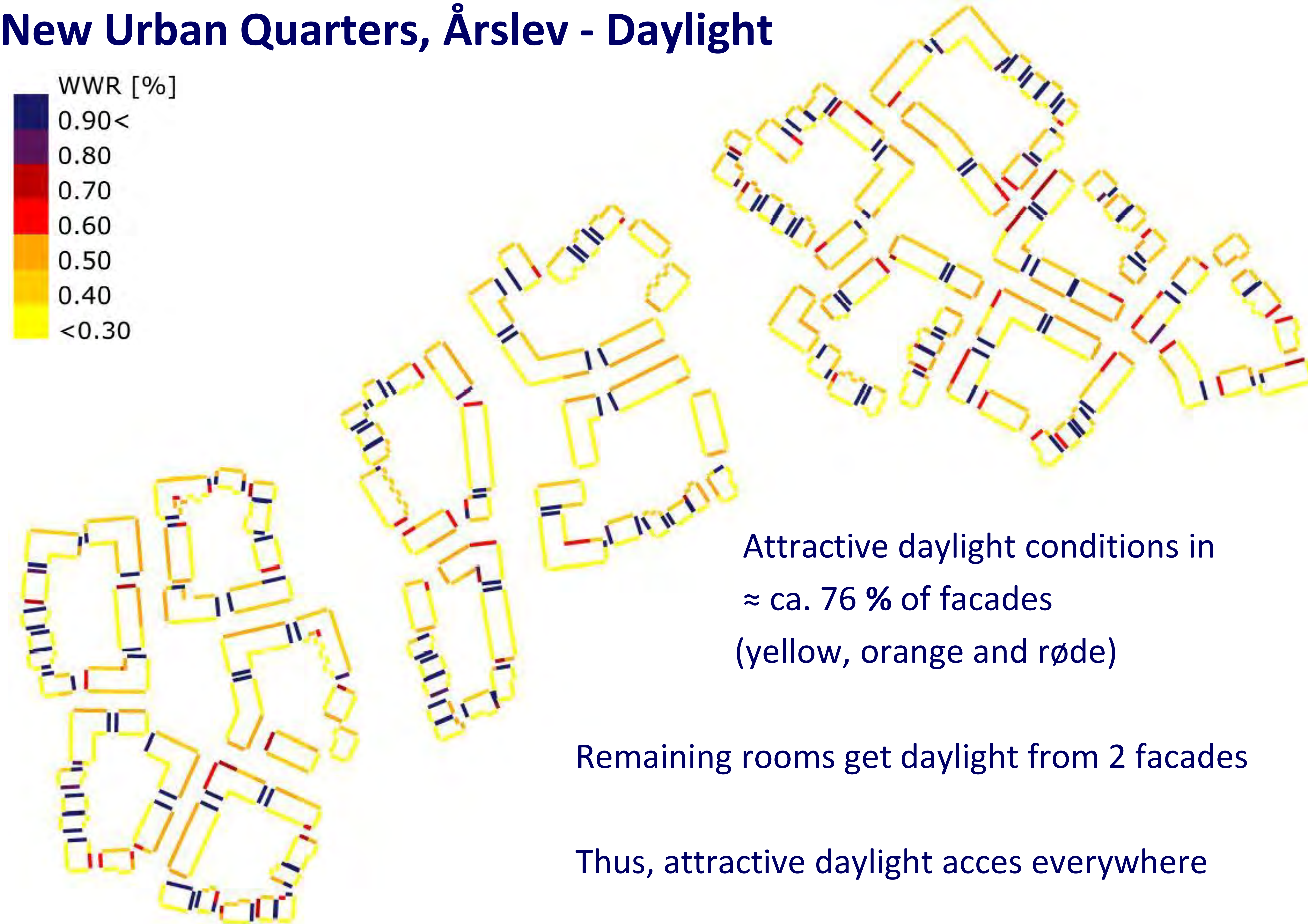
≈ 2.900 MWh/year

≈ 560 low energy homes – heat pumps (PV)

Total energy demand$_{build}$ = 2.600 MWh/year

Energy surplus of 300 MWh/year ≈ 65 homes

New Urban Quarters, Årslev - Daylight



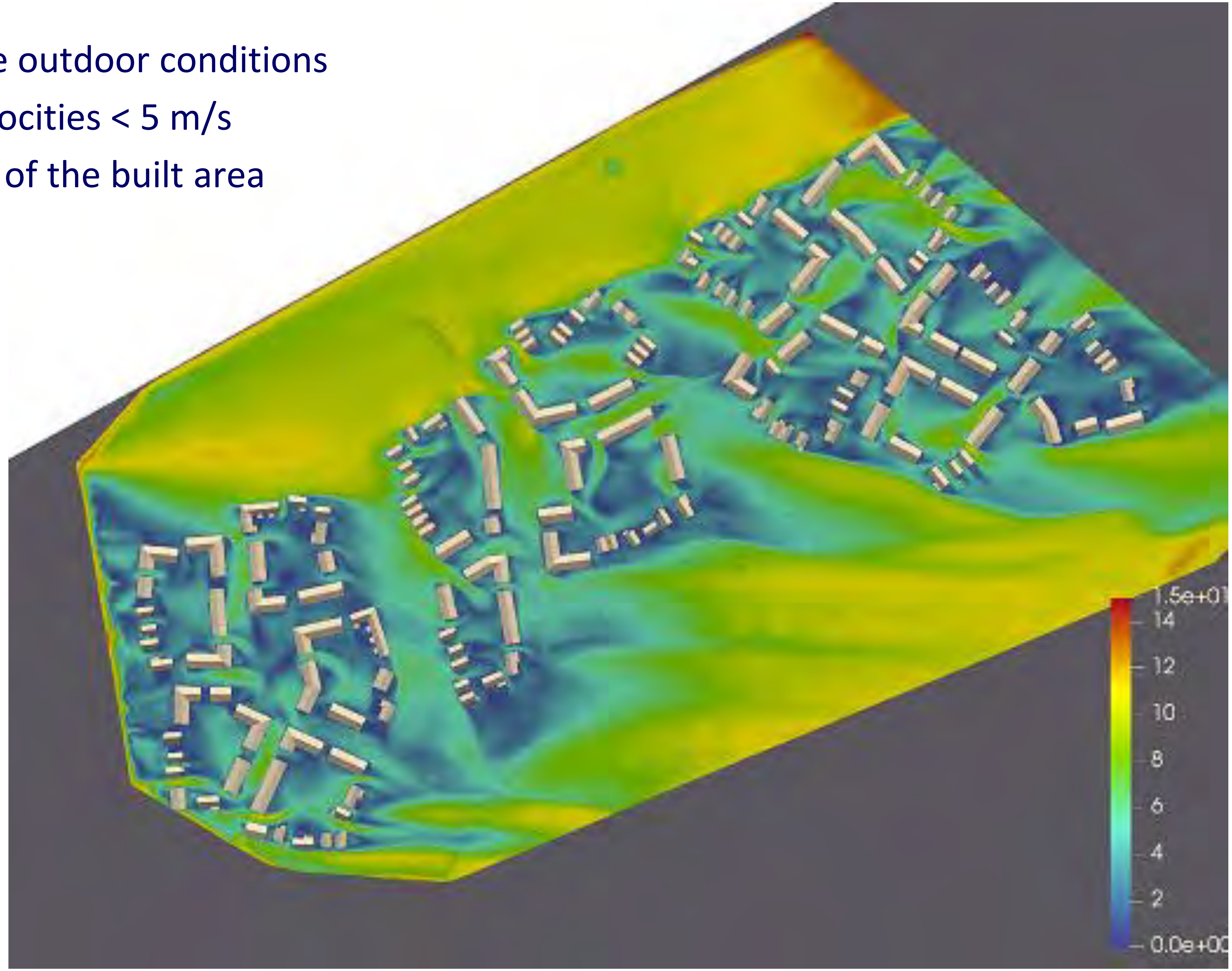
Attractive daylight conditions in
≈ ca. 76 **%** of facades
(yellow, orange and røde)

Remaining rooms get daylight from 2 facades

Thus, attractive daylight acces everywhere

New Urban Quarters, Årslev - Wind

Attractive outdoor conditions
(wind velocities < 5 m/s
in + 70 % of the built area



Software:
SimScale

DANISH ENERGY MANAGEMENT
DEM
FOR SUSTAINABLE IMPACT

Carlsberg - A new urban area in central Copenhagen

Participants:

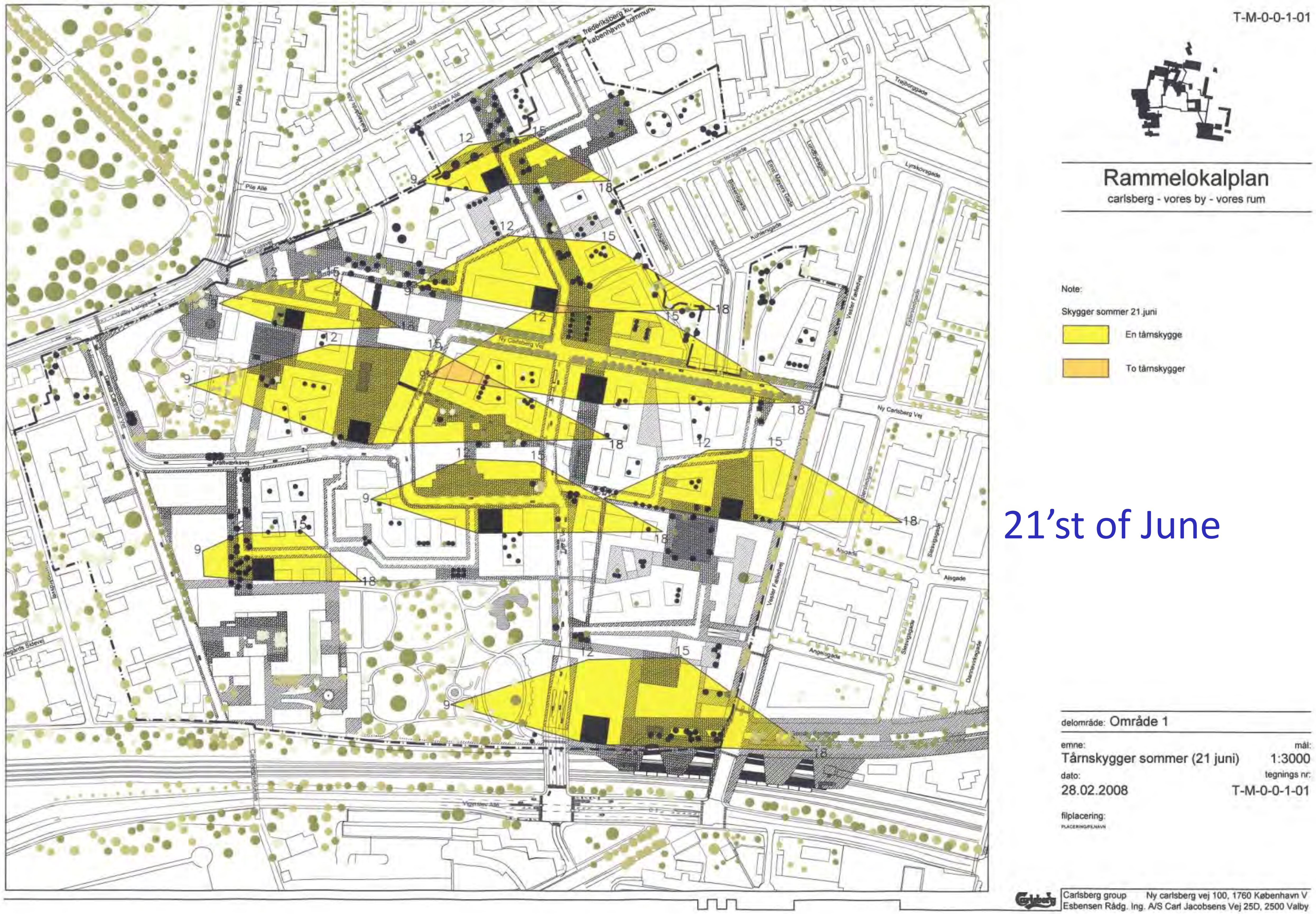
- Carlsberg
- Entasis architects
- Danish Energy Management

Area:	300.000 m²
Floor area	600.000 m²

Time schedule:

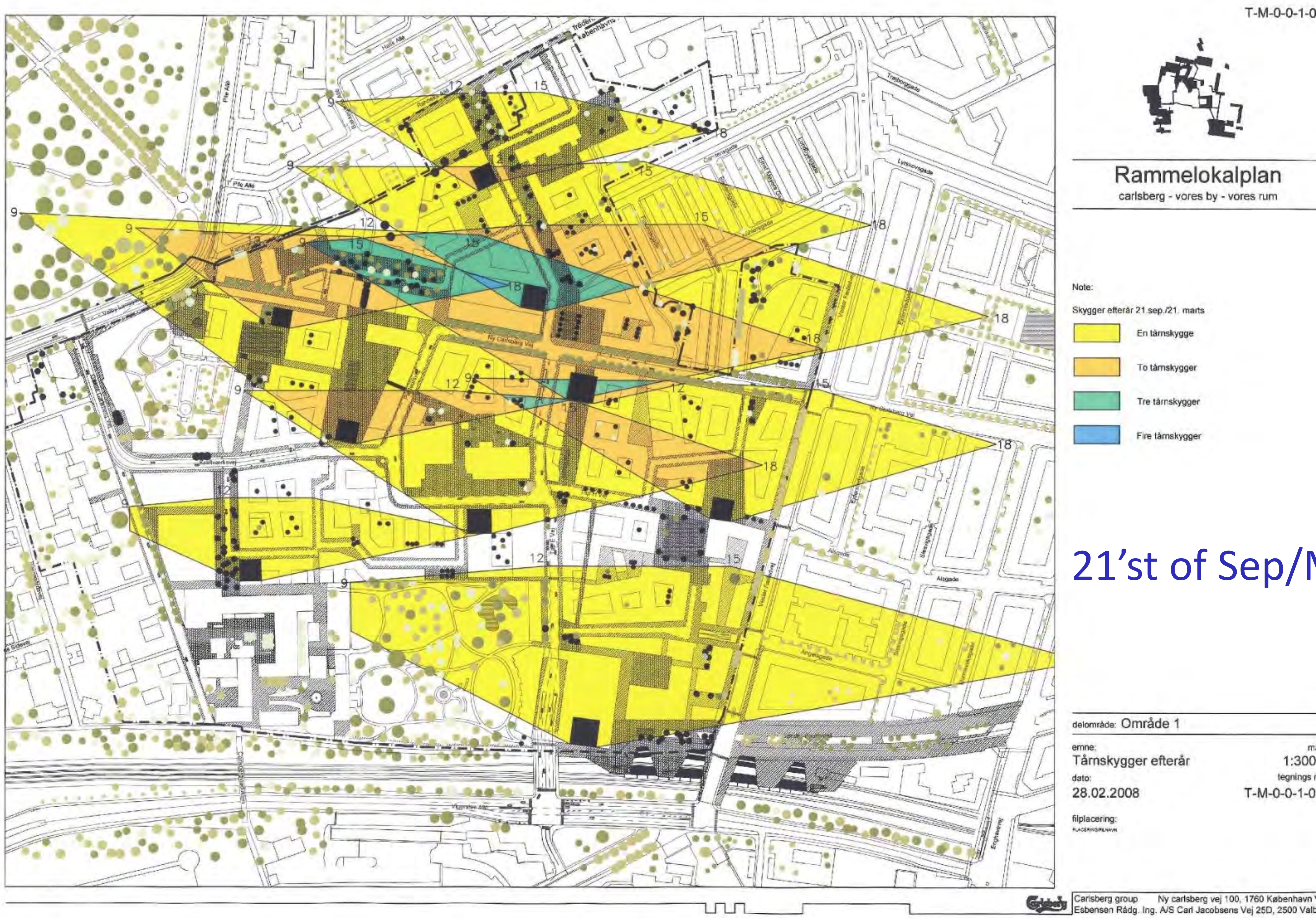
2007 - 2027

Carlsberg - Solar



21'st of June

Carlsberg - Solar



21'st of Sep/Mar

Solar Digitization Techniques to Enhance Optimal Exploitation of Solar Energy in the Nordics
Gabriele Lobaccaro and Mattia Manni

The presentation begins with an introduction to solar energy potential and the photovoltaic landscape in Nordic climates. It also explores opportunities for solar energy potential in different latitudes. This is followed by a presentation of the HELIOS Project, firstly by introducing a brief on HELIOS and the HELIOS NTNU Team, then by discussing Green 2050. The presentation concludes with a discussion on solar digitization techniques to enhance optimal exploitation of solar energy in the Nordics. The objective of this research was to develop and validate a solar irrandiance model chain that could be used in the Nordics.

Helios - NFR FRIPRO FRINATEK

Solar digitalization techniques to enhance optimal exploitation of solar energy in the Nordics

Gabriele Lobaccaro

Associate Professor

E-mail: gabriele.lobaccaro@ntnu.no

Seminar ON SOLAR NEIGHBORHOODS

Calgary (Canada)
Friday 23.09.2022

The Research Council of Norway

hepia

NTNU

Kunnskap for en bedre verden

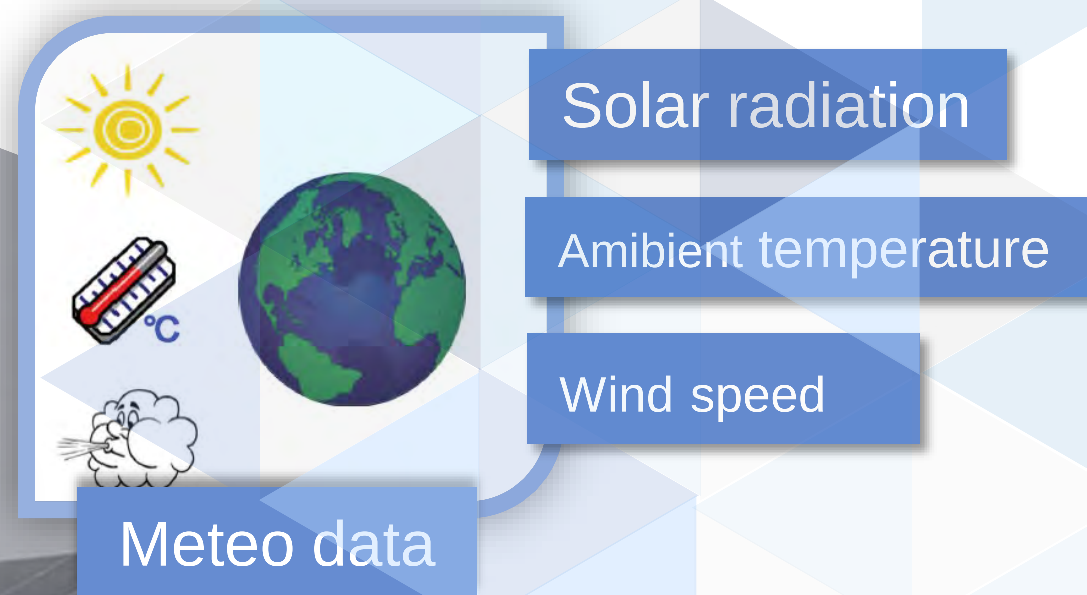
SOLAR ENERGY POTENTIAL

01

The solar energy potential

- Solar energy potential
- Opportunities for the solar energy potential in different latitudes

PV Landscape in Nordic climate



Reference: fjordkraft.no

Referanse: fjordkraft.no

CHALLENGE SOLAR

In the Nordic climate!

Nordic Energy Research

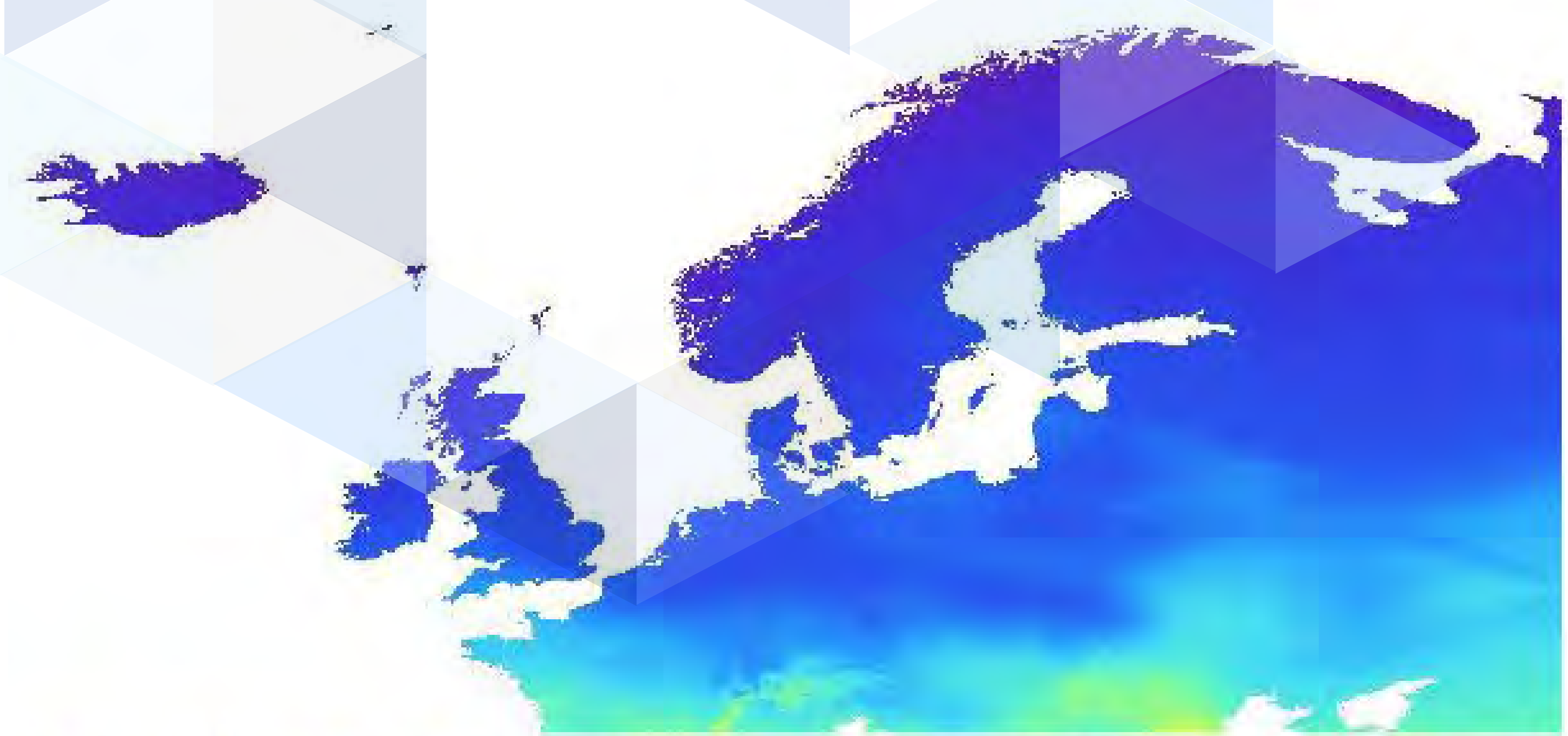
Sustainable Energy Systems 2050
NORDIC ENERGY RESEARCH PROGRAMME

Solar energy potential

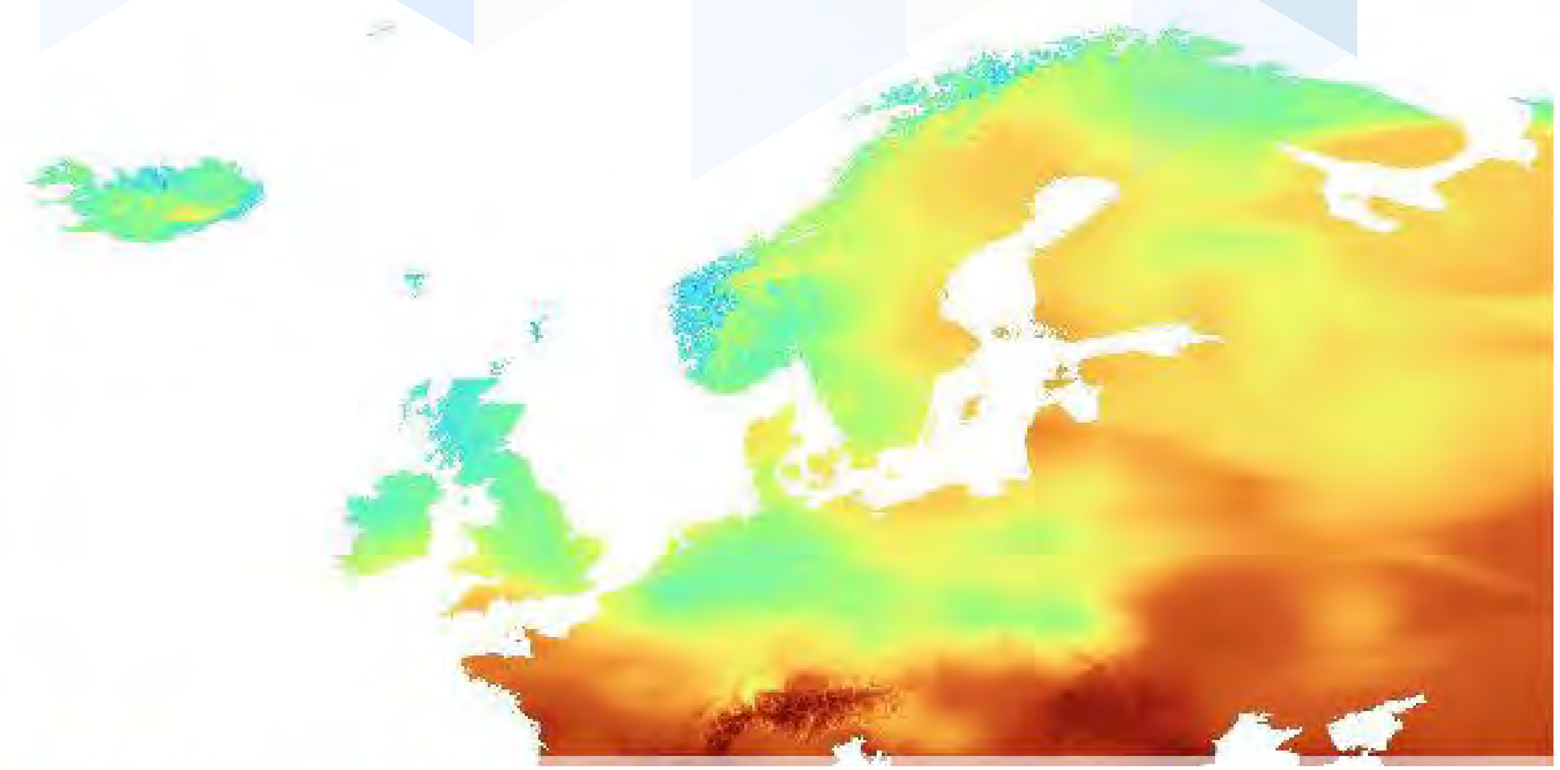
NorthSol Solar Power Plants in the Nordic Climate
Common notions and myths

- Too little sunlight FALSE
- Too expensive FALSE
- Too cold FALSE:Lower temperature gives higher efficiency

Country	City	Annual Sun Hours
UK	London	1500
Germany	Freiburg	1700
Sweden	Piteå	2000



Solar radiation on a horizontal surface (kWh/m²år)



Solar radiation on a 2-axis solar tracking surface (kWh/m²år)

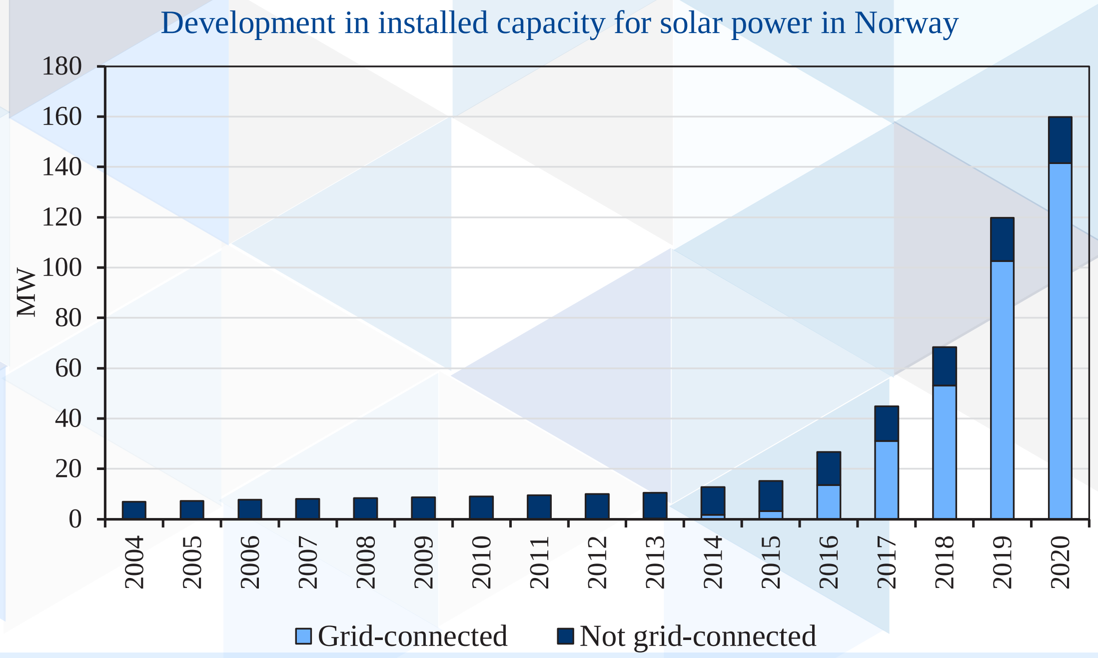
Solar cells in the Nordic climates

Referanse: solenergiklyngen.no / multiconsult.no / tu.no / fmezen.no

Solar installation in Norway

Cumulative installed power in Norway

- Installed capacity for solar power in Norway has increased **tenfold** during the last five years
- Misconception that the level of irradiation in the Nordics is much lower than in the Continental Europe
- **New opportunities** for solar energy (i.e., building-integrated photovoltaic, agri-photovoltaic, floating solar systems)
- Needs for tools and platforms such as the **Solar Cadastre** to support designers and urban planner

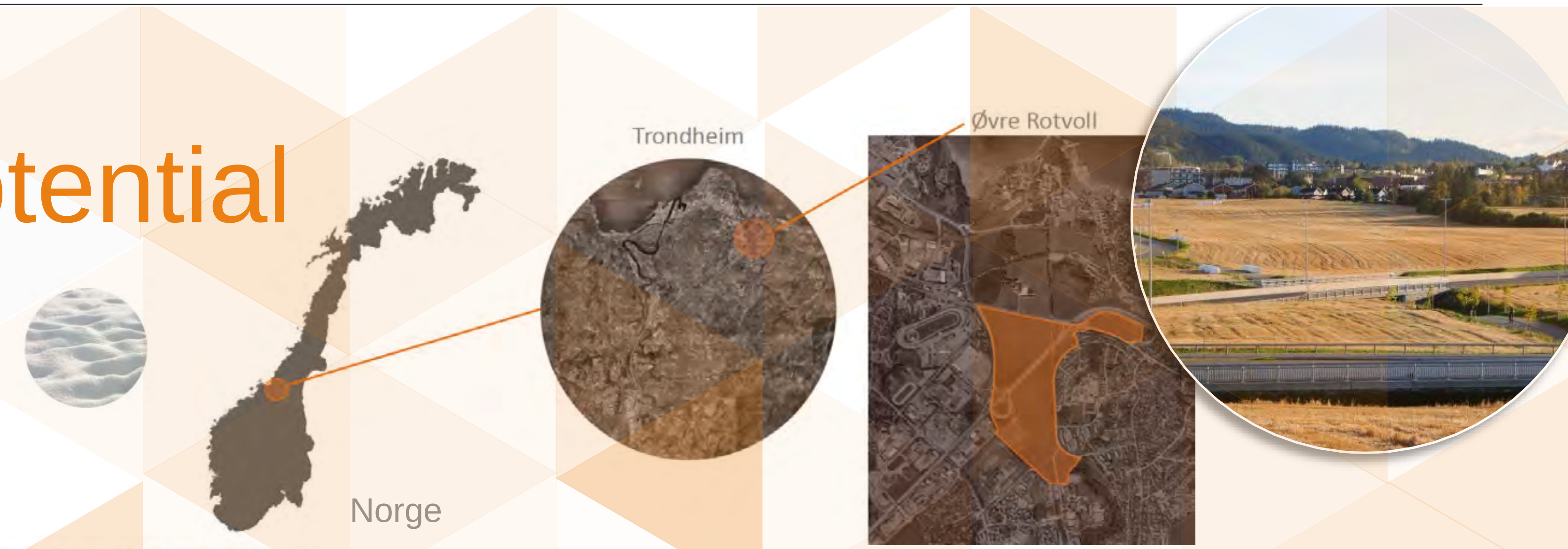


Objective Development and validation of solar irradiance model chain to be used in the Nordics

Referanse: solenergiklyngen.no / multiconsult.no / tu.no / fmezen.no

Solar energy potential at high latitudes

Case study of solar energy potential in Norway



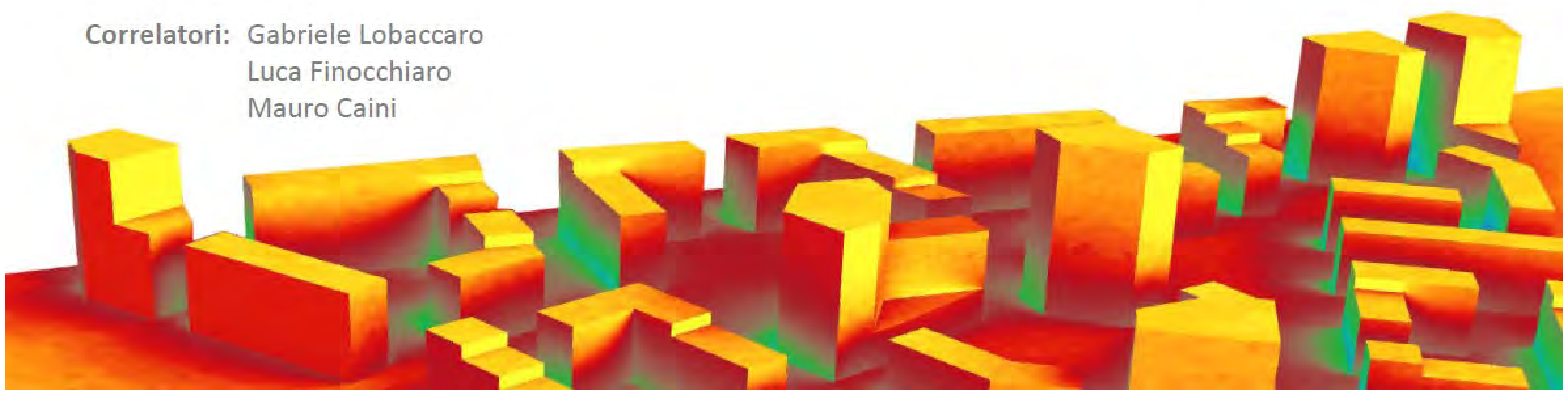
SOLAR POTENTIAL OPTIMIZATION IN URBAN PLANNING IN EXTREME COLD CLIMATE CONDITIONS

Design guidelines for solar accessibility and solar design for developing the masterplan of Øvre Rotvoll neighbourhood in Trondheim (Norway)

Laureanda: Silvia Croce

Relatore: Rossana Paparella

Correlatori: Gabriele Lobaccaro
Luca Finocchiaro
Mauro Caini



Reference: Lobaccaro G., Carlucci S., Croce S., Paparella R., Finocchiaro L., Boosting solar accessibility and potential of urban districts in the Nordic climate: A case study in Trondheim, Solar Energy Vol. 149, (2017), pp. 347-369.

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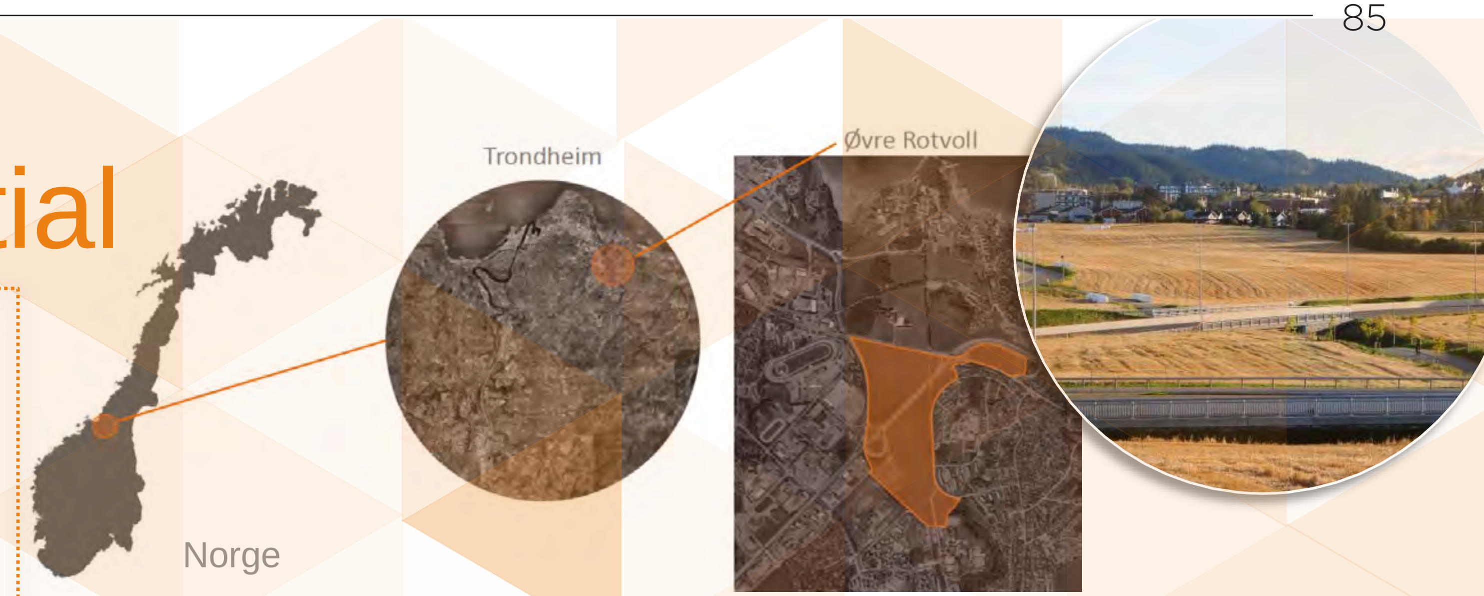
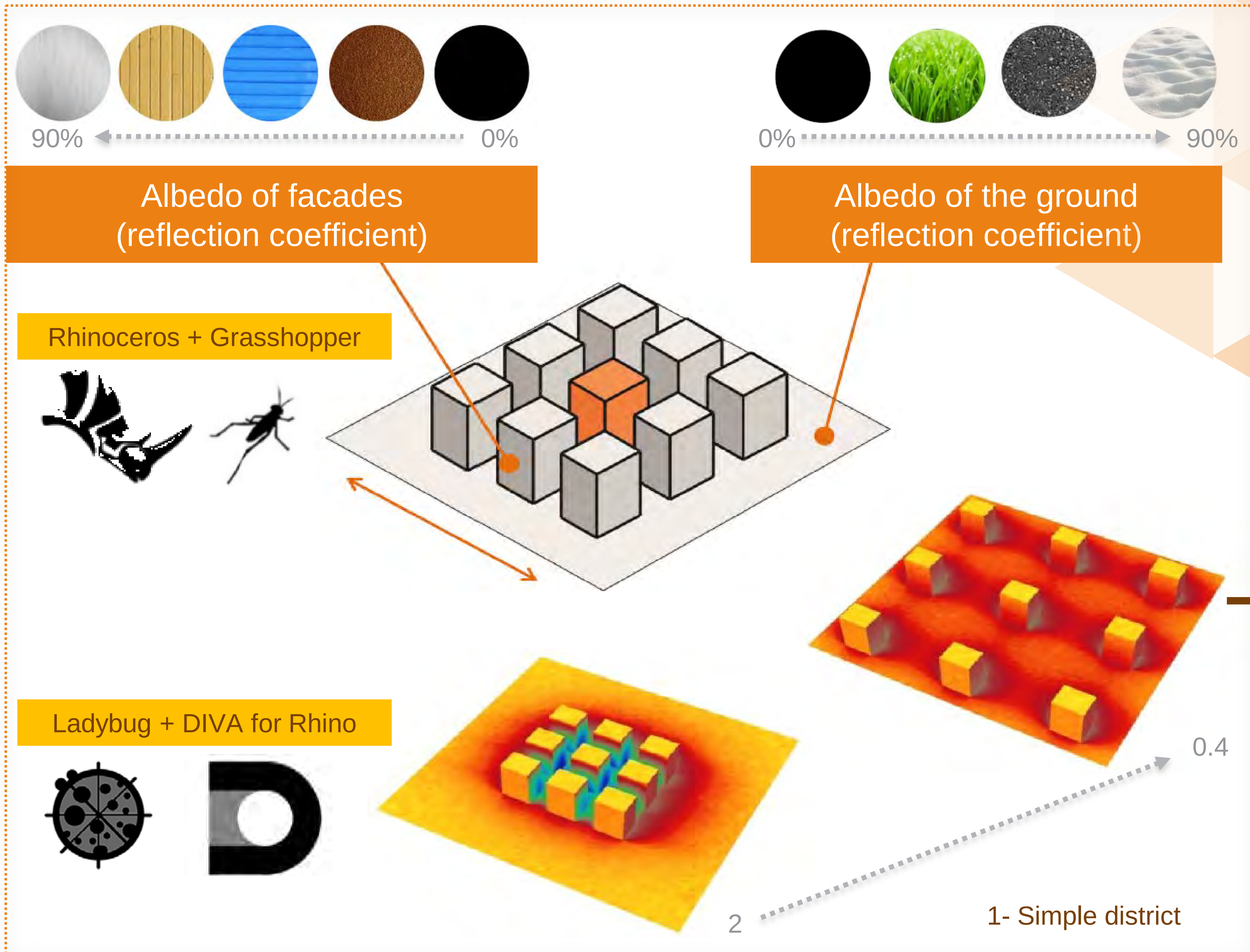
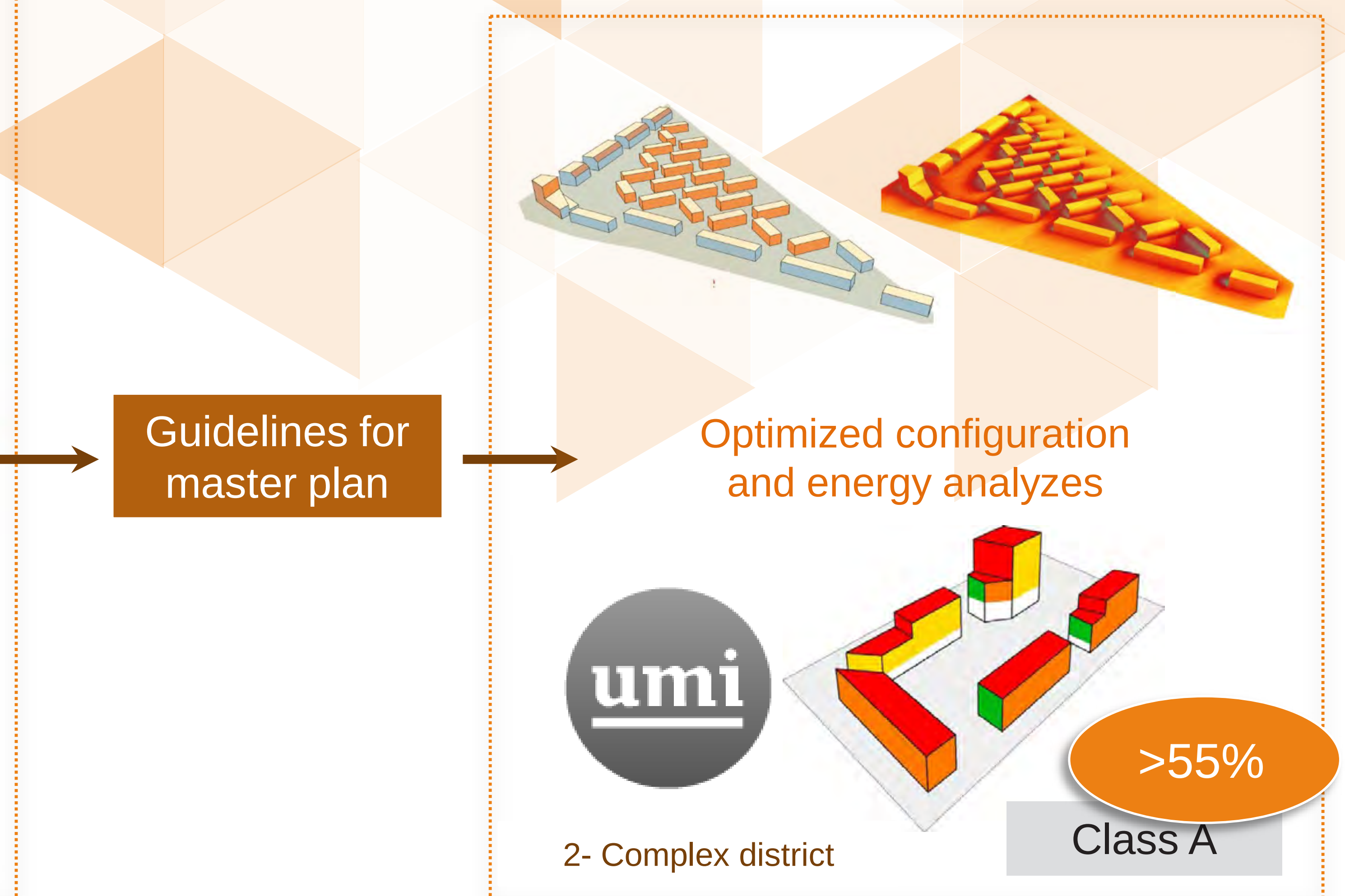
10

Case study of solar energy potential

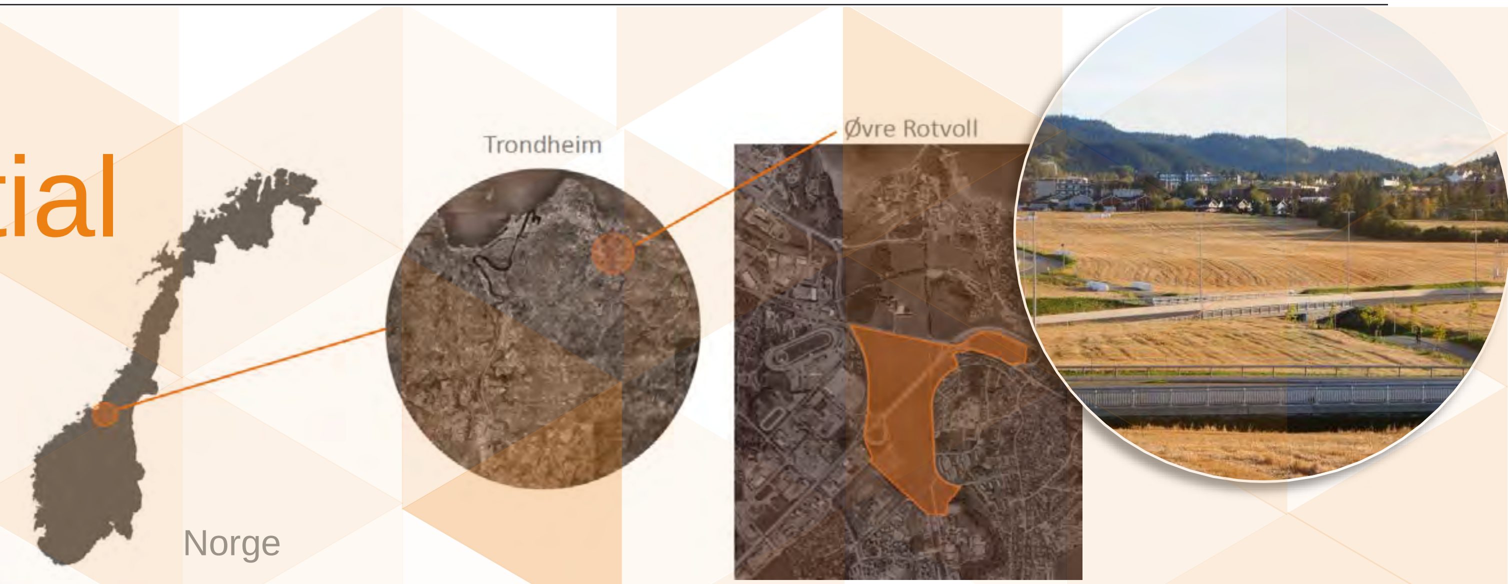


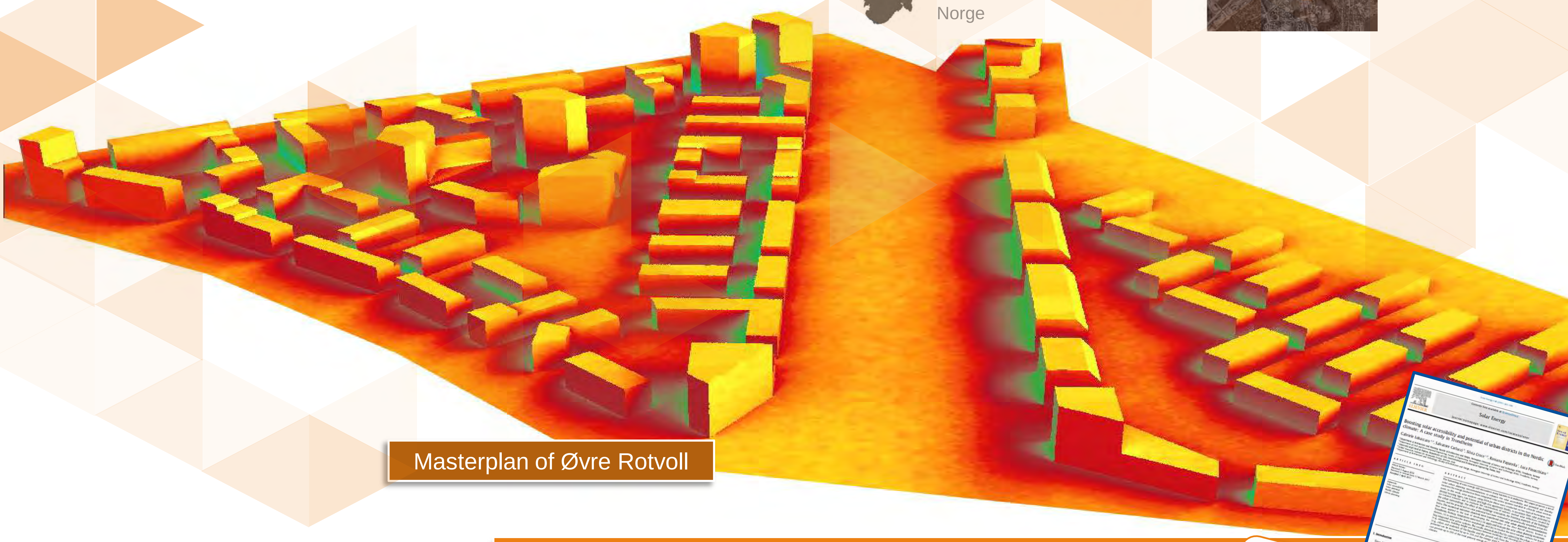




Reference: Lobaccaro G., Carlucci S., Croce S., Paparella R., Finocchiaro L., Boosting solar accessibility and potential of urban districts in the Nordic climate: A case study in Trondheim, Solar Energy Vol. 149, (2017), pp. 347-369.

Case study of solar energy potential in Norway





Masterplan of Øvre Rotvoll

Reference: Lobaccaro G., Carlucci S., Croce S., Paparella R., Finocchiaro L., Boosting solar accessibility and potential of urban districts in the Nordic climate: A case study in Trondheim, Solar Energy Vol. 149, (2017), pp. 347-369.

Master thesis

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Solar systems in the Lerkendal district

Data of photovoltaic facade:

- 200 m2 South and West facades;
- 27.2 kWp, 9 strings;
- Annual production: 18 000 kWh;
- Actual production (2013): 15 000 kWh (+15%simulated)

Data of the building:

- Building area: 11 000 m2;
- Annual consumption 84 kWh/m2 - Energy class A.
- Connected to district heating and power grids.

Destination of the district and functions:

- Sports facilities,
- Commercial buildings
- Service warehouse

View of the area from the top- Reference: google maps og flere

Solar systems in the Lerkendal district

How to avoid and prevent these situations?

View from the top of Lerkendal Studentby - Reference: http://www.adressa.no/

Analysis using dynamic simulations

1: Local solar potential
(isolated scenario)

2: Local solar potential
(urban scenario)

DIVA FOR RHINO
ENVIRONMENTAL ANALYSIS FOR BUILDINGS

DiVA for Rhino
Based on Radiance ray-tracing method

DAYSIM
ADVANCED DAYLIGHT SIMULATION SOFTWARE

3: Energy production

PVSYST

PVsyst
PV simulation

polysun SIMULATION SOFTWARE

Polysun
Solar thermal

Referance: Good C.S., Lobaccaro G., Hårklau S., Optimization of solar energy potential for buildings in urban areas - a Norwegian case study, Energy Procedia, Volume 58 (2014) pp 166-171

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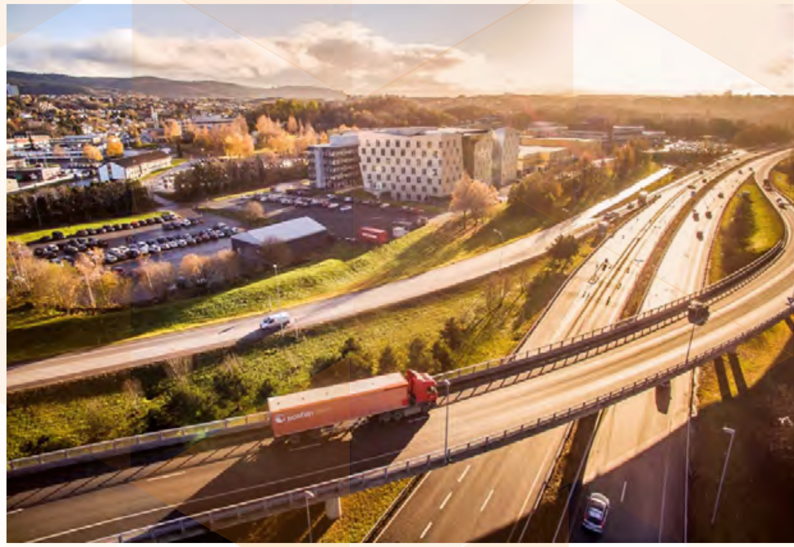
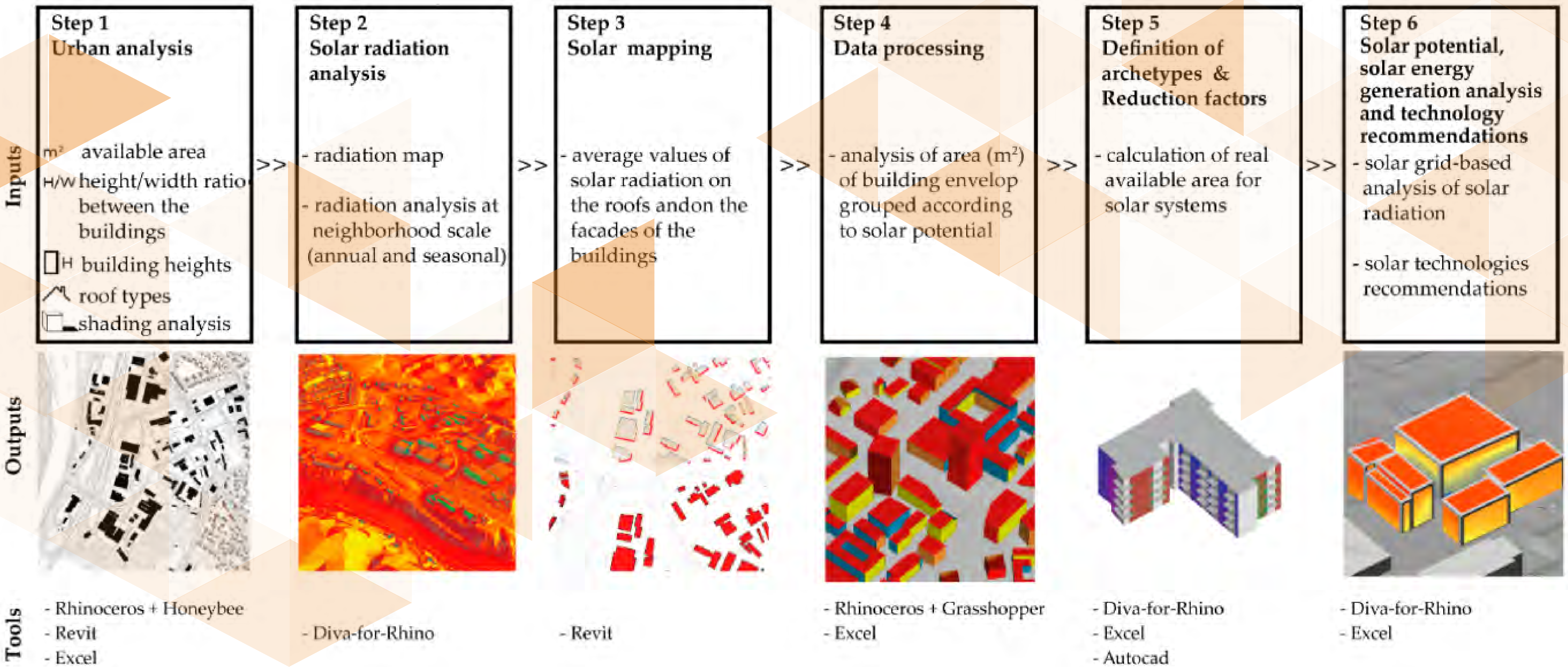
Sluppen – Feasibility study….2050?



Referanse: Trondheim Kommune

Sluppen – Feasibility study….2050?

New and existing buildings in existing situation (a) Feasibility study I (b) and II (c)



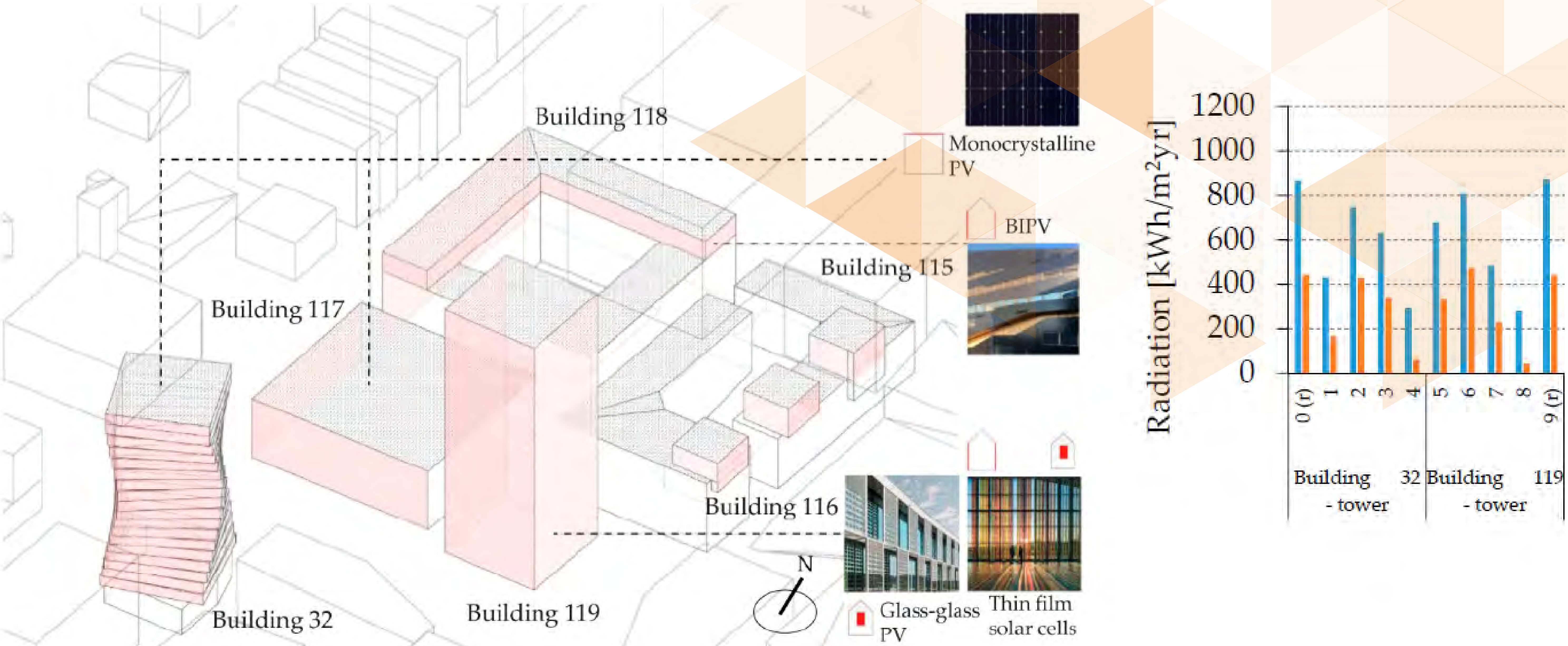
Reference: Lobaccaro, G.; Lisowska, M.M.; Saretta, E.; Bonomo, P.; Frontini, F. A Methodological Analysis Approach to Assess Solar Energy Potential at the Neighborhood Scale. Energies 2019, 12, 3554

Reduction factors

Reference: Lobaccaro, G.; Lisowska, M.M.; Saretta, E.; Bonomo, P.; Frontini, F. A Methodological Analysis Approach to Assess Solar Energy Potential at the Neighborhood Scale. Energies 2019, 12, 3554

Recommendations on solar technology

Recommendations on solar technology for the critical area for the feasibility study II



Reference: Lobaccaro, G.; Lisowska, M.M.; Saretta, E.; Bonomo, P.; Frontini, F. A Methodological Analysis Approach to Assess Solar Energy Potential at the Neighborhood Scale. Energies 2019, 12, 3554

International activities IEA SHC Task 51 & Task 63

On-line map

Task 51/Report C1
Collection of International Case Studies

Task 51/Report C2
National and International Comparison of Case Studies

Task 51/Report C3
Lesson Learnt from Case Studies

Task63 Case Studies

Reference: Lobaccaro G., Croce S., Lindkvist C., Munari Probst M.C, Scognamiglio A., Dahlberg, J., Lundgren M., Wall M., A cross-country perspective on solar energy in urban planning: lessons learned from international case studies, (2019), Renewable & Sustainable Energy Reviews , pp. 209-237

HELIOS – Project presentation

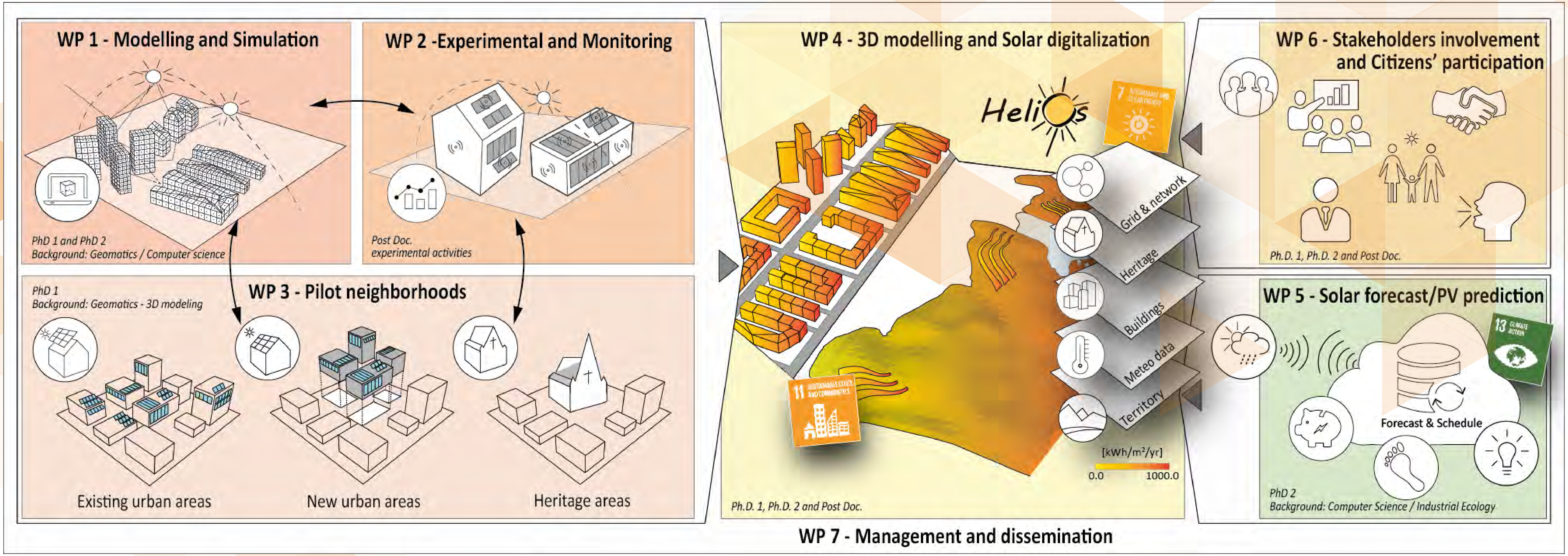
02

HELIOS is presenting

- Brief on HELIOS
- HELIOS NTNU Team
- Green 2050

HELIOS – NFR Fripro FRINATEK

enHancing optimal ExpLoitatIOn of Solar energy in Nordic cities through digitalization of built environment / Dec. 2021 - Apr.2025



Project owner: *NTNU / IV / IBM*
Project manager: *Ass. Prof. Gabriele Lobaccaro*
NTNU Partners: *IDI, IndEcol, MTP, IMA*
National partners: *SINTEF Community, Trondheim Kommune*

International partners:
HEPIA - Geneva School of Eng., Arch. and Landscape – Univ. of Applied Sciences and Arts Western Switzerland;
USMB/INES - University Savoie Mont Blanc / National Institute of Solar Energy (France);
UCB Lyon 1/CETHIL - Claude Bernard University / Centre d'énergétique et de thermique de Lyon (France).

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HELIOS - enHancing optimal ExpLoitatIOn of Solar energy in Nordic cities through digitalization of built environment

Deep learning-based approach for automated reconstruction of 3D building models with semantic information

1 - Building dataset for deep-learning based façade parsing

to achieve façade parsing in street-level images with complex scenes ----
(multi view, multi-illumination, distortion, foreground occlusion, background interference)

2 - Deep learning based complex-scene façade parsing

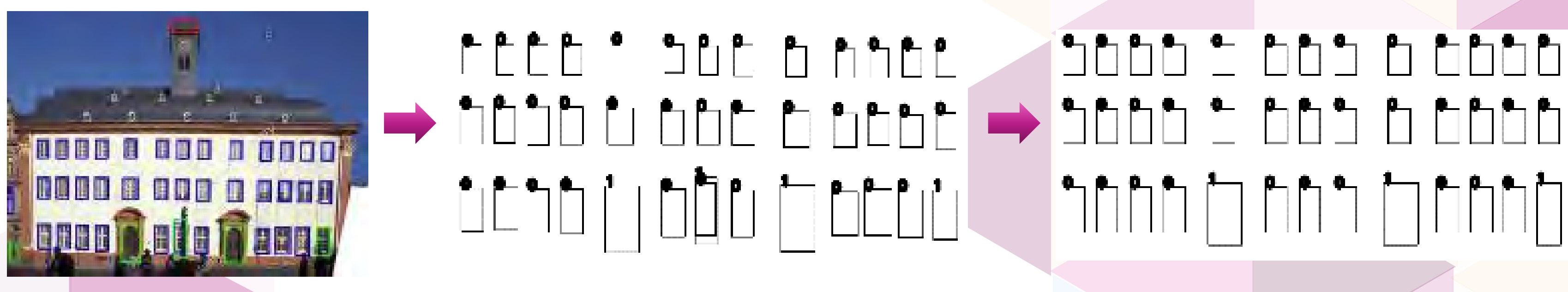
Using **object detection CNN** to extract window/door/balcony and roof/shop, respectively

(a) Mapillary Street-View Images (b) Segmentation Datasets (c) Object Detection Datasets

Kong, G., & Fan, H. (2020).
Enhanced Facade Parsing for Street-Level Images Using Convolutional Neural Networks. IEEE Transactions on Geoscience and Remote Sensing

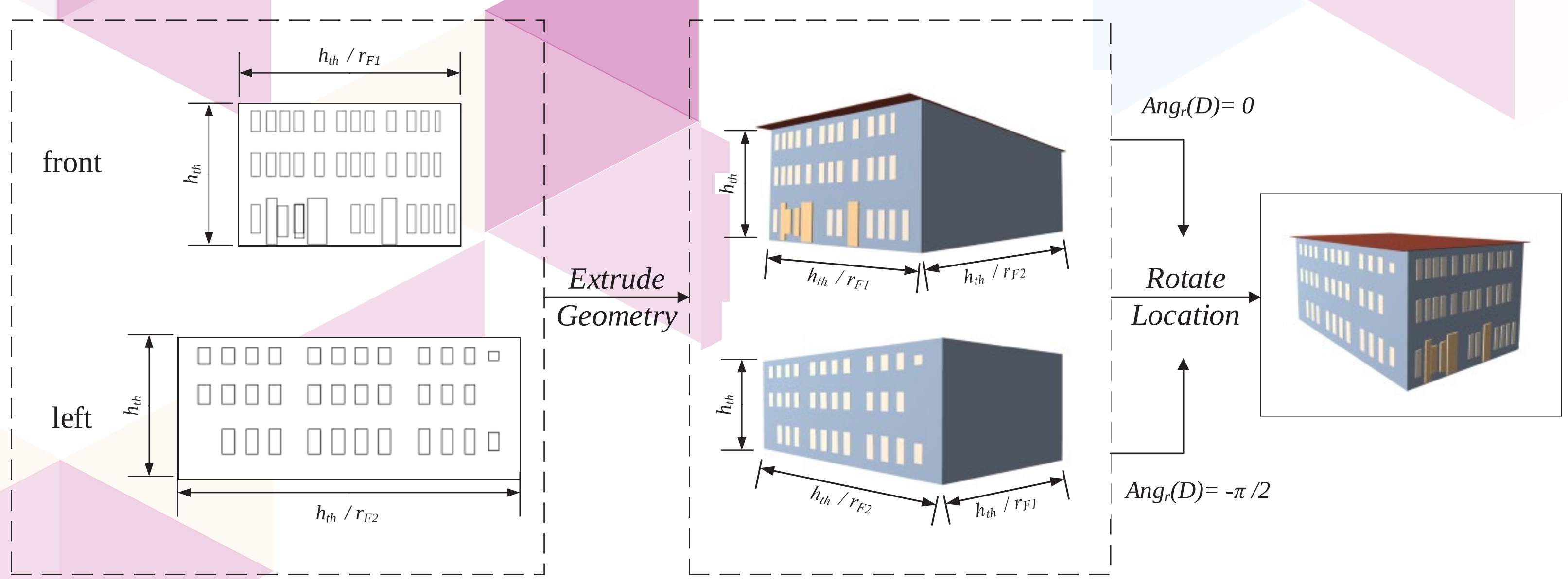
Deep learning-based approach for automated reconstruction of 3D building models with semantic information

Layout correction using clustering



Façade elements — Perspective correction — Layout correction

Layout recovery using user input and rotation matrix



(a) directions and 2D locations of every façade (X_{nrF}, Y_{nrF}) & $(C_{nr1}, C_{nr2}, classcode)_{ni}$

(b) 3D locations of every façade *ni* $((X_{3D}, Y_{3D}, Z_{3D}), classcode)_{ni}$

(c) 3D building model

Semi-automatic 3D building reconstruction

Fan, H., Kong, G., & Zhang, C. (2021).
An Interactive platform for low-cost 3D building modeling from VGI data using convolutional neural network. Big Earth Data, 5(1), 49-65.

Deep learning-based approach for automated reconstruction of 3D building models with semantic information

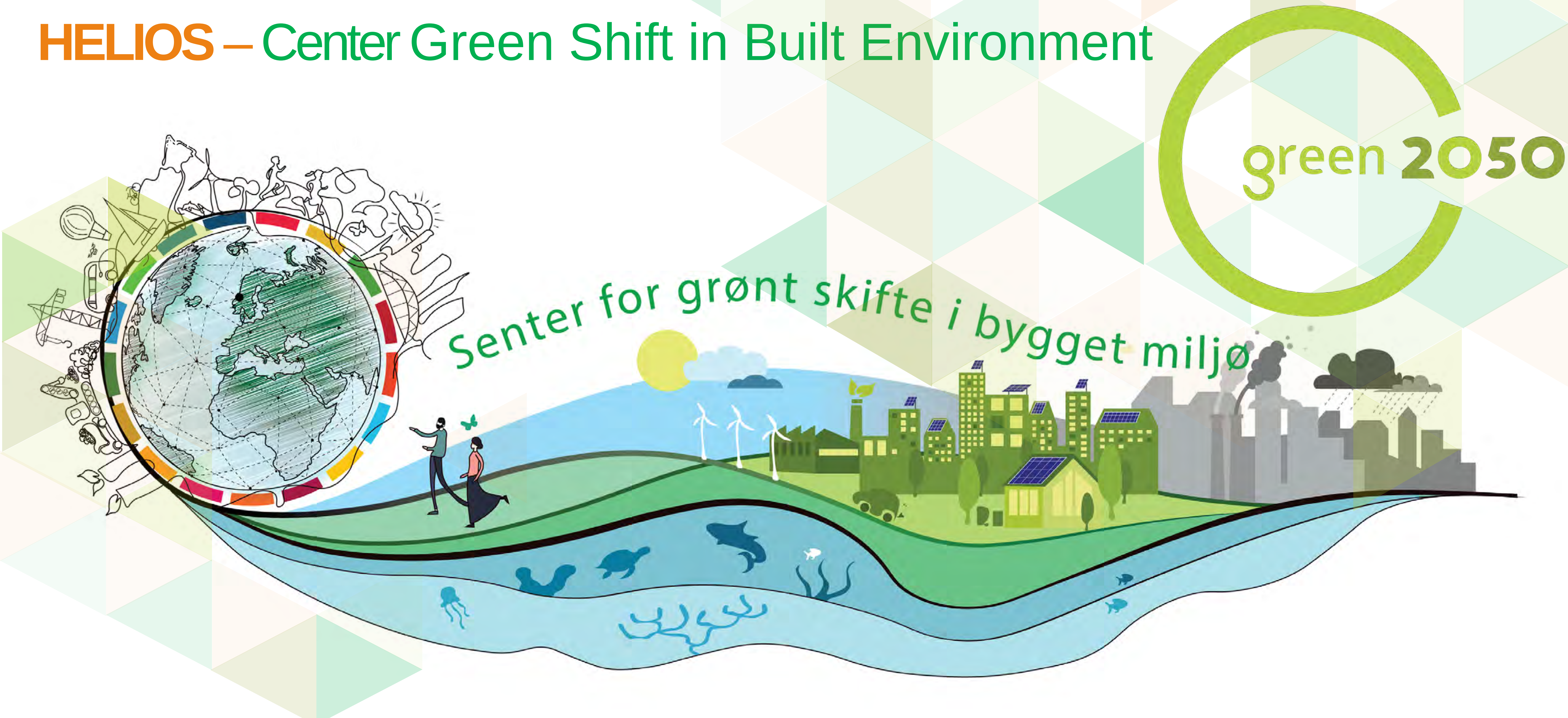
3D building models are usually divided into **5** levels:

Energy analysis (from internet)

3D building models in LoD3 level play an important role in the fields of urban planning and geographical analysis.

Biljecki, F., Ledoux, H., & Stoter, J. (2016).
An improved LOD specification for 3D building models. Computers, Environment and Urban Systems, 59, 25-37.

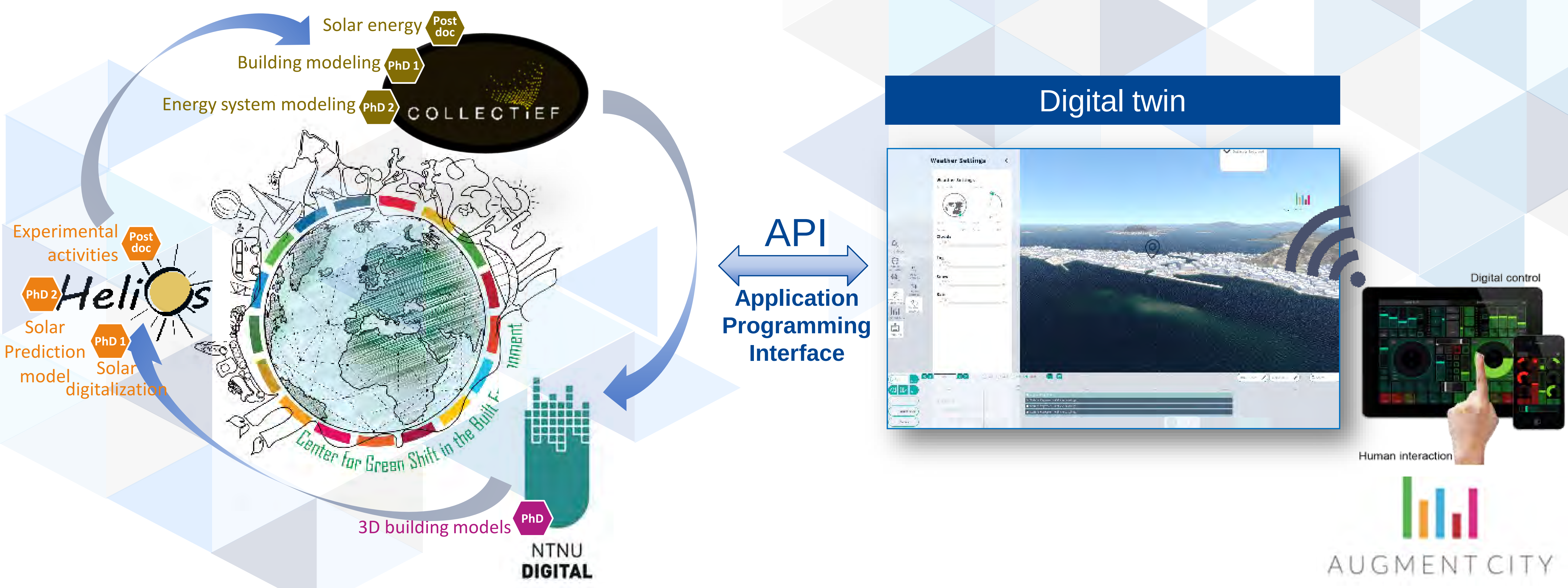
HELIOS – Center Green Shift in Built Environment



NTNU | Kunnskap for en bedre verden

https://www.ntnu.edu/green2050

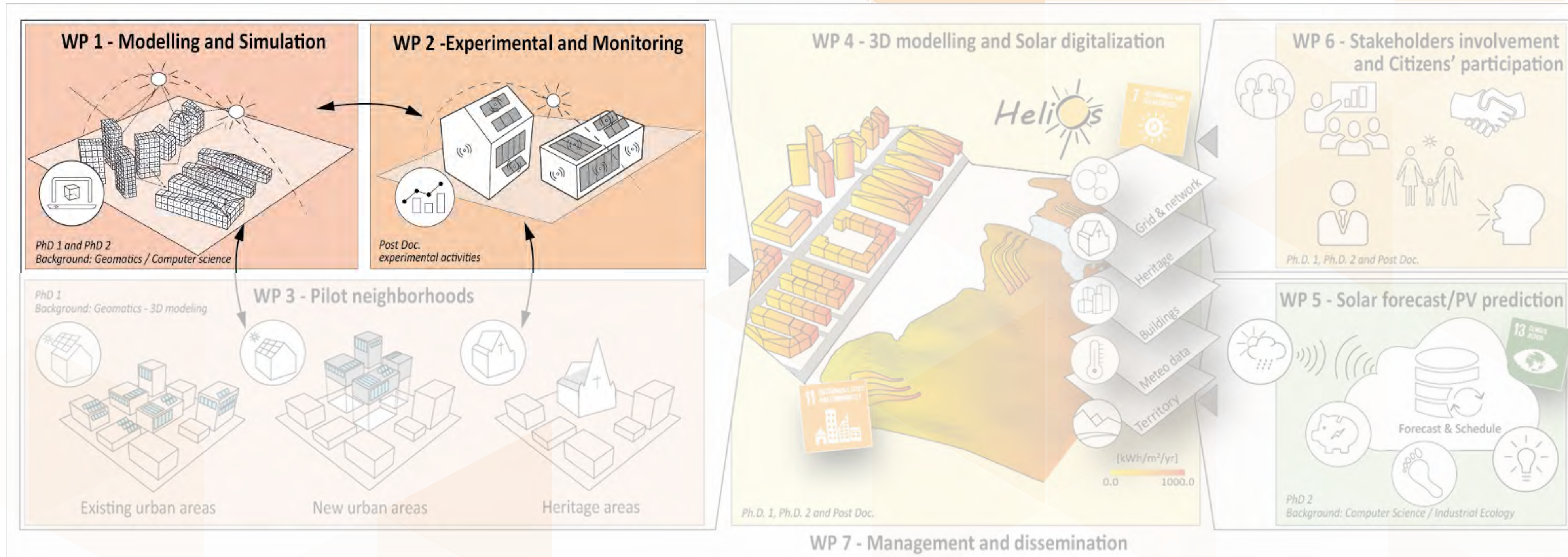
Synergies NTNU projects & User Interface in Digital Twin



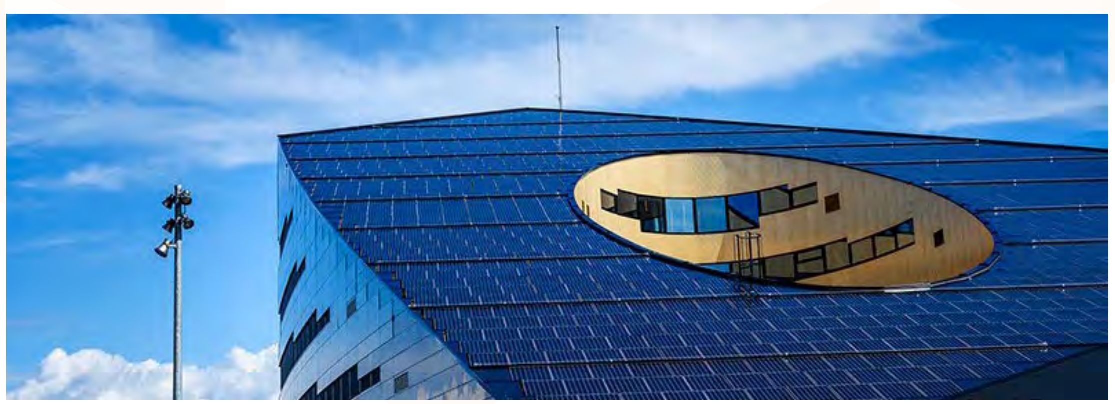
2021 → 2025

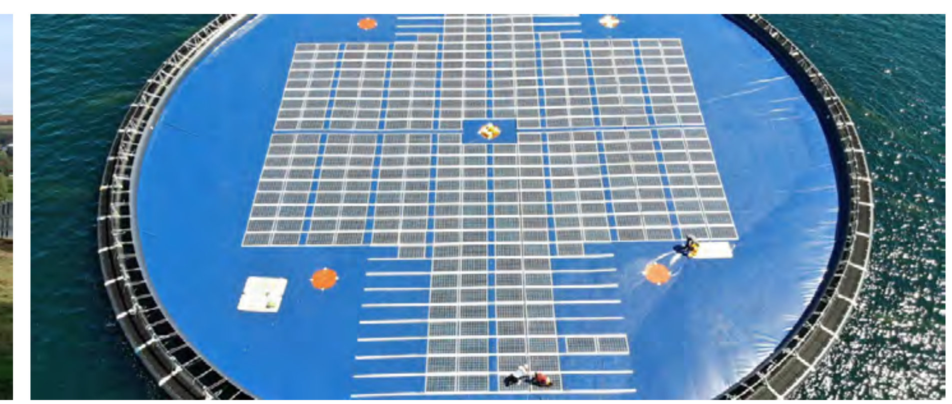

Helios - NFR FRIPRO FRINATEK
Solar digitalization techniques to enhance optimal exploitation of solar energy in the Nordics
Mattia Manni
PostDoc Fellow
E-mail: mattia.manni@ntnu.no
Seminar ON SOLAR NEIGHBORHOODS
Calgary (Canada)
Friday 23.09.2022
Lyon 1
The Research Council of Norway
hepia
NTNU
Kunnskap for en bedre verden

Problem statement and research objective



Objective Development and validation of solar irradiance model chain to be used in the Nordics



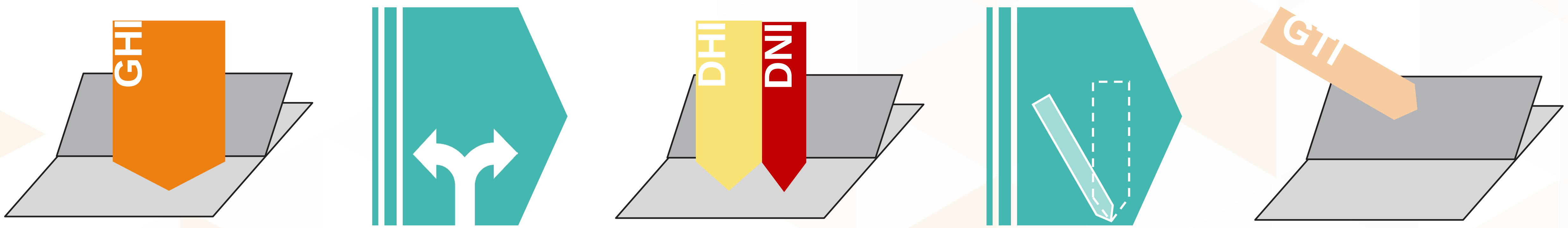


[1] Formolli, M., Lobaccaro, G., Kanters, J., 2021. Solar Energy in the Nordic Built Environment: Challenges, Opportunities and Barriers. Energies 14

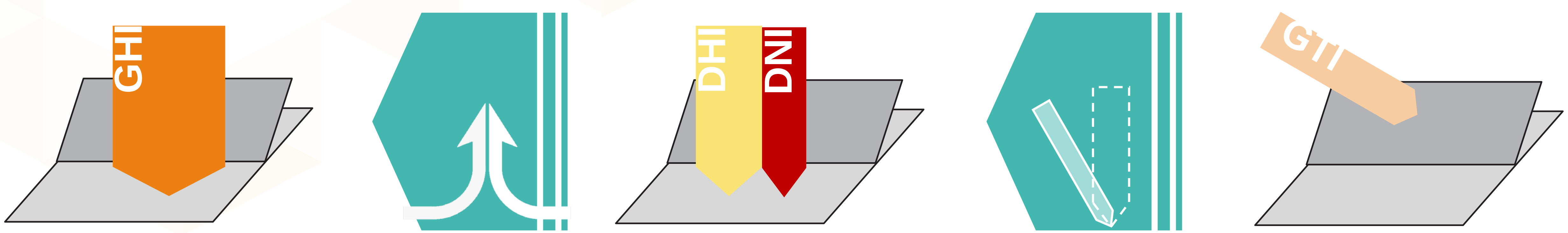
Solar irradiance model chain

Helios

Model chain DECOMPOSITION TRANSPOSITION



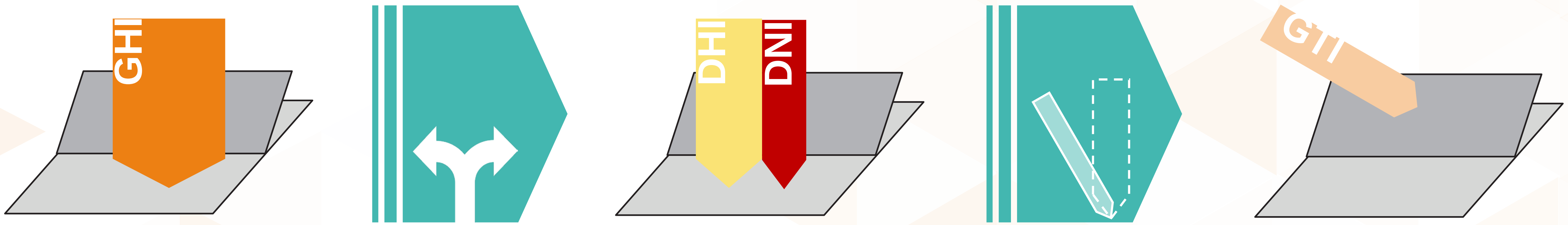
- The solar irradiance model chain (SIMC) permits to estimate the **global tilted irradiance** (GTI) from the global horizontal irradiance (GHI) or from both diffuse horizontal irradiance (DHI) and direct normal irradiance (DNI)
- The SIMC is **flexible** (i.e., can include indifferently a combination of decomposition and transposition models or only transposition models) and **bidirectional** (i.e., from GTI to GHI)
- The SIMC's flexibility represents a solution to **data unavailability** (i.e., too many and/or too expensive sensors)



Solar irradiance model chain

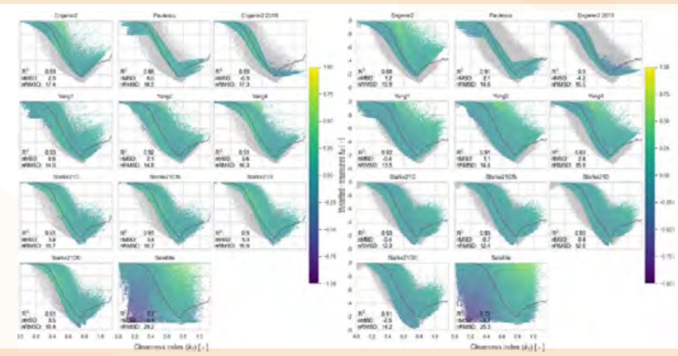
Helios

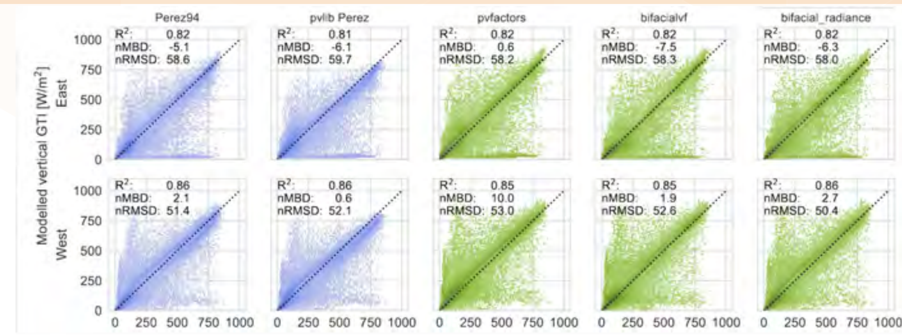
Model chain	DECOMPOSITION		TRANSPOSITION



Calcuated	GHI	DHI/DNI	GTI

ECMWF
EUROPEAN CENTRE FOR MEDIUM RANGE WEATHER FORECASTS
esa
copernicus
Europe's eyes on Earth



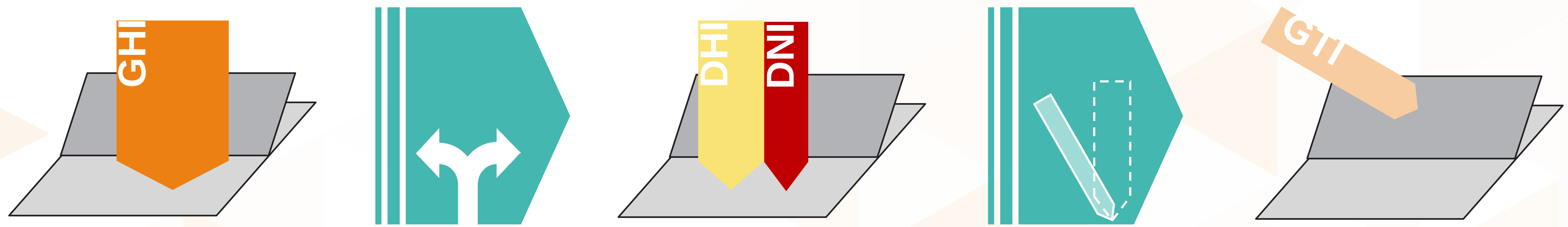


Measured	GHI	DHI/DNI	GTI

Solar irradiance model chain

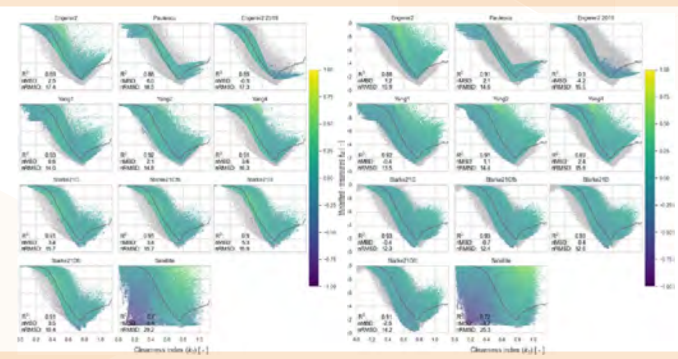
Helios

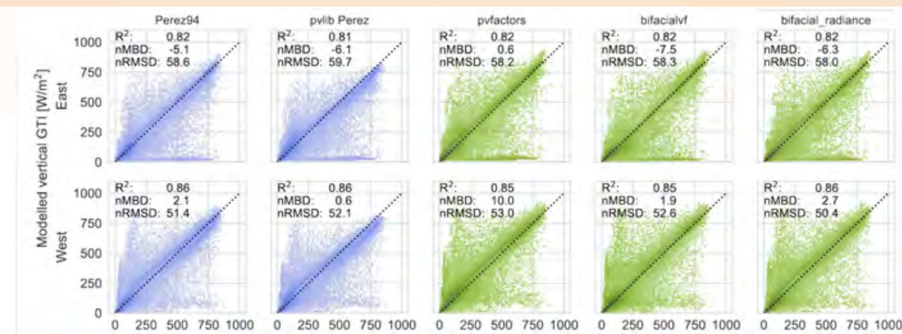
Model chain | DECOMPOSITION | TRANSPOSITION



Calcuated | GHI | DHI/DNI | GTI

ECMWF
EUROPEAN CENTRE FOR MEDIUM RANGE WEATHER FORECASTS
esa
opernicus
Europe's eyes on Earth



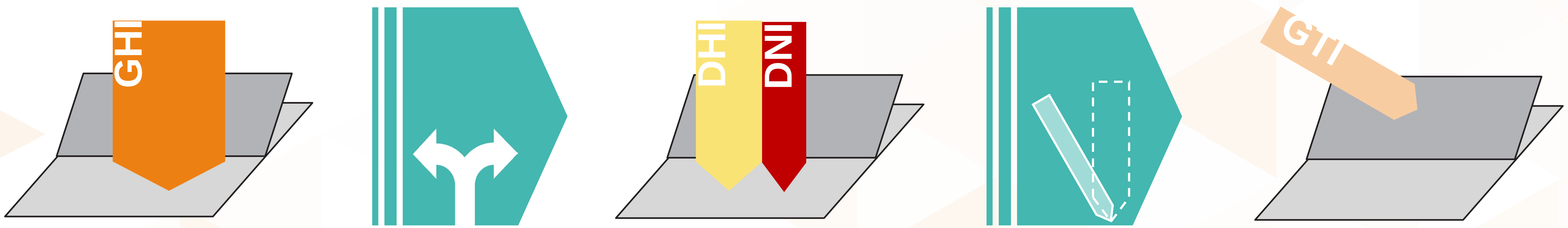


Measured | GHI | DHI/DNI | GTI

Solar irradiance model chain

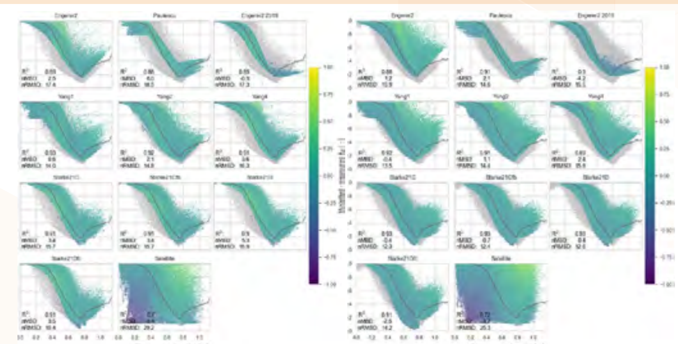
Helios

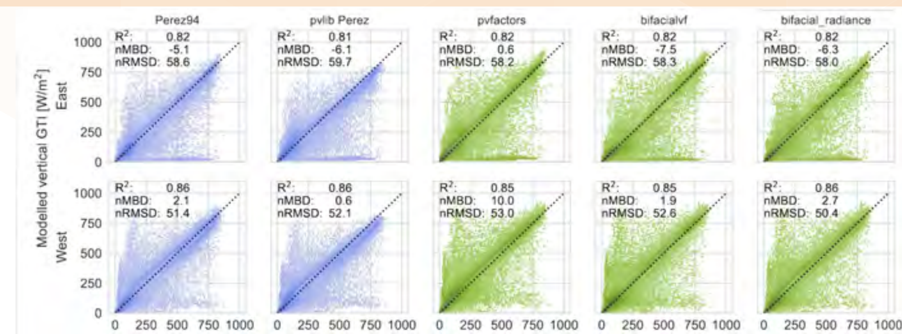
Model chain | DECOMPOSITION | TRANSPOSITION



Calcuated | GHI | DHI/DNI | GTI

ECMWF
opernicus
esa

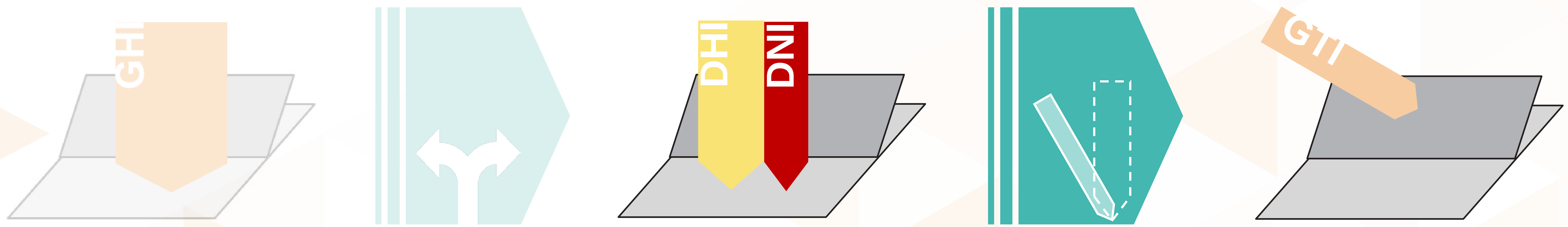




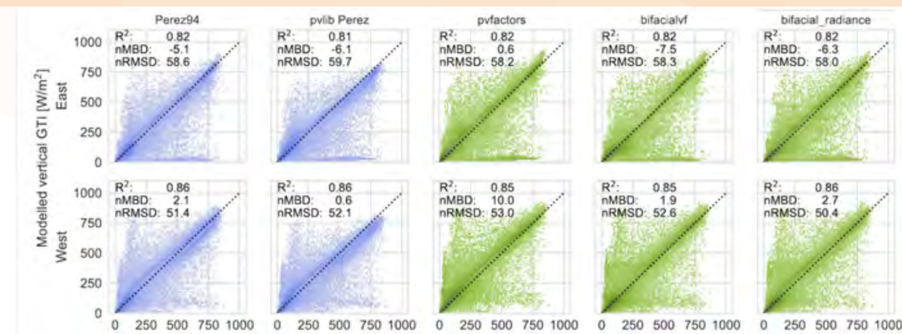
Measured | GHI | DHI/DNI | GTI

Solar irradiance model chain

Model chain	DECOMPOSITION	TRANSPOSITION



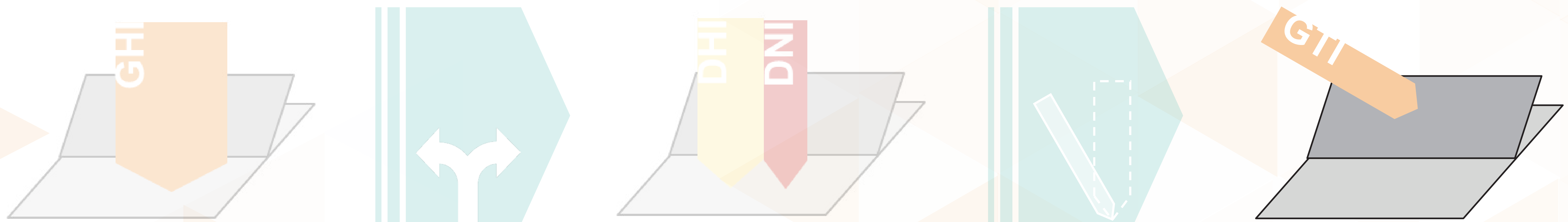
Calcuated	GHI	DHI/DNI	GTI



Measured	GHI	DHI/DNI	GTI

Solar irradiance model chain

Model chain | DECOMPOSITION | TRANSPOSITION



Calcuated | GHI | DHI/DNI | GTI

Measured | GHI | DHI/DNI | GTI

Dataset identification

- Datasets from various **sources** and different **time resolutions** are considered to predict photovoltaic energy generation.
- Photovoltaic energy output is monitored with a one-hour timestep in the Test Cell Lab, Trondheim (Norway).
- Model chain **length** changes accordingly to the input parameters.
- Numerical results are **validated against experimental data** considering the MBE and RMSE indicators.
- The **most adequate dataset** to predict photovoltaic energy production at high latitudes is determined.

Dataset identification

SOLAR RADIATION DATASETS

From the **ERA5-Land**:

- One-hour GHI

From **CAMS**:

- One-minute DHI/DNI

In the **Test Cell Lab**:

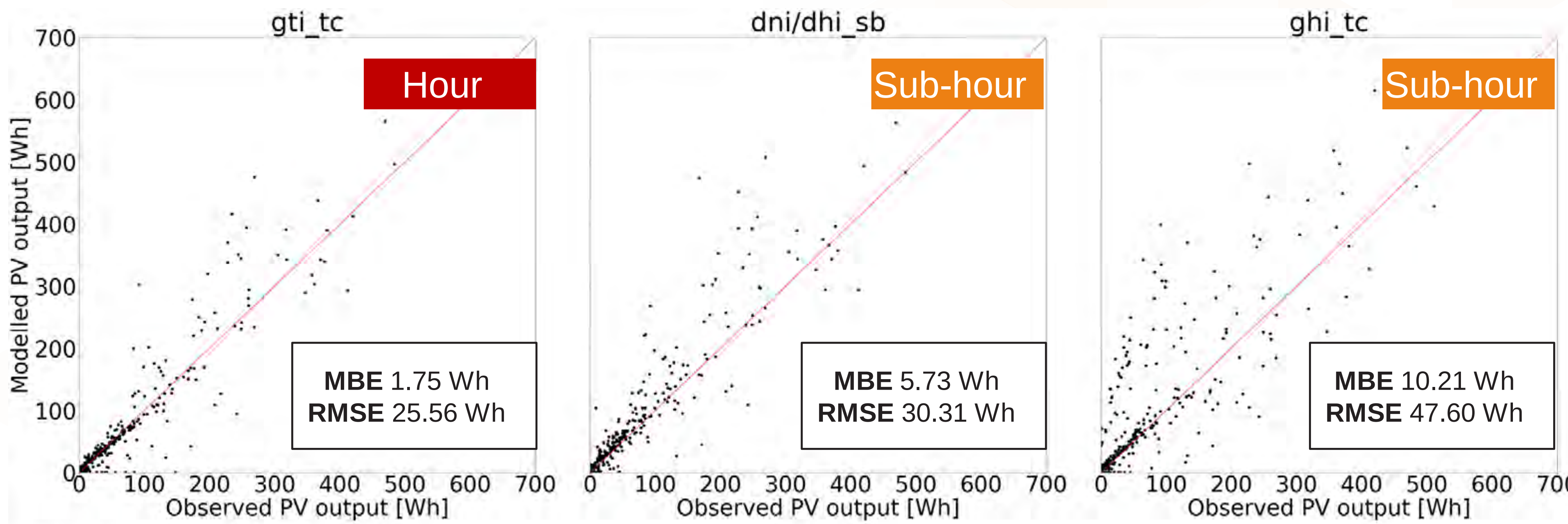
- Five-minute GHI
- One-hour GTI
- One-hour PV power output

In **Gløshaugen Sentralbygg**:

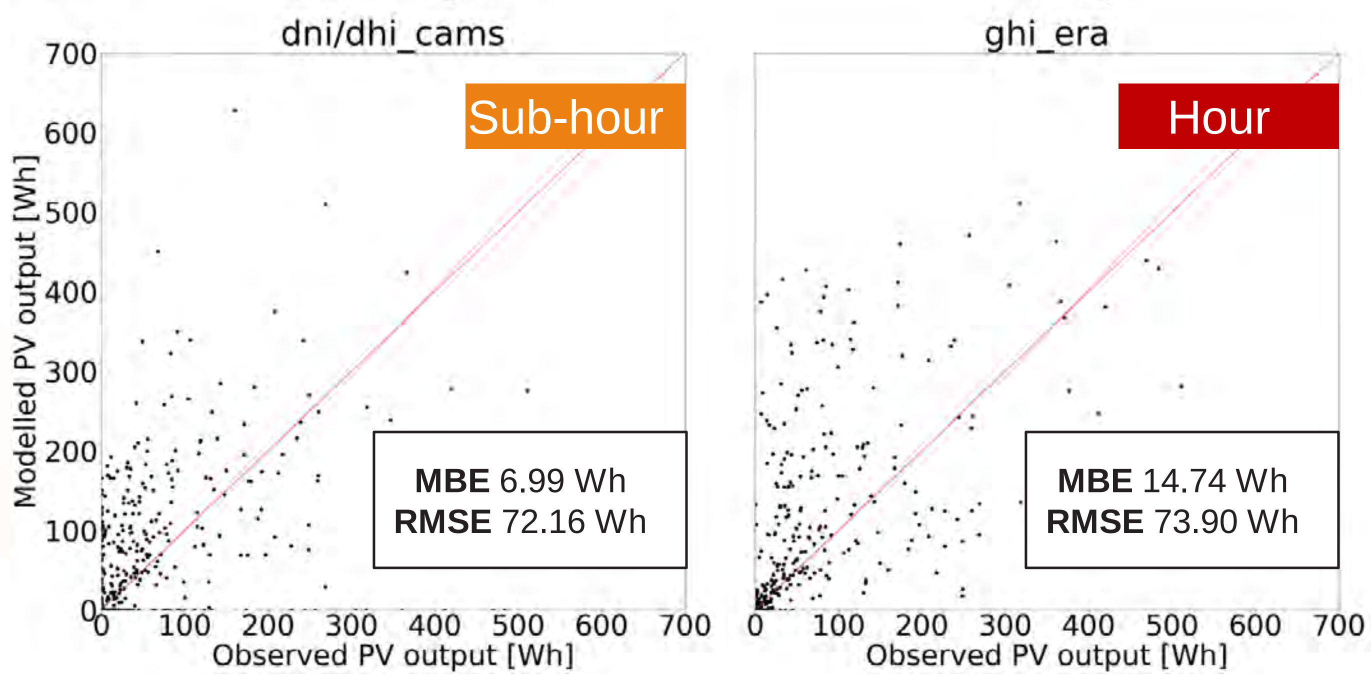
- One-minute DHI/DNI

Dataset identification

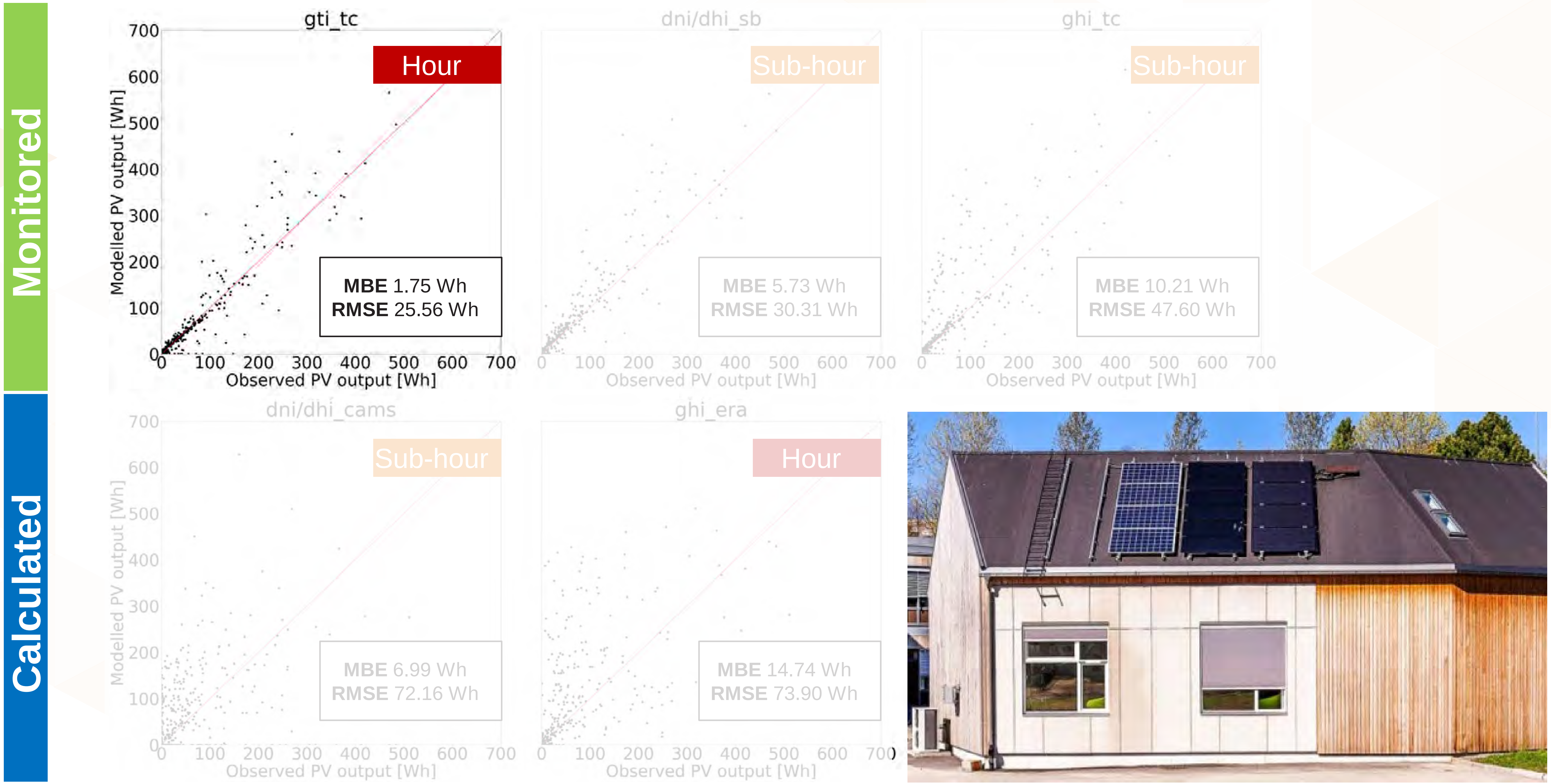
Monitored



Calculated



Dataset identification



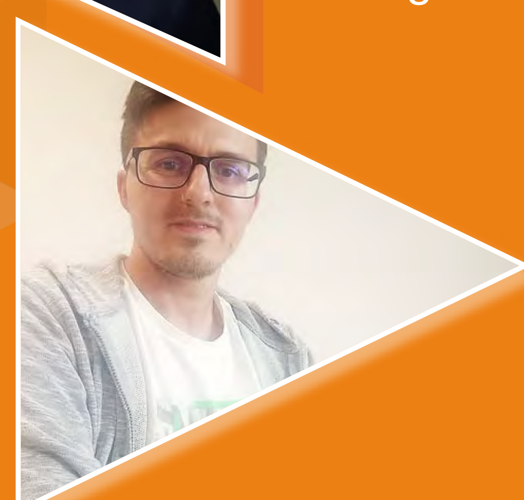
Dataset identification

CONCLUSIONS

- Measured solar radiation should be prioritized despite their time resolution.
- Measured DHI and DNI or satellite imaging methods should be used instead of GHI datasets.
- Measuring GTI is also a valid option.

Thank you!

Gabriele Lobaccaro
Associate Professor
E-mail: gabriele.lobaccaro@ntnu.no



Mattia Manni
Post Doctoral Research Fellow
E-mail: mattia.manni@ntnu.no

Australian Insights and Case Study Examples for Solar Neighborhood Planning

Mark Snow

This presentation investigates several architectural case studies that have incorporated solar energy into the building's design, including 550-558 Spencer Street (Melbourne), 435 Bourke Street (Melbourne), One Central Park (Sydney), and White Gum Valley (Perth).

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Australian case study contributions to SubTask D

AUSTRALIAN PV INSTITUTE

Dr Mark Snow

21 SEPTEMBER, 2022
TASK 63 CALGARY MEETING

Task Manager: Maria Wall, Lund University, Sweden
Task Duration: 1 September 2019 – 31 October 2023

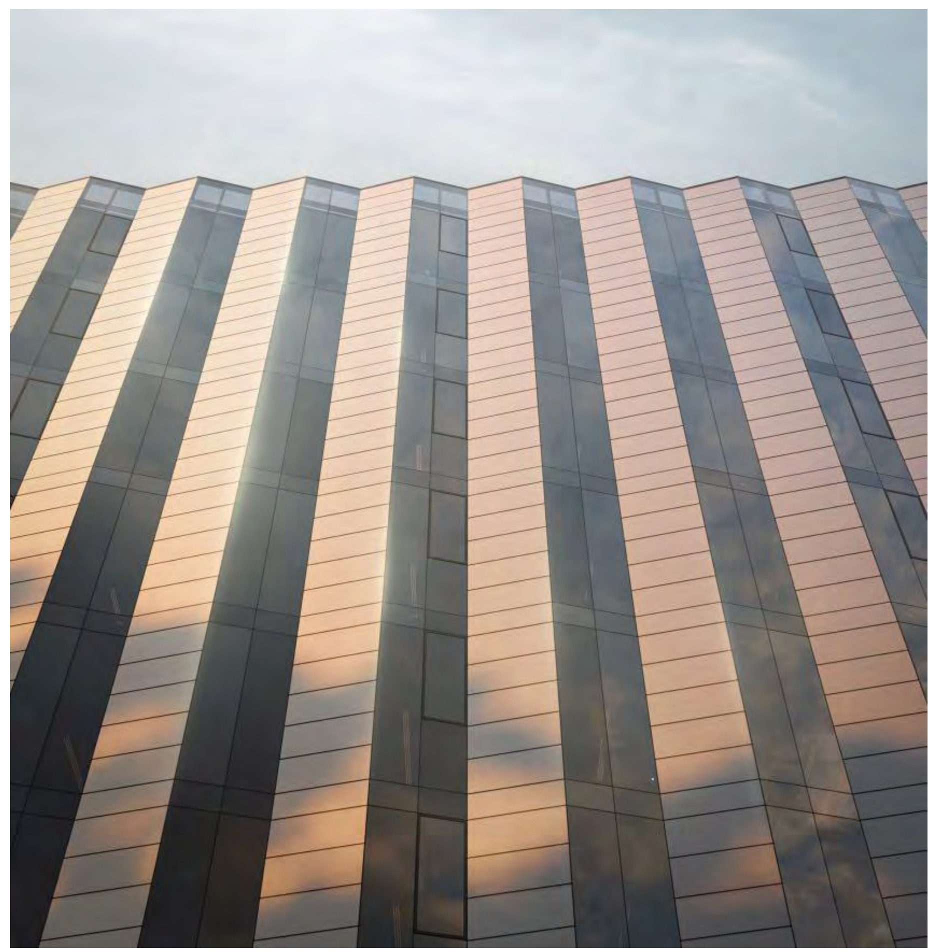
Technology Collaboration Programme
by iea

550-558 Spencer Street Melbourne

8 storey tower
1,180 solar CIGS panels
11-13% efficiency
@120W/m^2
Completion – 2024
Kennon Architects

50 times more electricity than a standard rooftop solar panel system used in residential projects.

Special fire safety testing undertaken to meet national building codes



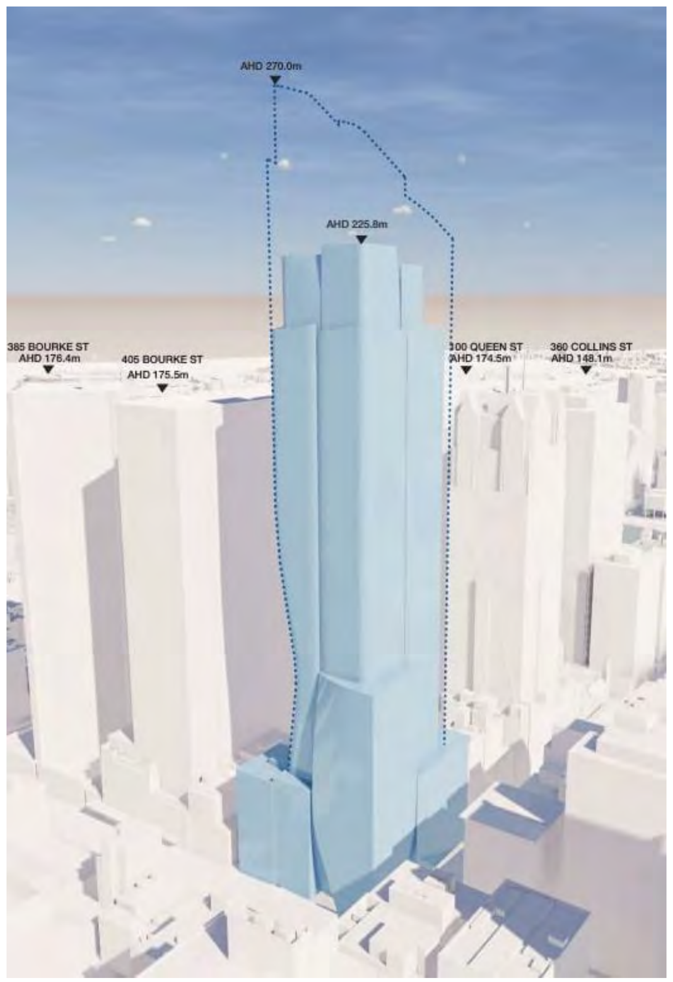
Source: Pete Kennon Architect https://www.kennon.com.au

An artist's rendering of the Spencer Street building.
Image: Neoscape (https://www.neoscape.com.au/)

Visualisation: https://www.cuubstudio.com

435 Bourke Street Melbourne

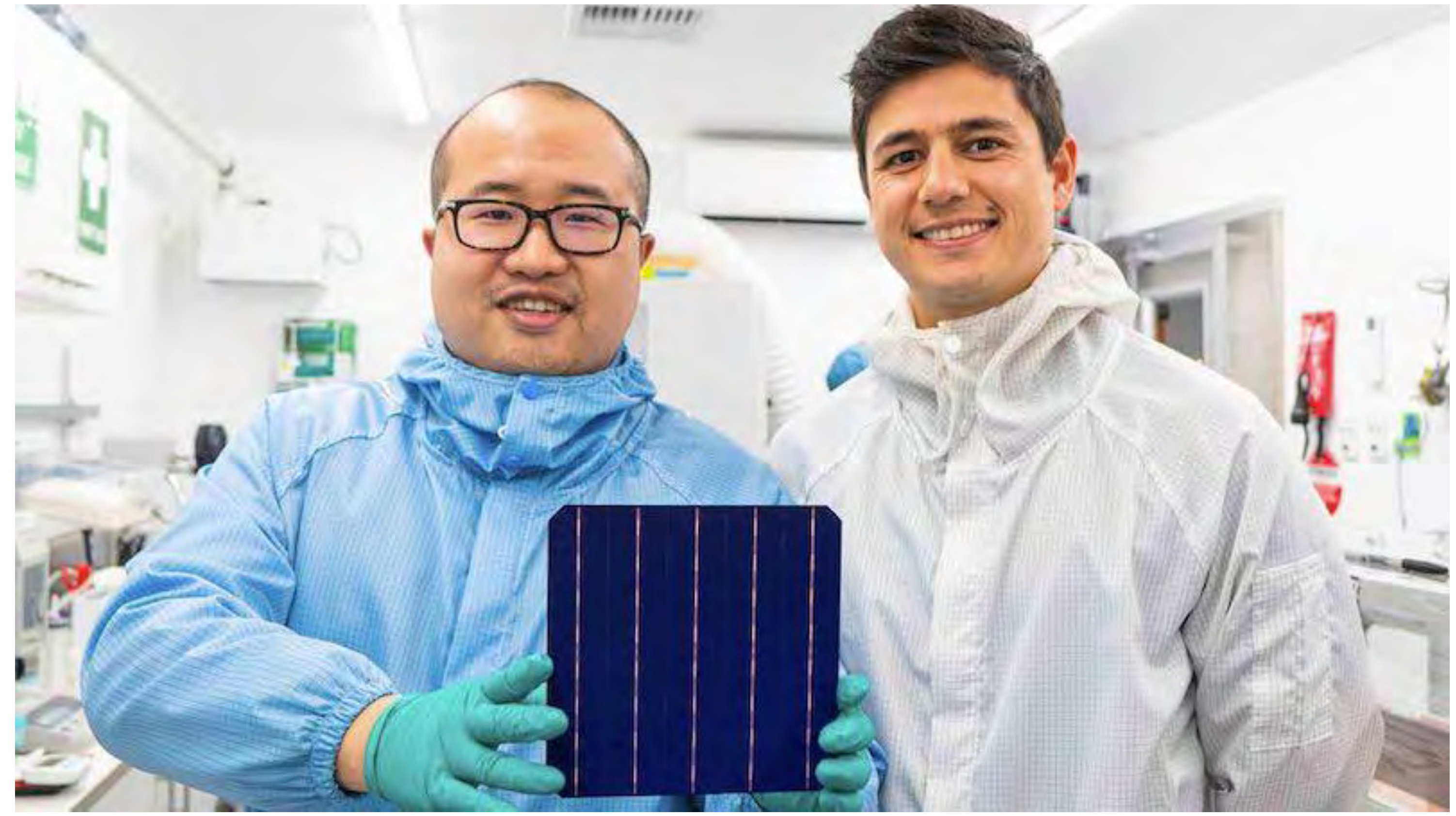
Cbus Property's $1 billion tower
Designed by Bates Smart
48-level tower in the Melbourne CBD



Before and after designs.
Reduced from 250 to 180m
Source: Bates Smart

PV glass façade system AVANCIS Skala panels
Generate 20% of the building's base power
Completion – 2026
[Link to initial planning development application]

SUNDRIVE www.sundrivesolar.com



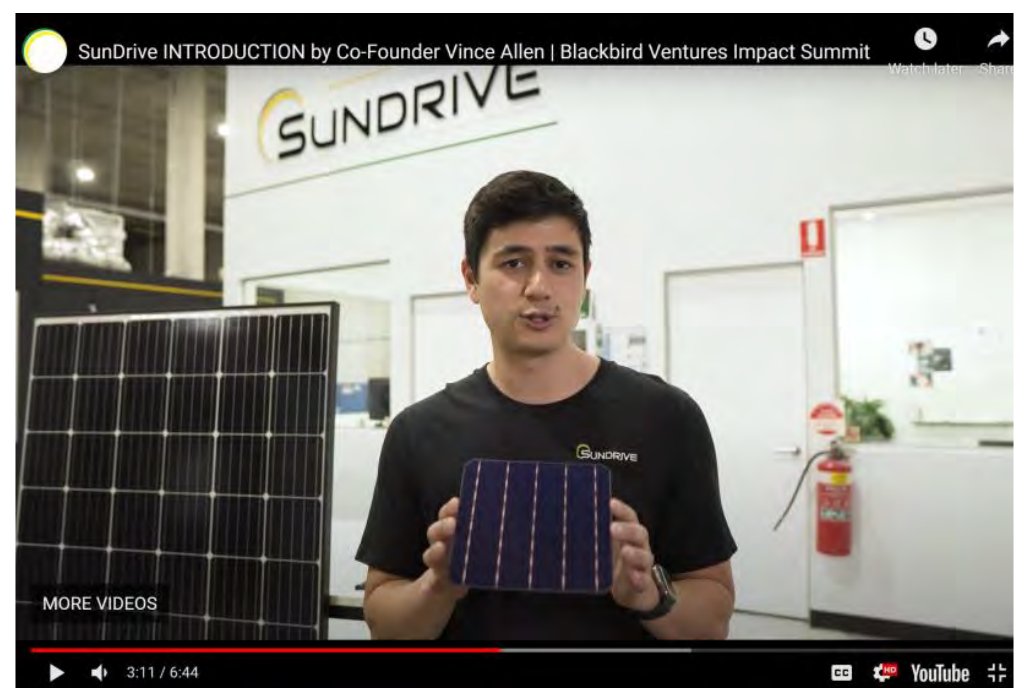
Vince Allen and David Hu (UNSW students) established SunDrive in 2015

26.07% efficiency record for heterojunction PV cell in mass production using Copper instead of Silver – *March 2022*

Increased to 26.41% – *September 2022*

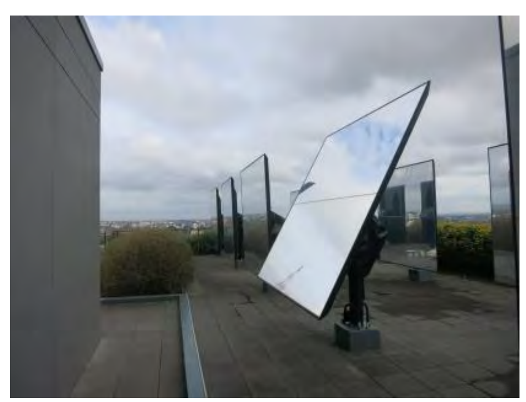
Pilot production line planned for mid 2023

Copper is around 100 times cheaper per kilogram and around 1,000 times more abundant than silver.



Video link

One Central Park Sydney



Billbergia's 39-storey tower at Rhodes Central Inner West Sydney

Billbergia Group - Heliostat construction video

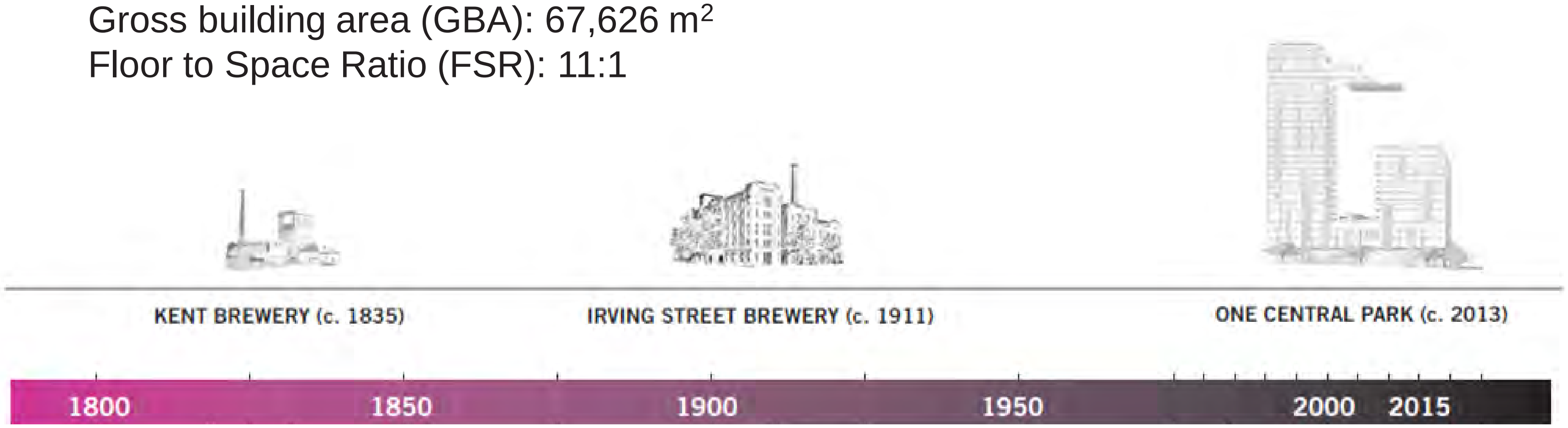
HeliostatSA, SJB Architecture, Inhabit Technical Design and Samaras Engineering

Plastic sheeting covers the reflective surface and filters out UV light in order to ensure harmful UV rays are not directed towards the plaza.

One Central Park - Sydney

Source: PTW Architects

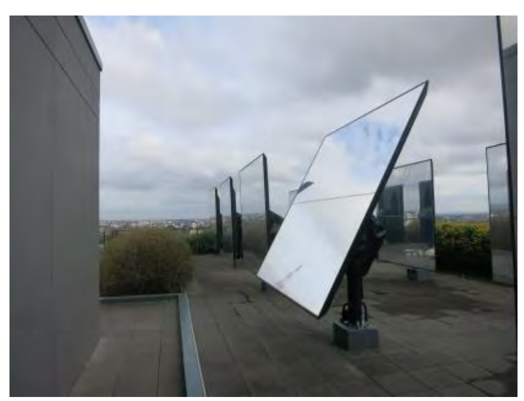
Site area: 255,500 m^2
Gross building area (GBA): 67,626 m^2
Floor to Space Ratio (FSR): 11:1

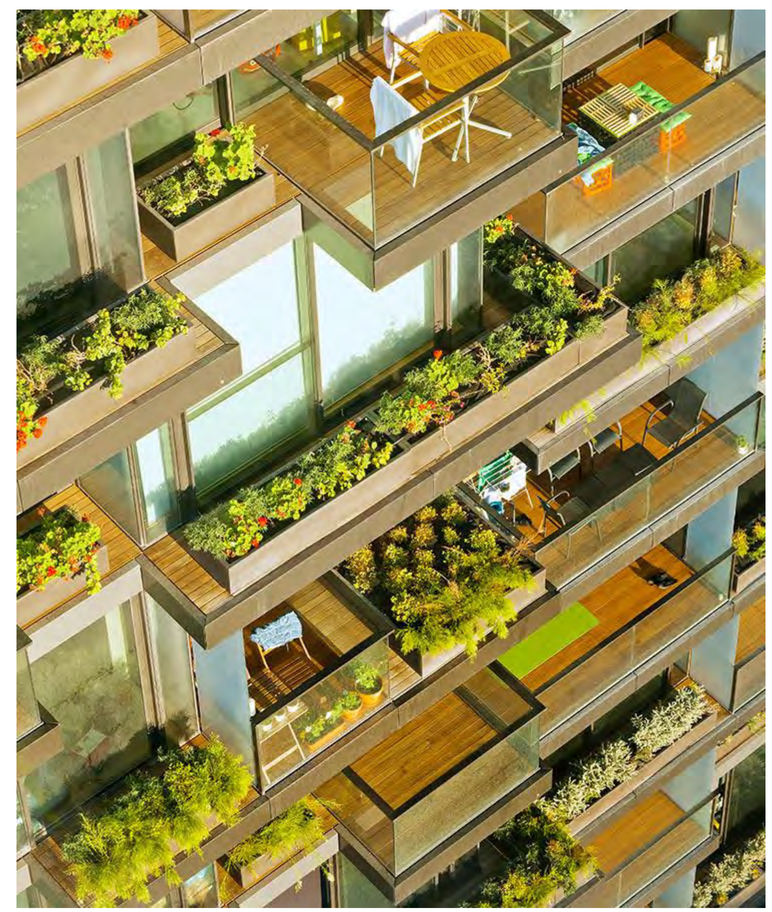


Trigen thermal system for power, heating and cooling integrated with rainwater collection and sewerage recycling that provides 1 megalitre of water per day and more than the site requires.
Also, 93% of demolition material was recycled from the 5.8 hectare construction site.

Architects/designers - PTW Architects/Ateliers Jean Nouvel (AJN)
Green Wall Design – Patrick Blanc
Heliostat lighting – Yann Kersalé
Owners/developers – Frasers Property and Sekisui House Australia
Main Contractor – Watpac Construction
Structural Engineers - Robert Bird Group

Source: Mark Snow





Source: PTW Architects

Groundbreaking green façade and a 120 tonne cantilevered heliostat to direct natural sunlight to parts of the development that would typically be in shade due to the density of the urban environment.

One Central Park - Sydney

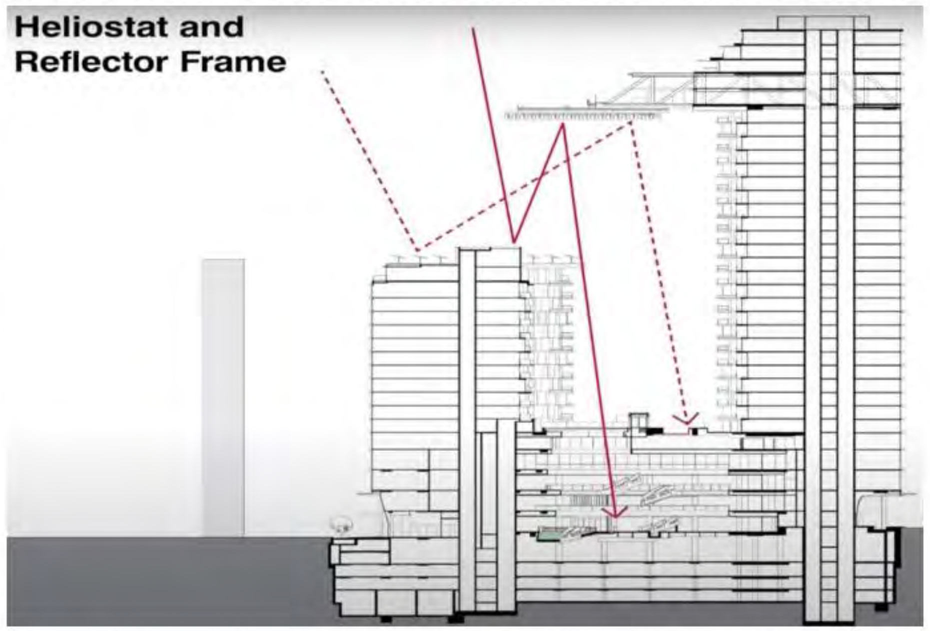


Figure 1 – Heliostat and Cantilever Reflector structure. (Photo/source: PTW Architects)

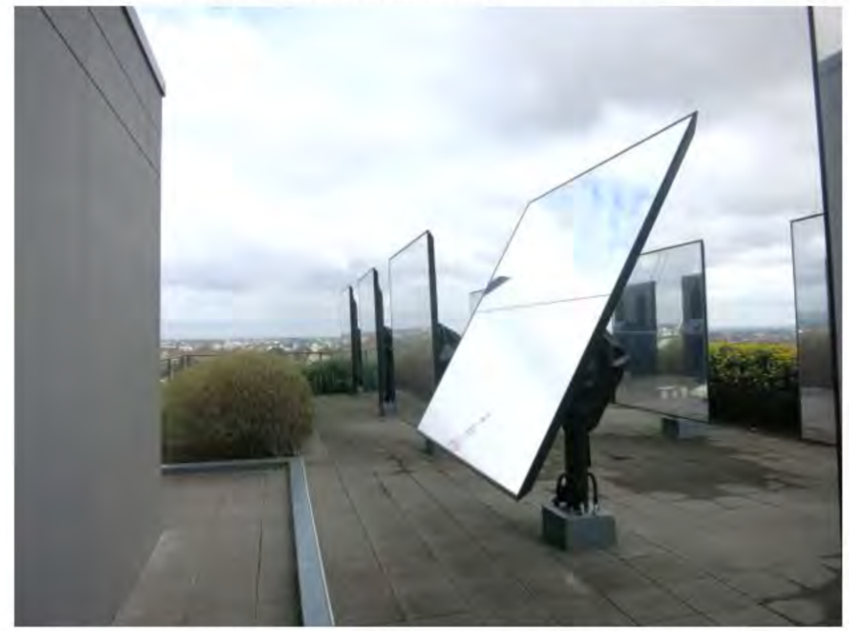


Figure 2 - Dual axis tracking Heliostats. (Photo/source: Mark Snow)

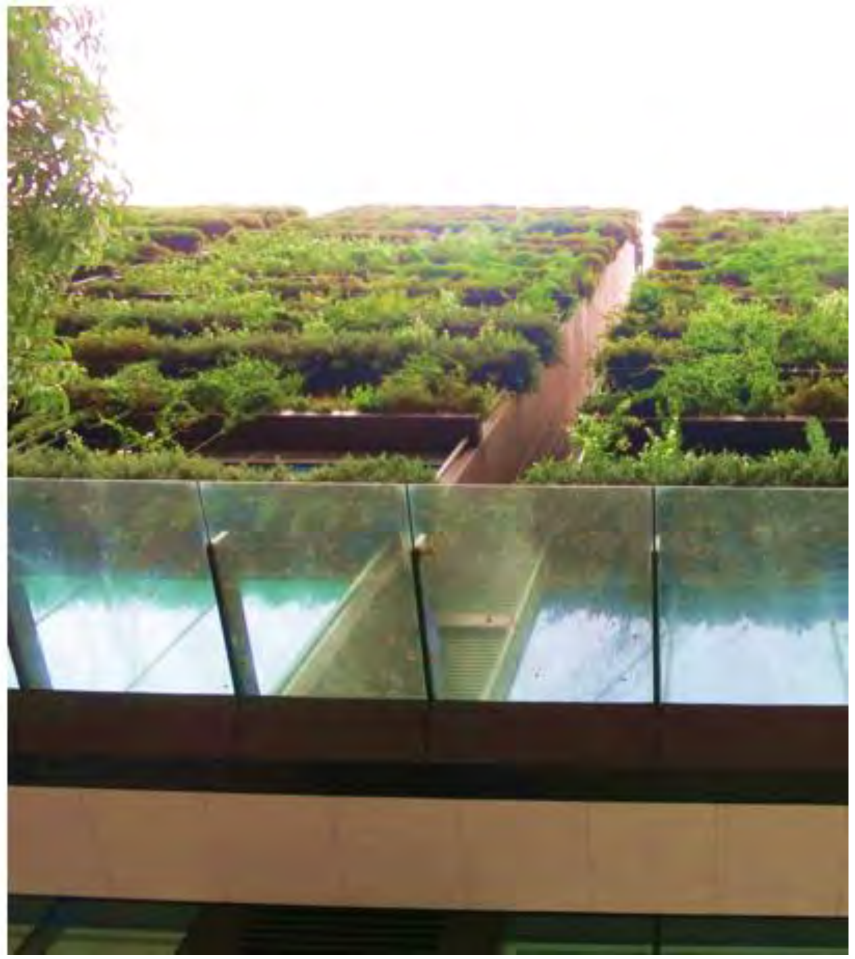
Figure 3 - Cantilever mirrors and Heliostats viewed by Task 51 experts on a site visit in 2017. (Photo/source: Mark Snow)

KEY HELIOSTAT FACTS

- 40 dual-axis tracking Heliostats (each 6.5m^2) on East Tower
- Redirects sunlight to the underside of a cantilevered reflector frame of 320 (1.25m^2) fixed mirrors on the West Tower.
- The heliostats are made of a plastic core and hail proof aluminium skin to provide a flat and rigid surface.
- 75-80% of normal redirected sunlight acting as a canopy with around 800 watts/m^2 delivered under clear sky conditions.

Green Façade details

- Covers 50% of the total façade
- Building heat load reduced by 15-20%
- 5km light weight linear planter boxes
- 85,000 plants and 250 different species
- 15km irrigation system



One Central Park - Sydney

Yellow Halo kinetic sculpture
by Jennifer Turpin and Michaelie Crawford

Heliostat night time lighting by Yann Kersalé

White Gum Valley Perth

Project: WGV

Location: White Gum Valley, WA
Scale: 2.2 ha mixed typology residential precinct (approx. 100 dwellings)
Lead: DevelopmentWA
Status: Commenced 2013

Source: DevelopmentWA

White Gum Valley
Perth

Source: DevelopmentWA

Refer to: Low Carbon CRC references from Prof. Peter Newman and Dr Josh Byrne
Josh Byrne and Associates project details

White Gum Valley Perth

Innovation for sustainability @ WGV
Source: Tanya Babaeff (2017)

One Planet Living (OPL) – Australia's first master planned One Planet Community.

Co-operative social housing – affordable housing + artists' studio for SHAC (Sustainable Housing for Artists and Creatives).

Gen Y demonstration house – a design competition for sustainable, flexible, affordable housing for Gen Y home buyers.

Revitalisation of old drainage sump into **community bore** – nature play public space and alternative water source.

Significantly **lower energy required to source water** (normally desalination water plants)

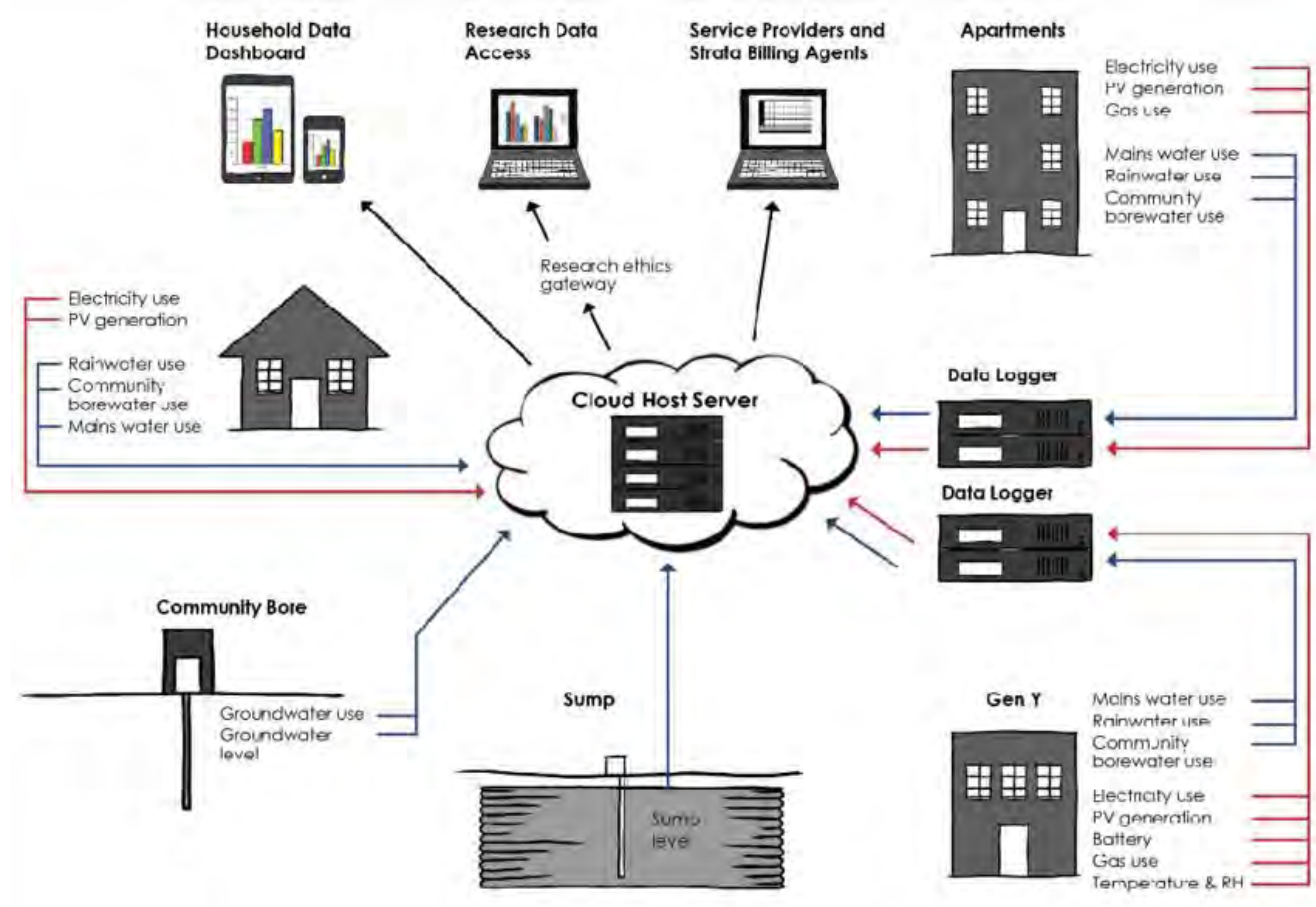
Baugruppen demonstration project – individuals as co-operative developers.

Research connections – Co-operative Research Centre **CRC living lab**;

SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

White Gum Valley
Perth

Source: Josh Byrne and Associates



Power Ledger – shared solar power and battery stoarge on strata-titled development

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Solar Energy and Daylighting in Swedish Case Studies

Alejandro Pacheco Diéguez

The presentation introduces first White Arkitekter and discusses the scope and goals of the firm. The two case studies, Stadsljus (Stockholm) and Uppsala Business Park (Uppsala), investigate the integration of environmental design methodologies in the building design and urban planning processes at the block scale and district scale, respectively.

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Integration of environmental design methodologies in the building design and urban planning processes

Alejandro Pacheco Diéguez, architect and environmental design specialist
Task 63 meeting, Calgary, September 23rd 2022

Integration of environmental design methodologies in the building design and urban planning processes

***STADSLJUS**: residential high-rise building*
(block scale)

***UPPSALA BUSINESS PARK**: Positive energy district,*
(district scale)

white

About WHITE

”Enable sustainable life through the art of architecture”

- **LEADING ARCHITECTURE FIRM**
- **EMPLOYEE-OWNED**
- **ALL PROJECTS CLIMATE NEUTRAL (2030)**
    - ***CROSS-DISCIPLINARITY***
    - ***DIGITALISATION***
    - ***EXPLORATIVE CULTURE***

@whitearkitekter
whitearkitekter.com

white

STADSLJUS

What?

- Unique high-rise residential building
- Architectural competition
- Clients: OBOS Nya Hem and Stockholms Stad

Where?

- Royal Seaport (Stockholm)

white

Enhanced workflow

High requirements

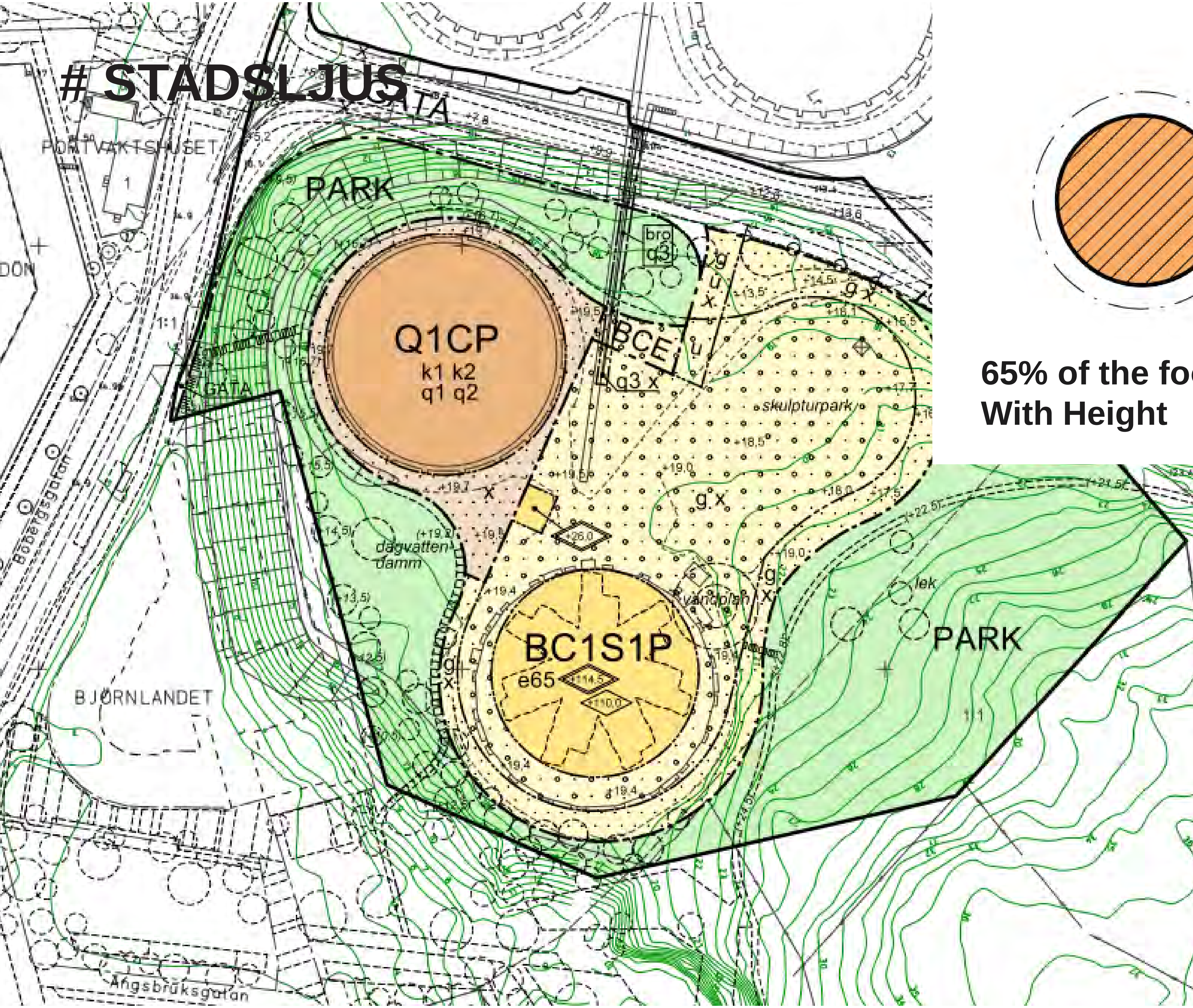
- Health and well-being
- Environmental impact
- Climate change adaptation
- Social sustainability

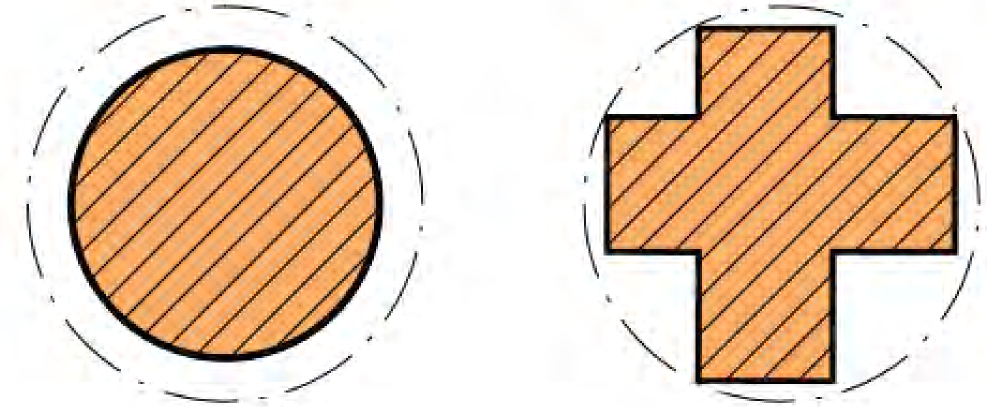
Design methodology

- Iterative
- Interdisciplinar
- Integrated
- Qualitative and quantitative sustainability analysis
- From early stages (indicators and rough analysis)
- Detailed analysis when needed
- Proof of compliance (final analysis)

white

STADSLJUS





65% of the foot print = building rights
With Height

EARLY STAGE MULTI-OBJECTIVE OPTIMIZATION: ENERGY VS. DAYLIGHT

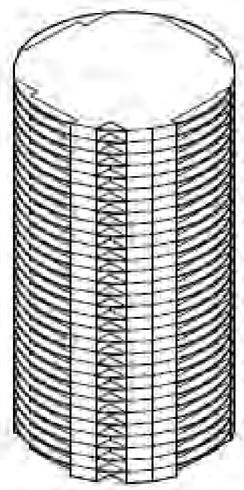
I. Energy performance factor (EPF = Shape Factor x Average U-valuel)

Min > Max = problem

A

SF =

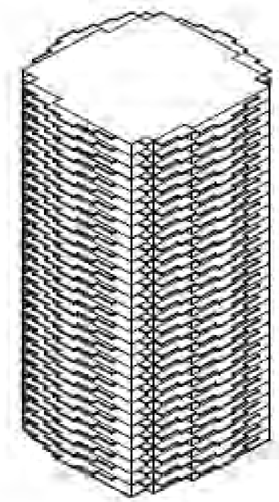
0,42



B

SF =

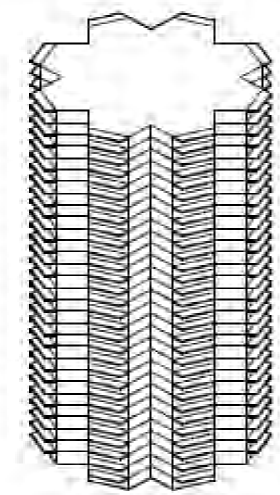
0,44



C

SF =

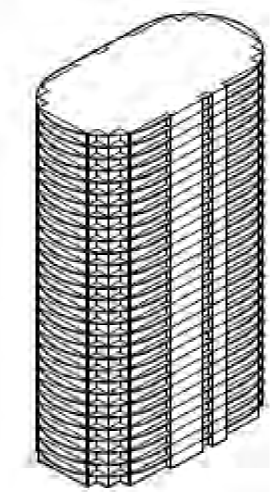
0,46



D

SF =

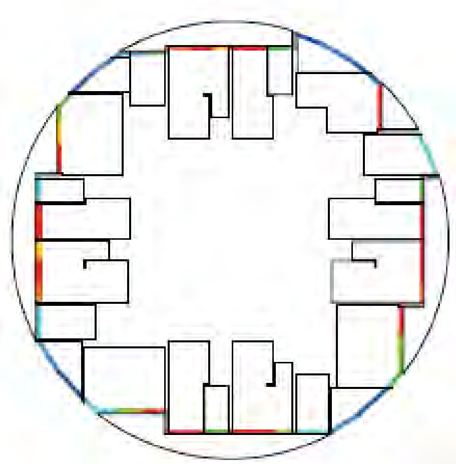
0,51

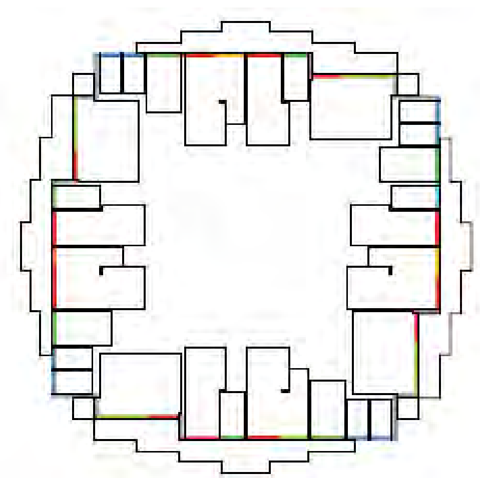


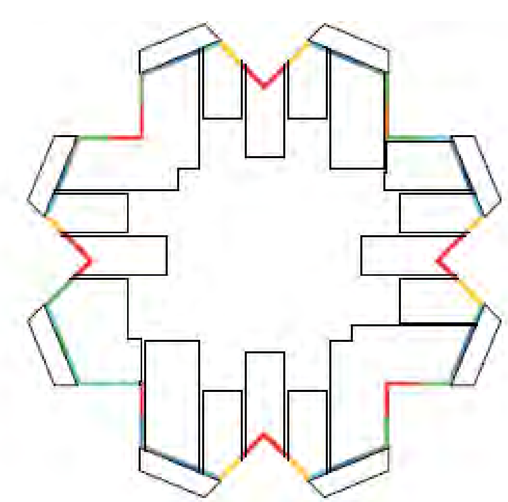
Max window size **(Heating energy)**

50% WWR | **48% WWR** | **45% WWR** | **41% WWR**

II. Daylight performance: Advanced VSC method



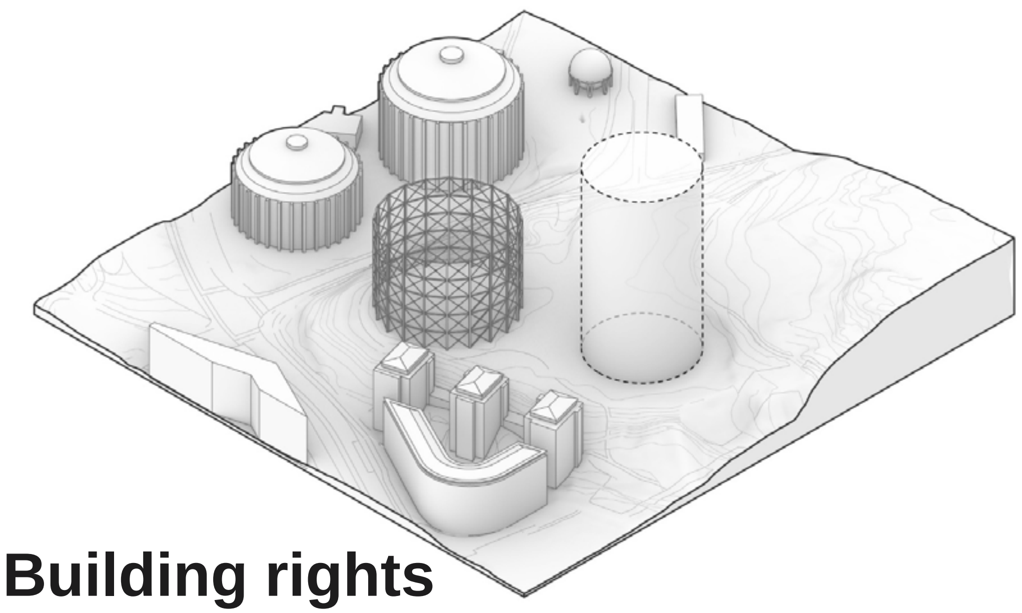




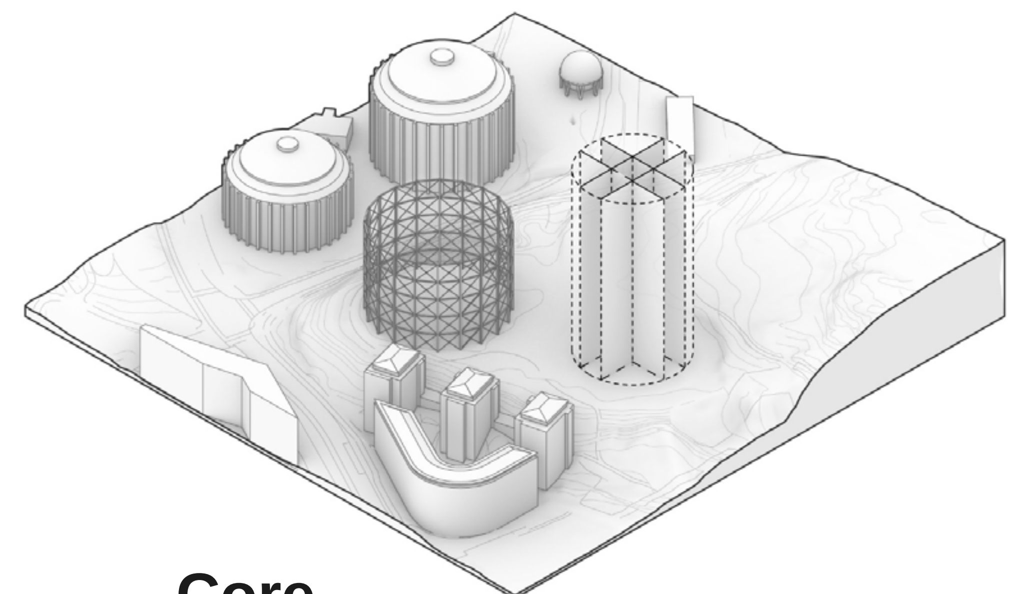
Min Window size **(Daylight)**

43% WWR | **42% WWR** | **41% WWR** | **30% WWR**

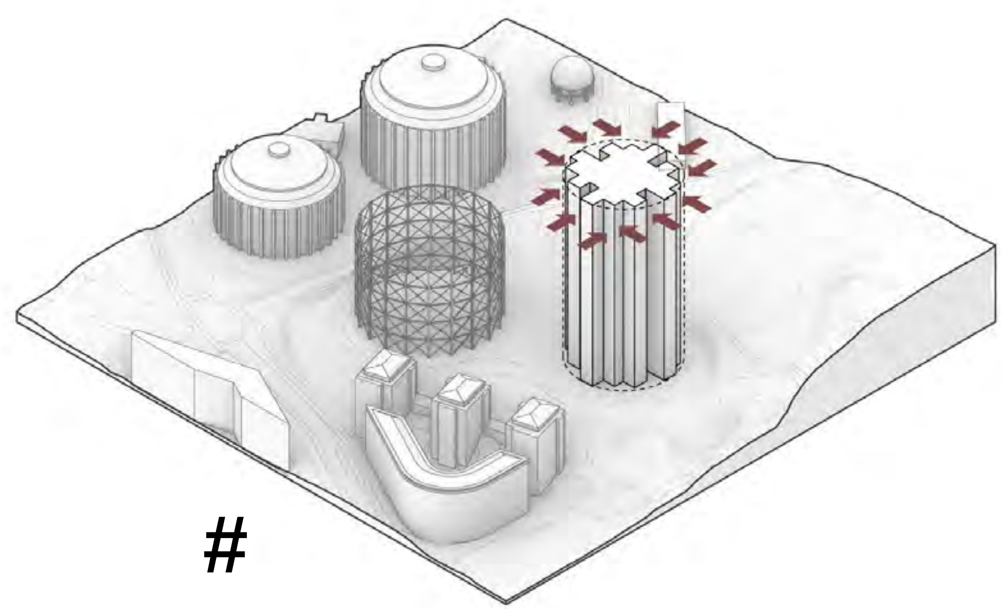
STADSLJUS



Building rights



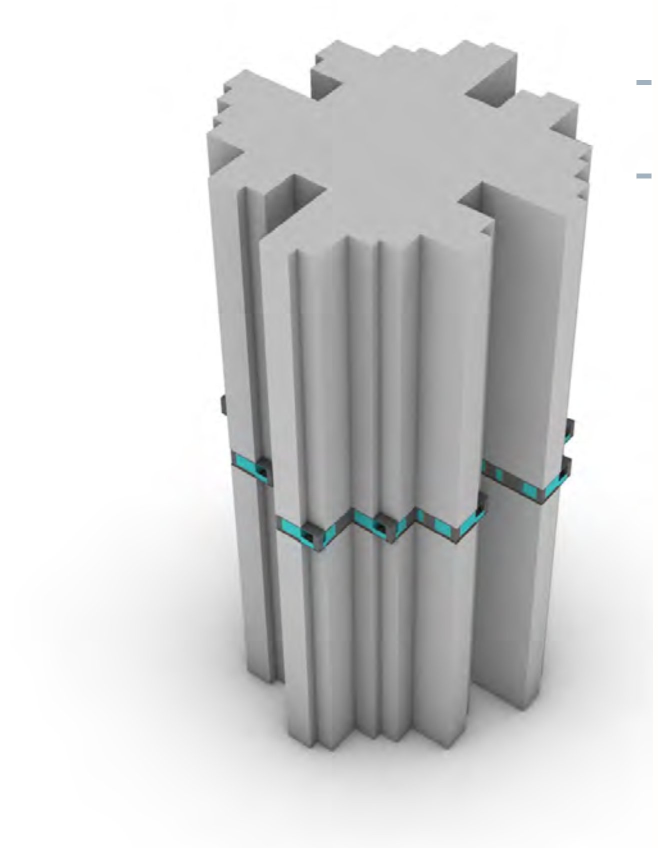
Core

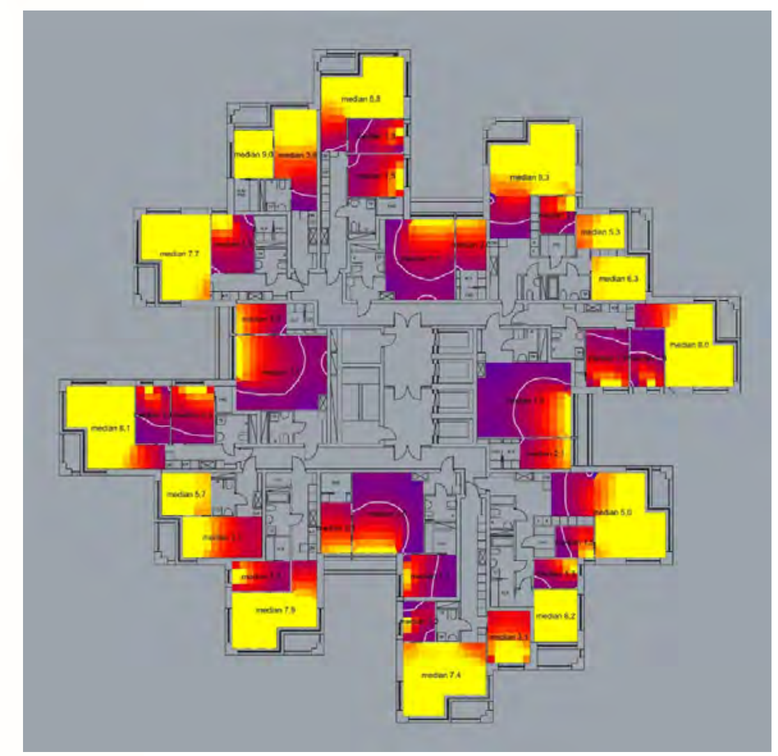


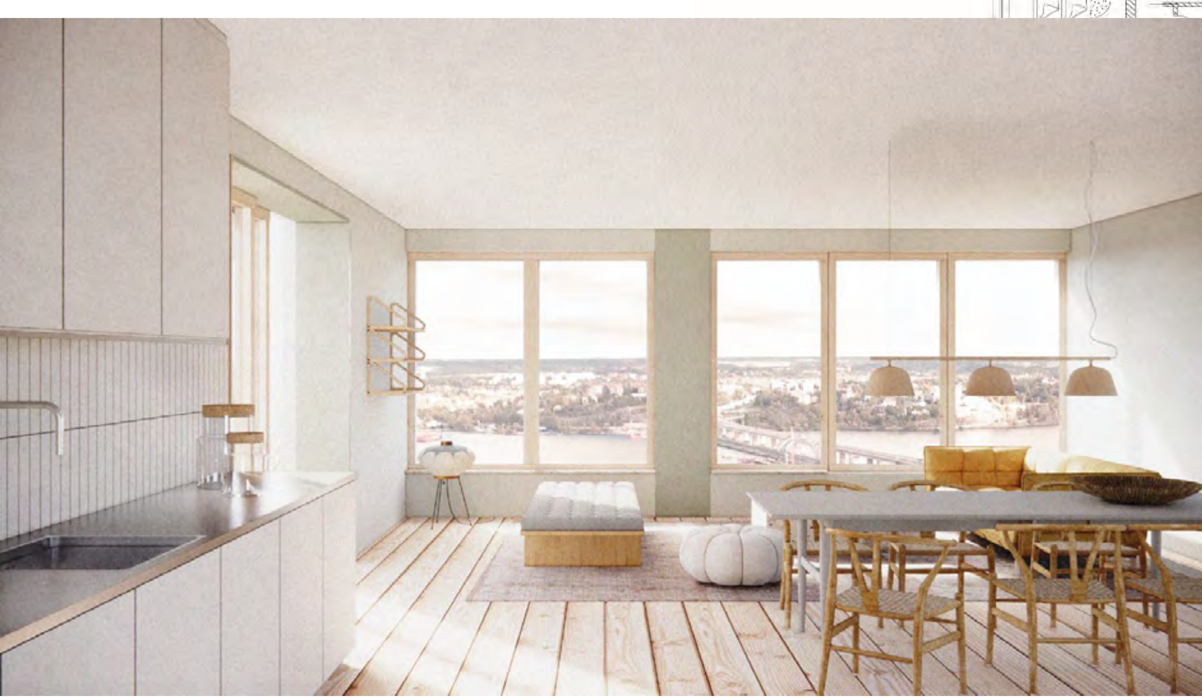
#

WELL-BEING

- Daylighting
- Direct sunlight
- Views
- # shape

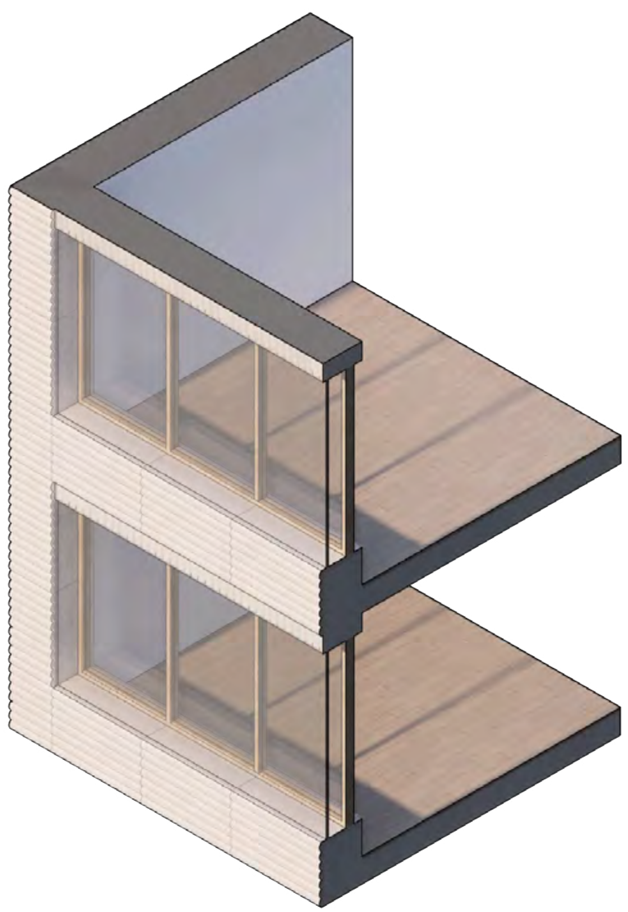






SOCIAL SUSTAINABILITY

- **Affordability (cost-efficiency)**
- **Design rationalization (modularity)**



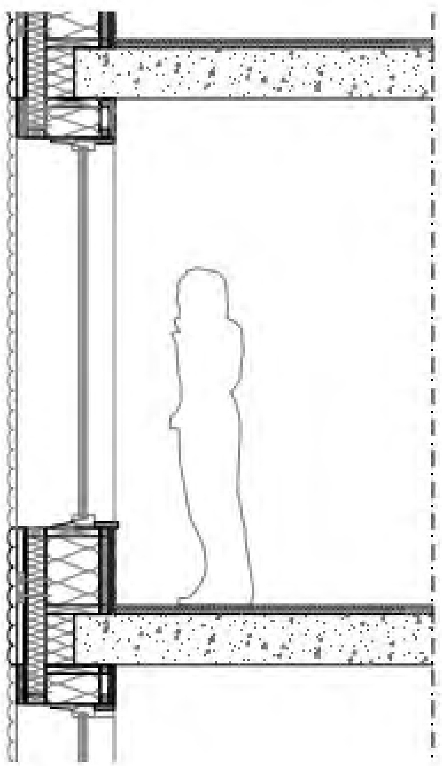
white

ENERGY EFFICIENCY IN DETAILS

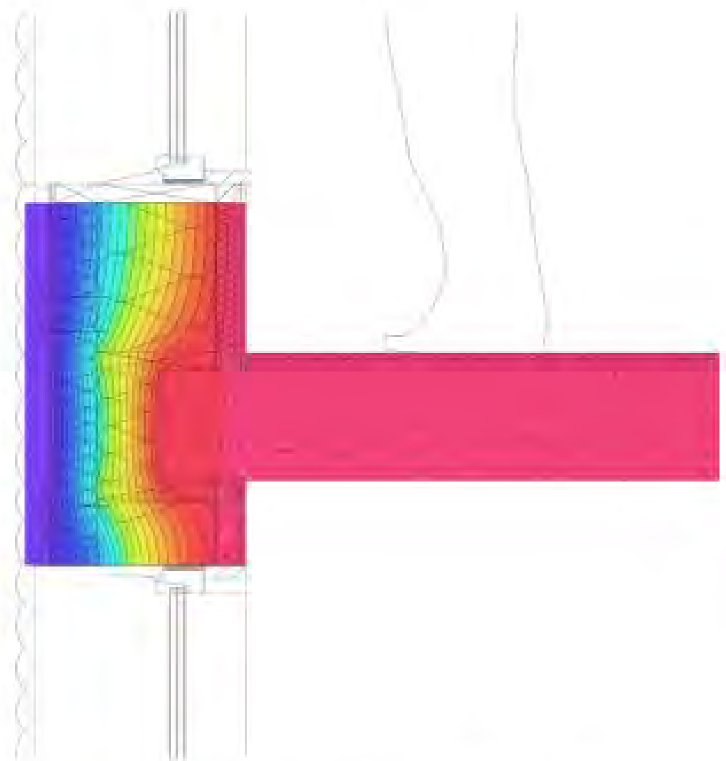
FASADUTSNITT
SKALA 1:20 (A1) / 1:40 (A3)

ENERGY EFFICIENCY IN DETAILS

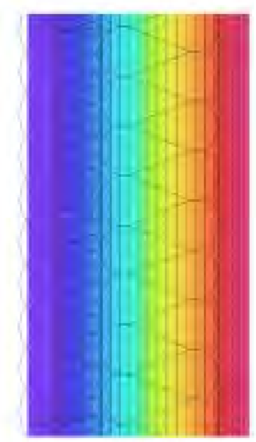
WHITE ARKITEKTER



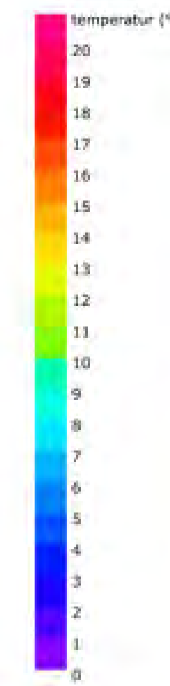
Bjälklagsdetalj



Beräknat värmeflöde genom bjälklagskant: 0,129 W/mK

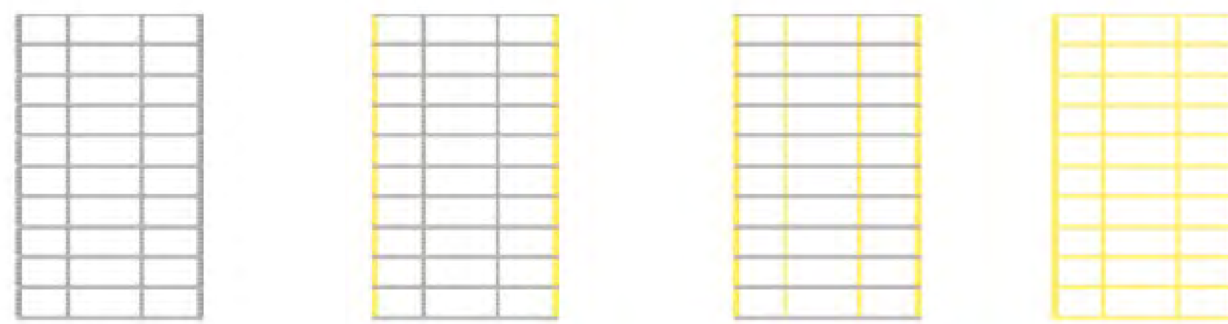


Beräknat värmeflöde genom referensfall yttervägg: 0,081 W/mK



ENVIRONMENTAL IMPACT

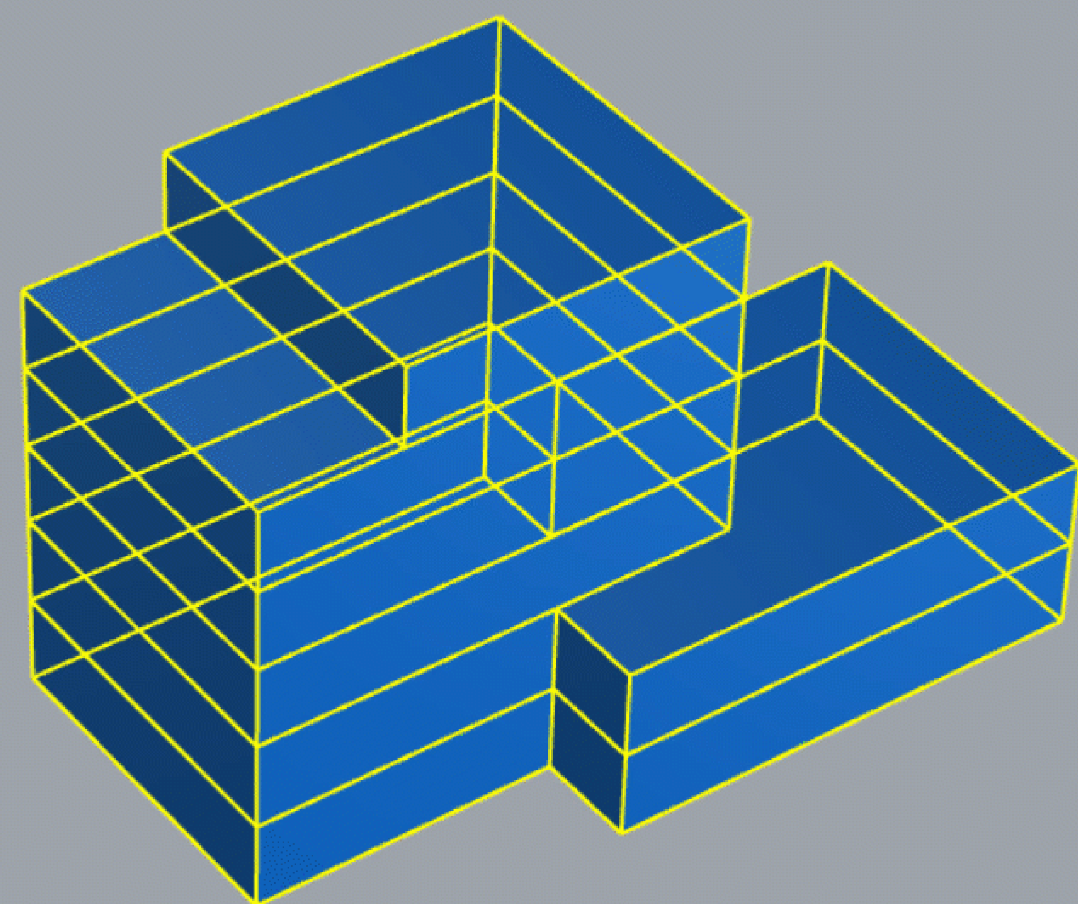
- **Low-embodied carbon: material choice**

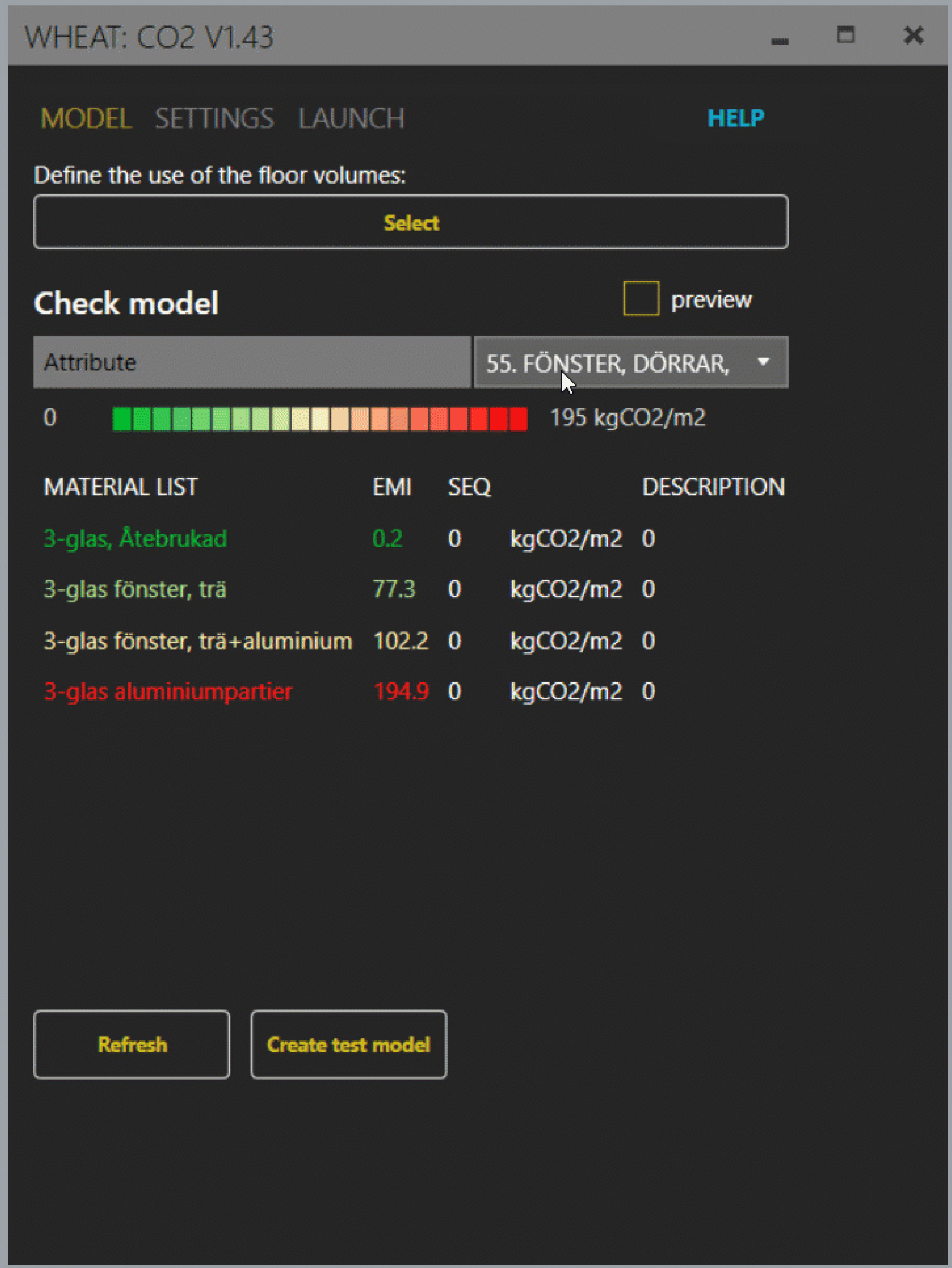


Slab	Concrete	Concrete	Concrete	Wood
Columns	Concrete	Concrete	Wood	Wood
Walls	Concrete	Concrete	Wood	Wood
Façade	Concrete	Wood	Wood	Wood

white

ESTIMATION OF CONSTRUCTION MATERIALS EMBODIED CARBON DURING EARLY DESIGN STAGES





CLIMATE CHANGE ADAPTATION

- **Wind comfort**
- **Wind risk**
- **Heat wave mitigation**
- **Biodiversity**


LESSONS LEARNED
In projects with high environmental targets:
• Start early
• Work iteratively
• High requirements (good driver)
• Integrate within the workflow of architects
white

Illustration: Mandaworks

UPPSALA BUSINESS PARK

What?

- Positive Energy District (PED)
- Existing biomedical factories
- New buildings (300 000 sqm): labs, offices, hotels and schools.
- With: Corem, Thermo Fisher, J&J, Vattenfall, Mandaworks

Where?

- Industrial area in Uppsala (Sweden)

When?

- 5 phases (finished in 2037)

PEPP

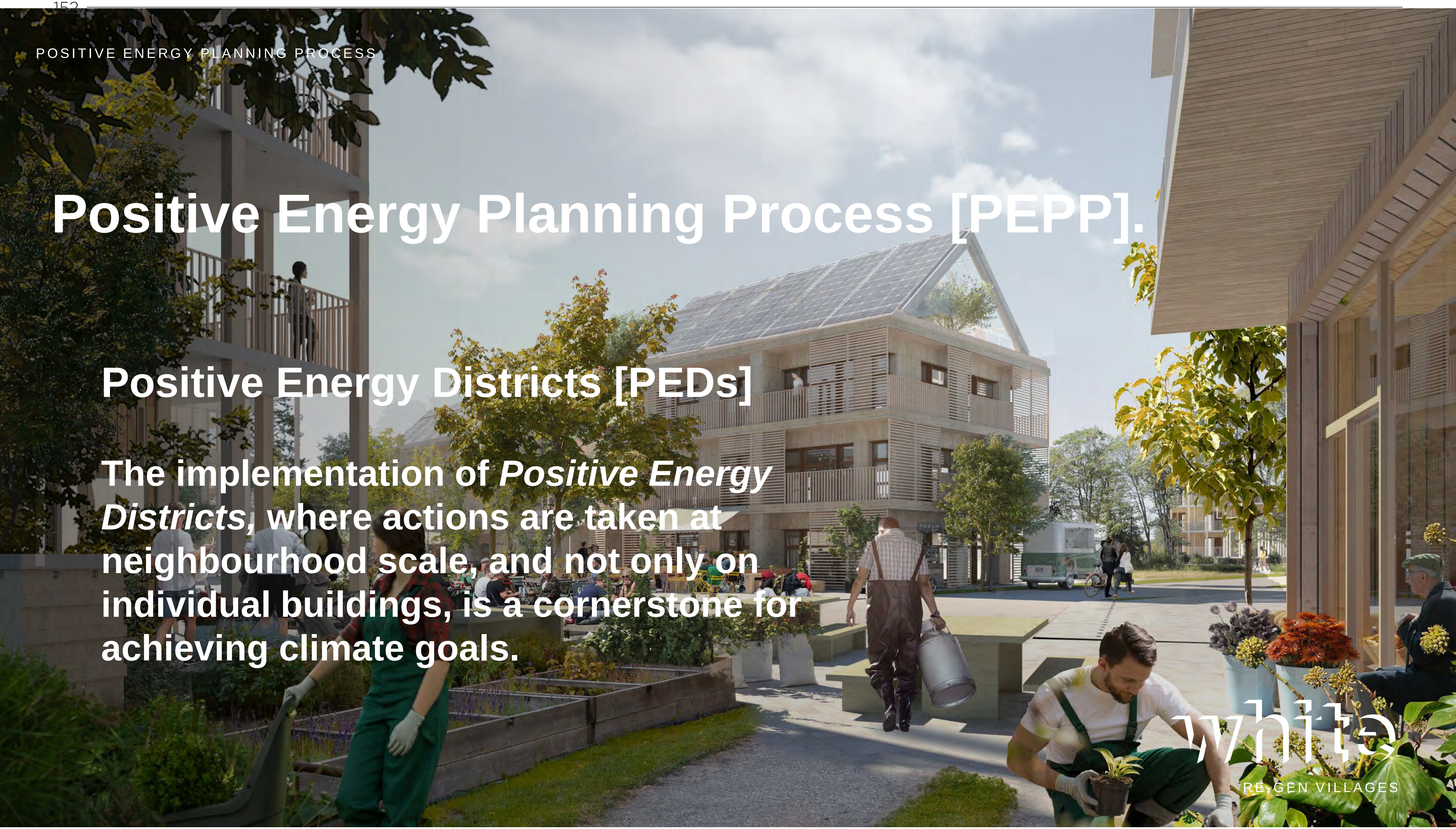
POSITIVE ENERGY PLANNING PROCESS

“Leading the development towards Energy-positive and climate neutral places where people, enterprises and nature can flourish”

Positive Energy Planning Process [PEPP].

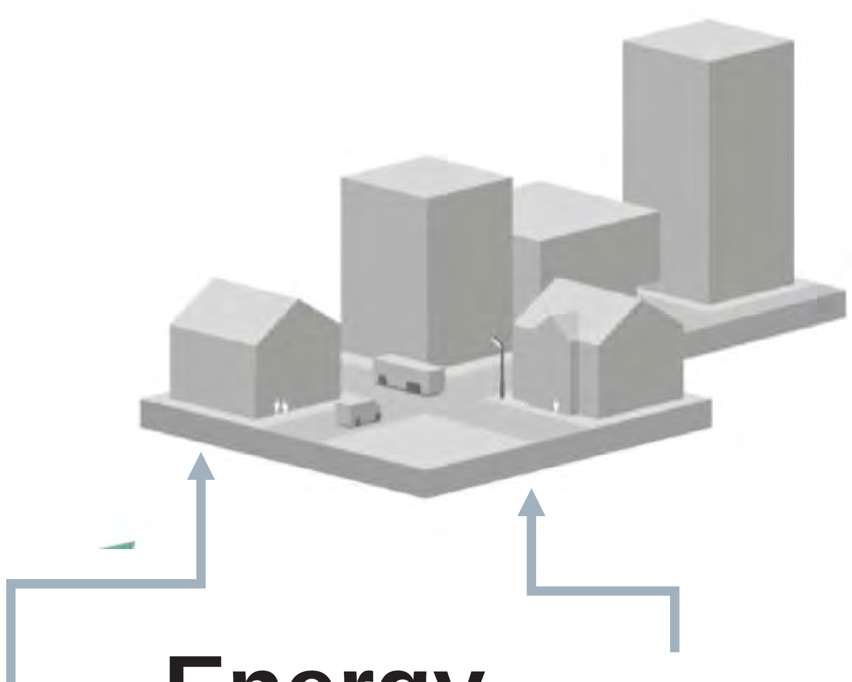
Positive Energy Districts [PEDs]

The implementation of *Positive Energy Districts,* where actions are taken at neighbourhood scale, and not only on individual buildings, is a cornerstone for achieving climate goals.



THE OPPORTUNITY / SOLUTION

Why PEDs ?



Energy Consumer

Business-As-Usual approach increases energy consumption and Co2

Energy “Prosumer”

The PED approach can result in a net surplus of energy and other energy services

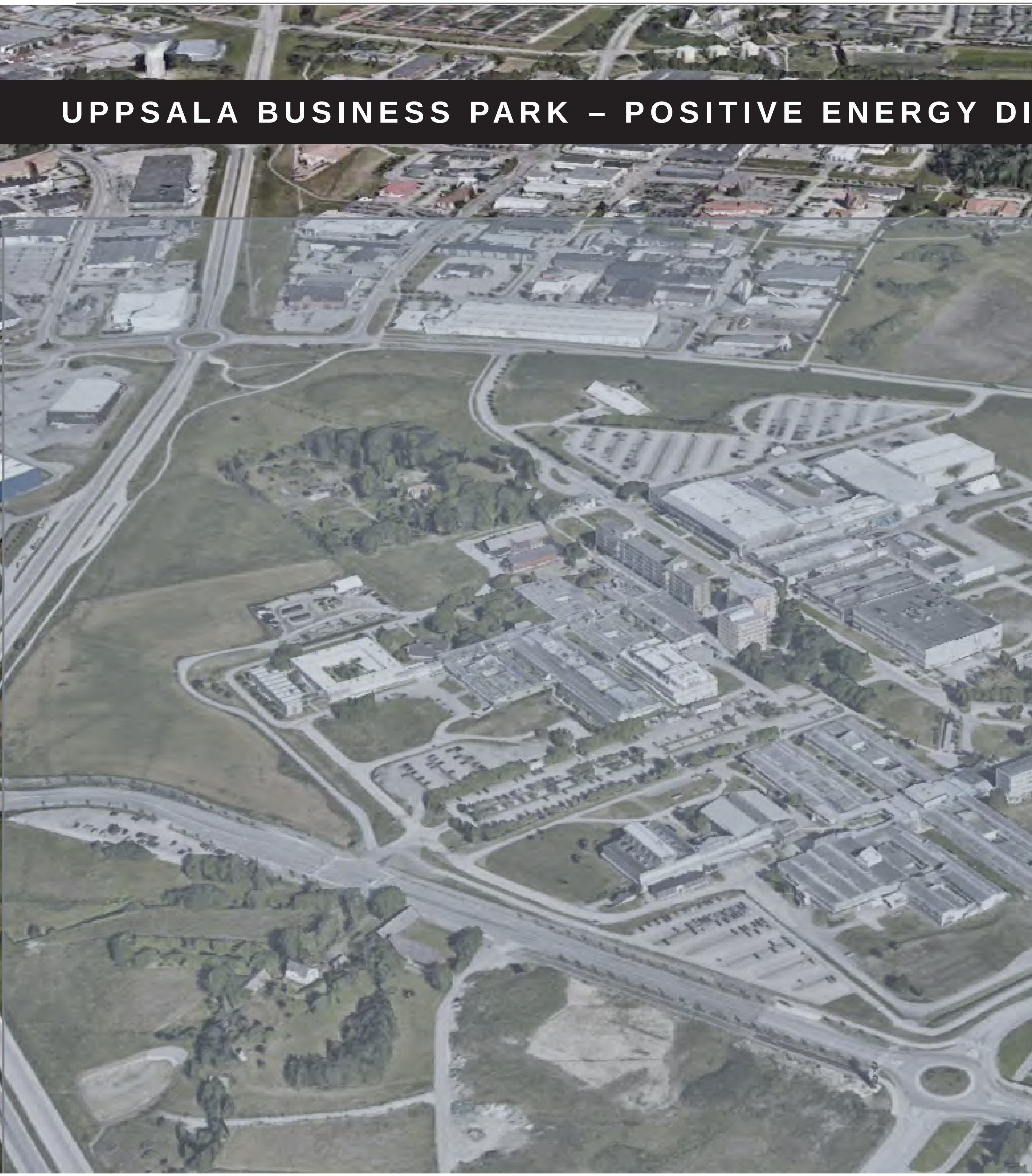
Towards “Positive-energy” Communities engaged with new energy solutions.

PEPP

Positive Energy Planning Process for Positive Energy Districts (PED)

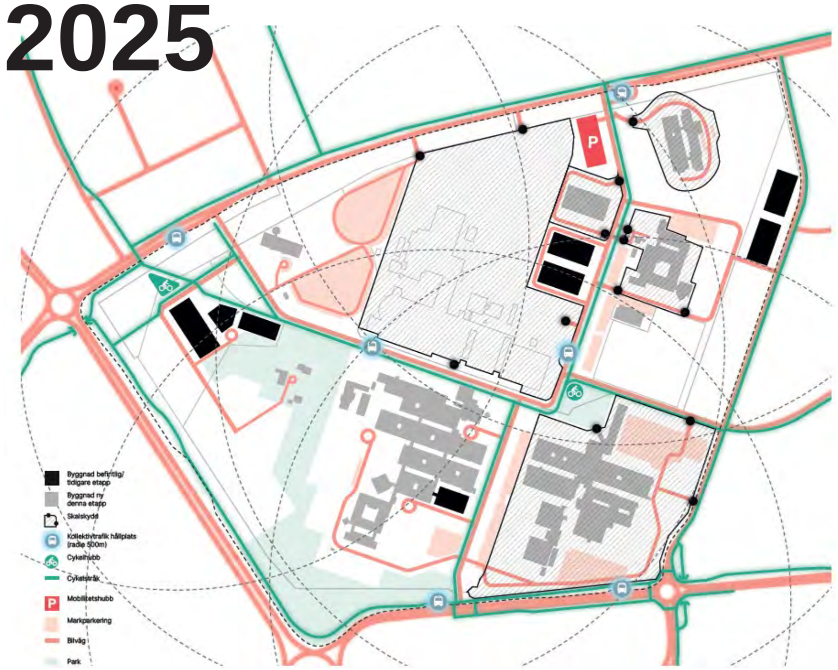
1. Create support for the process
2. Create a common vision
3. Energy mapping (current situation)
4. Energy and climate roadmap
5. Implementation and operational phase
6. Follow-up and continuous improvement
7. Diffusion and scaling up

UPPSALA BUSINESS PARK – POSITIVE ENERGY DISTRICT

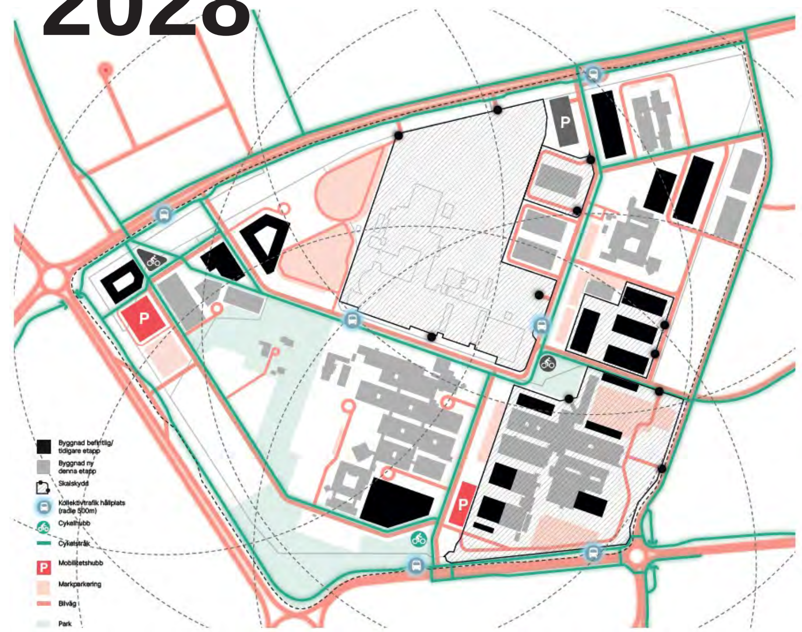


PHASES

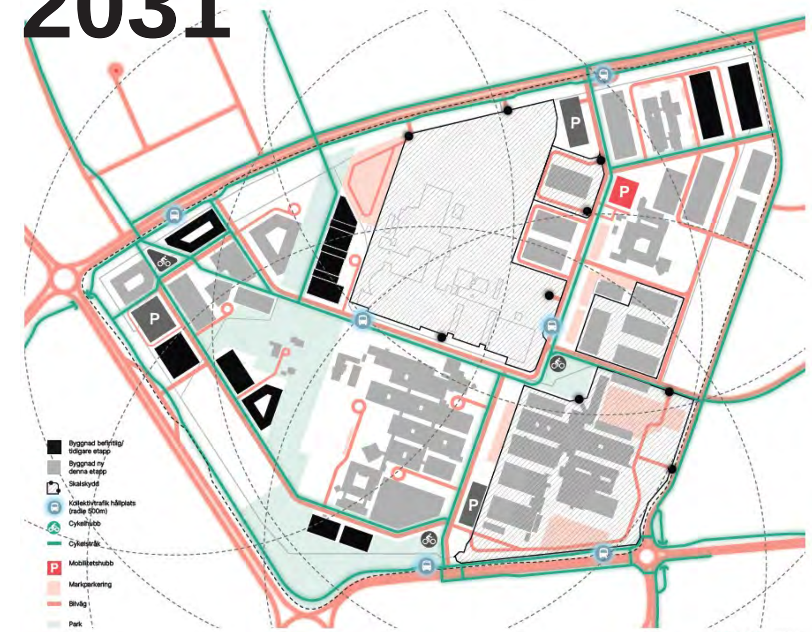
2025



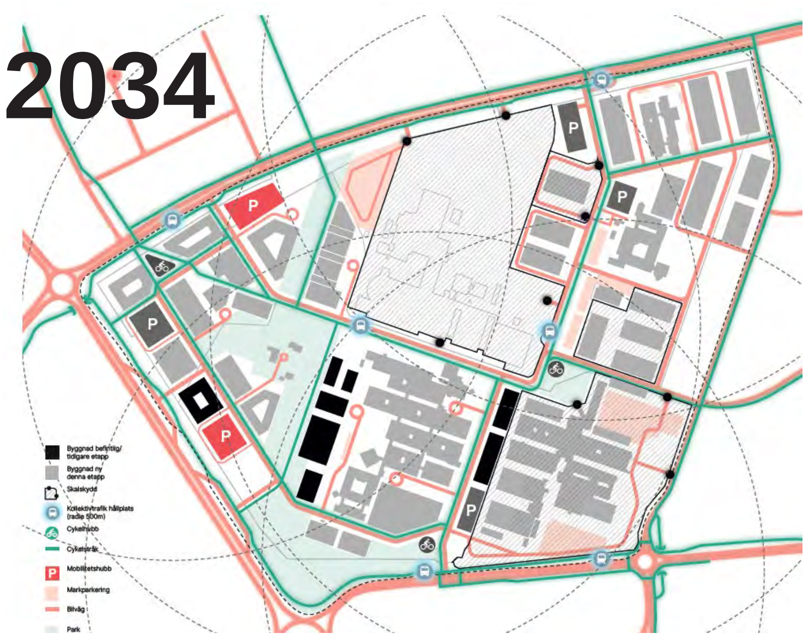
2028



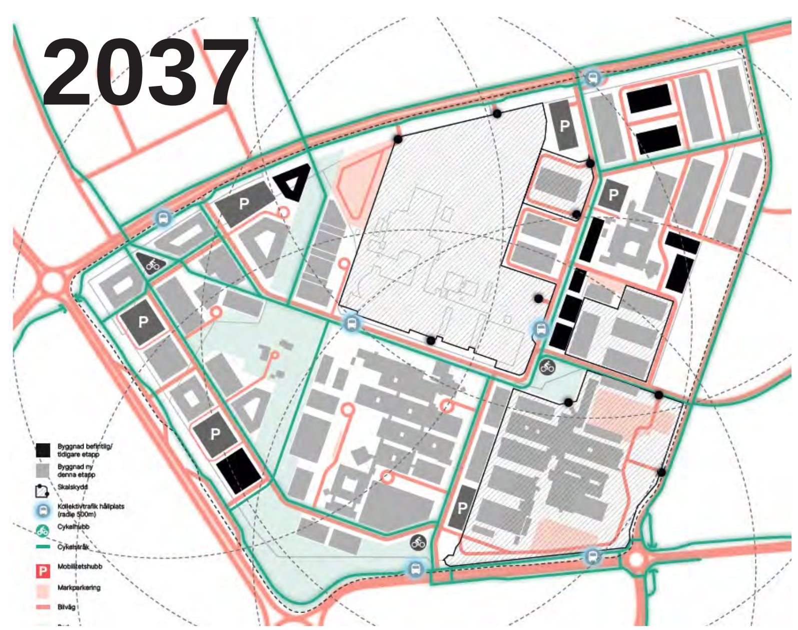
2031



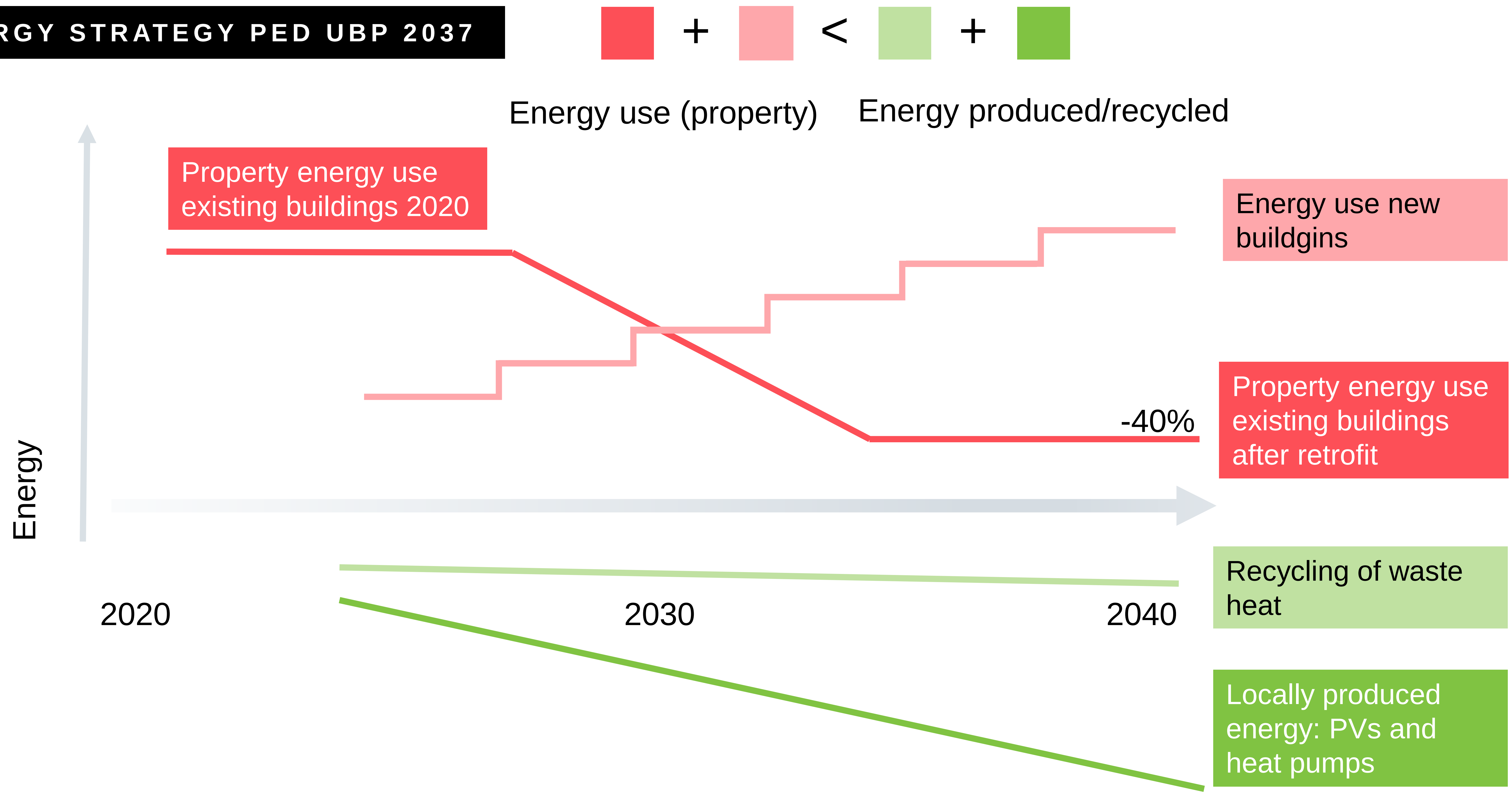
2034



2037

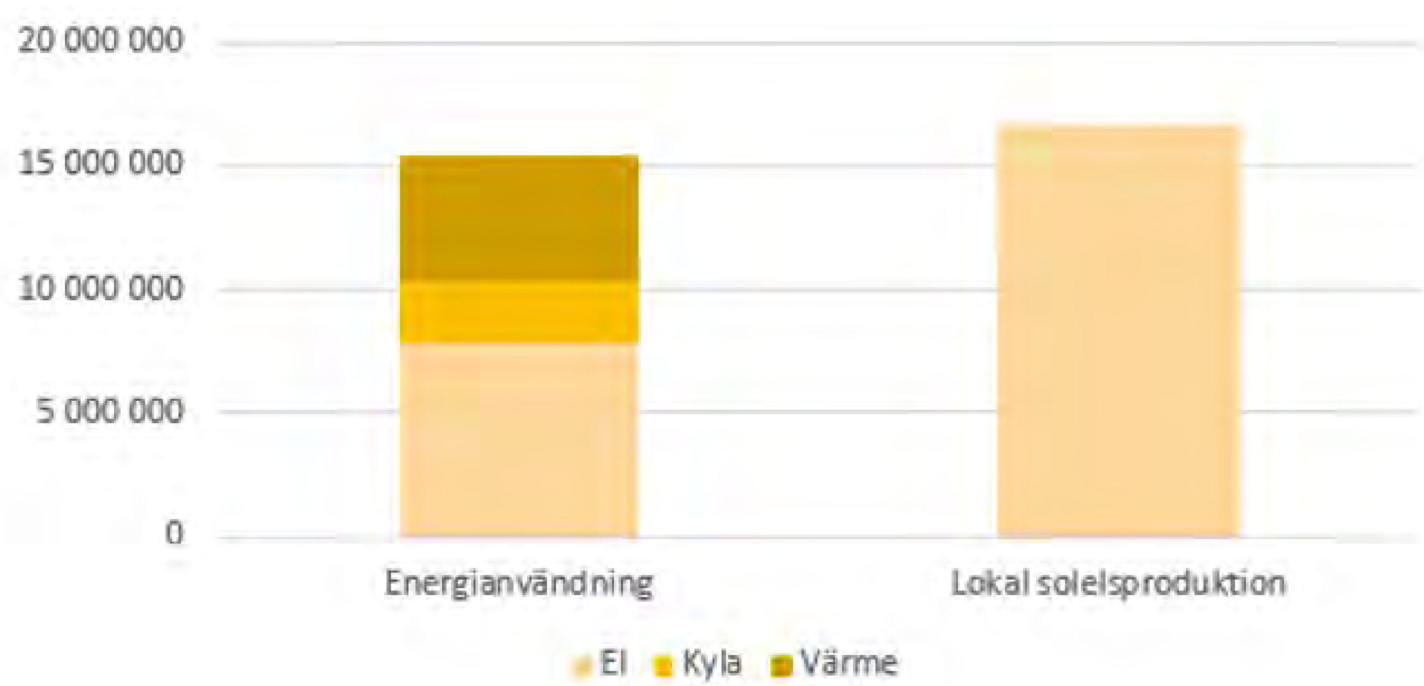


ENERGY STRATEGY PED UBP 2037

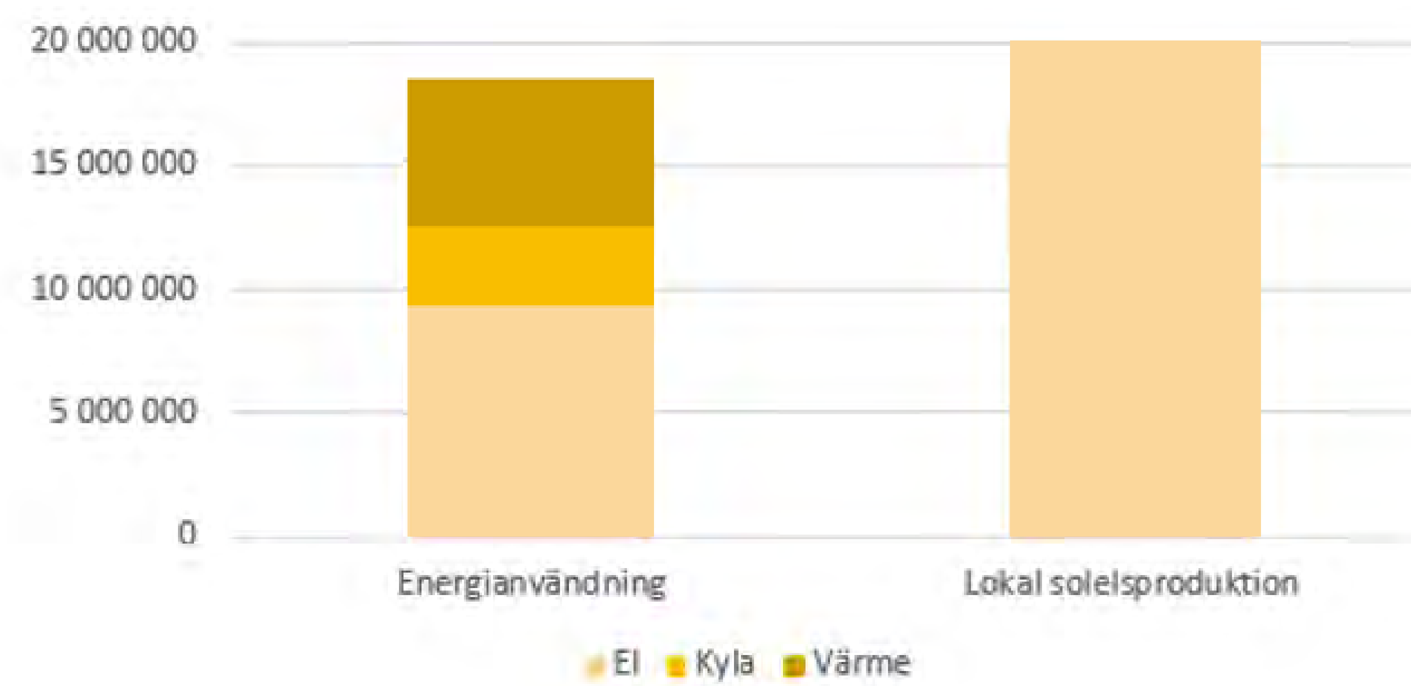


ENERGIBALANS

2031, kWh/year



2037, kWh/year



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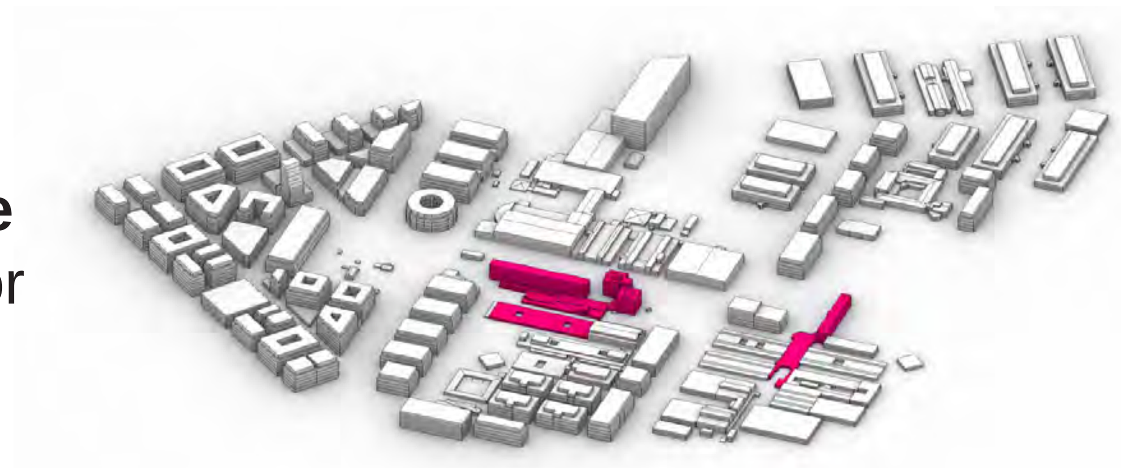
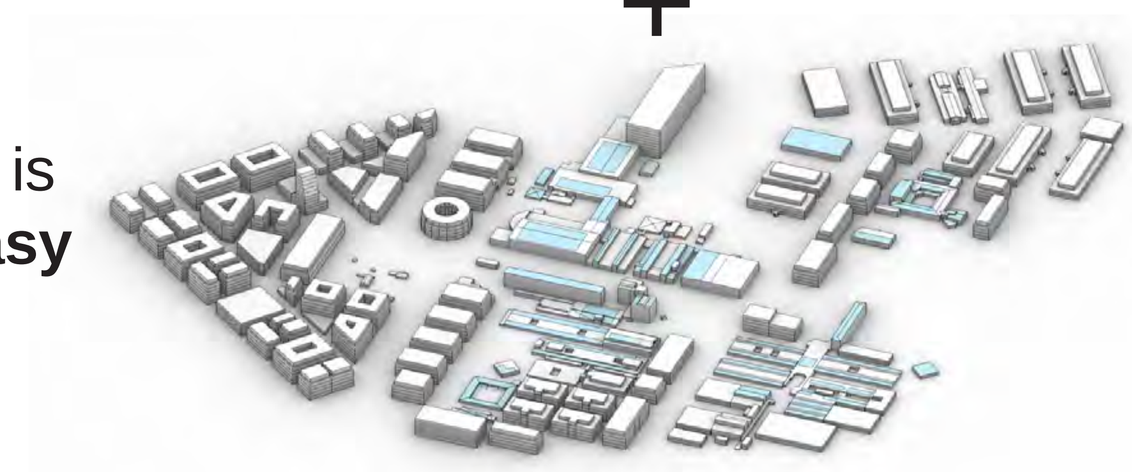
EXISTING BUILDINGS – SOLAR PANELS

Buildings with **heritage value** (not suitable for PVs)



+

Areas where it is **technically easy** to place PVs



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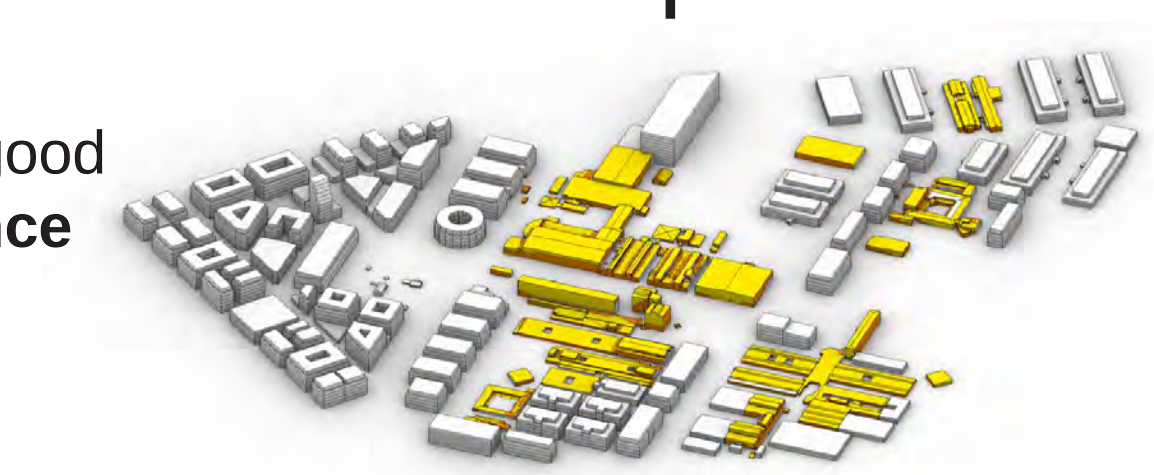
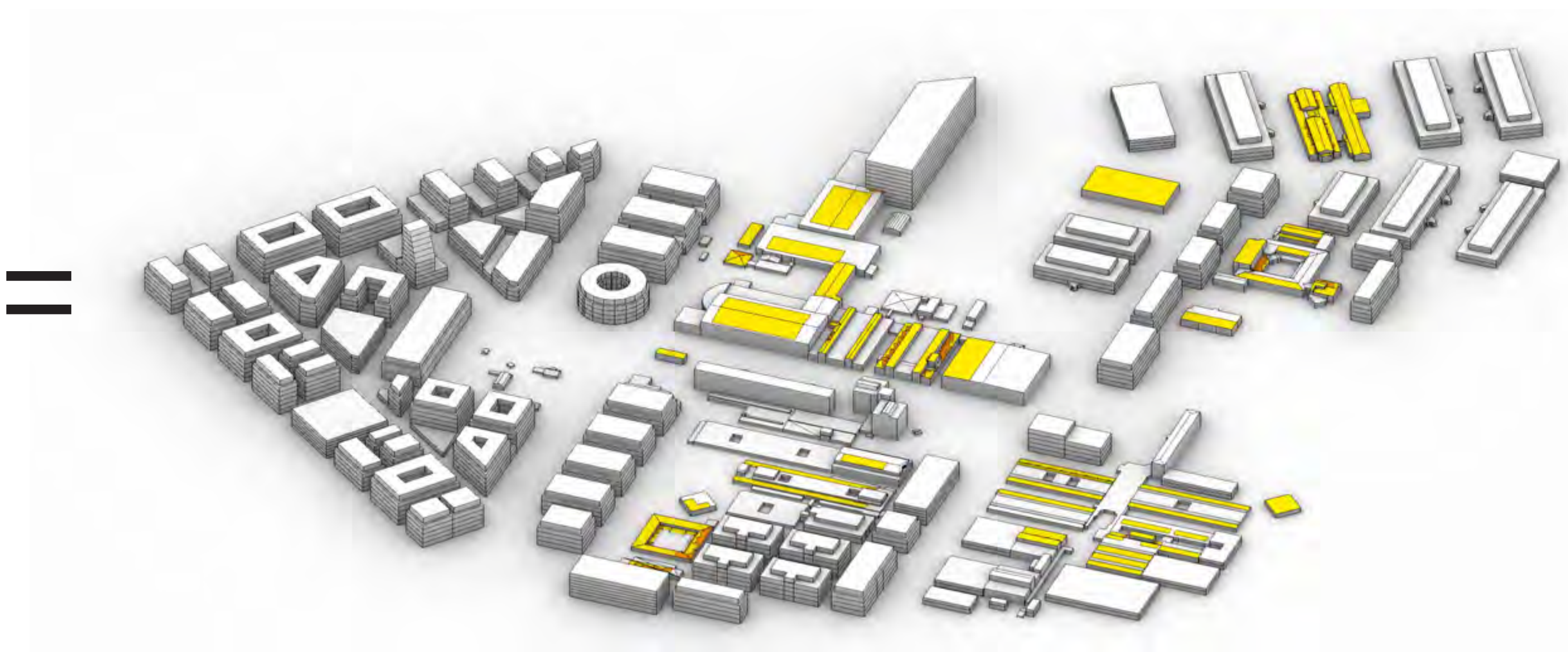
Areas with a good **solar irradiance**



=

Areas suitable for solar panels



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DETAILED SOLAR PANEL DESIGN

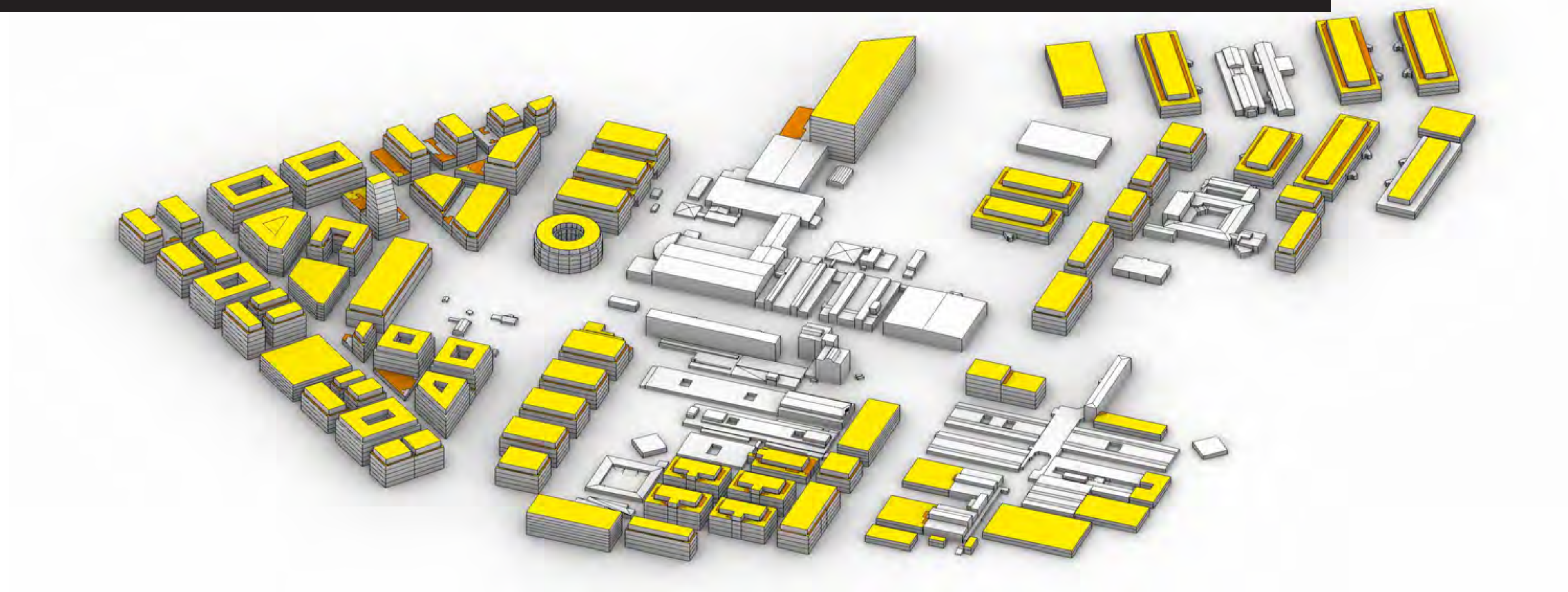
Buildings 1 and 16

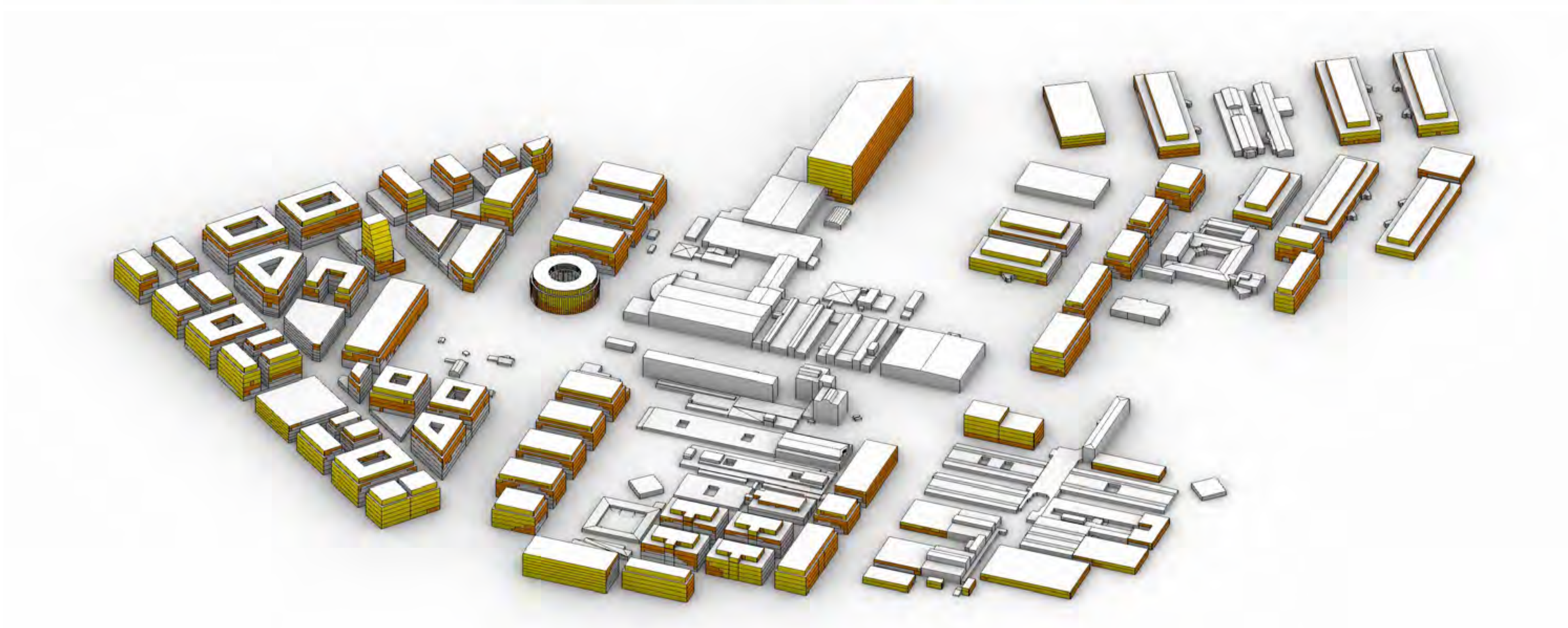
Solinstrålningssimuleringsmodell
Vy från syd

Solinstrålningssimuleringsmodell
Vy från syd

white

NEW BUILDINGS – PLACEMENT OF SOLAR PANELS





Green roof

(Climate change adaptation)

+

Solar panels

(Climate change mitigation)

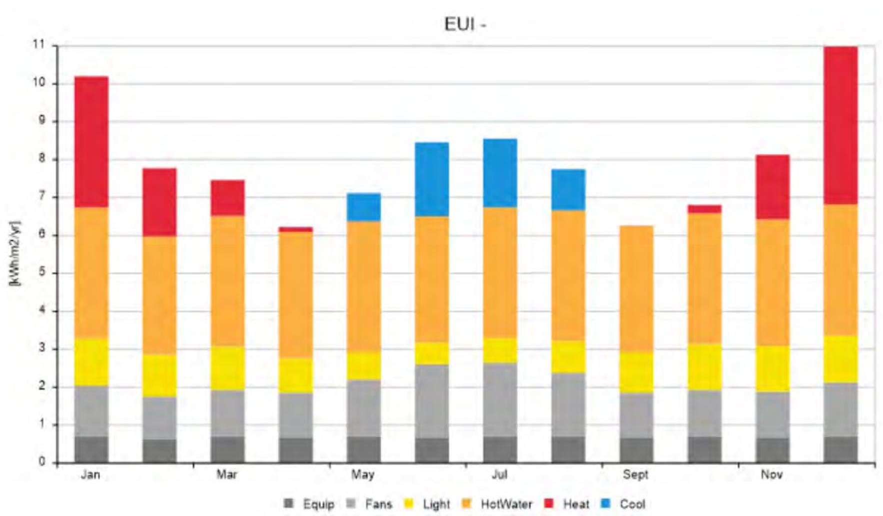
=

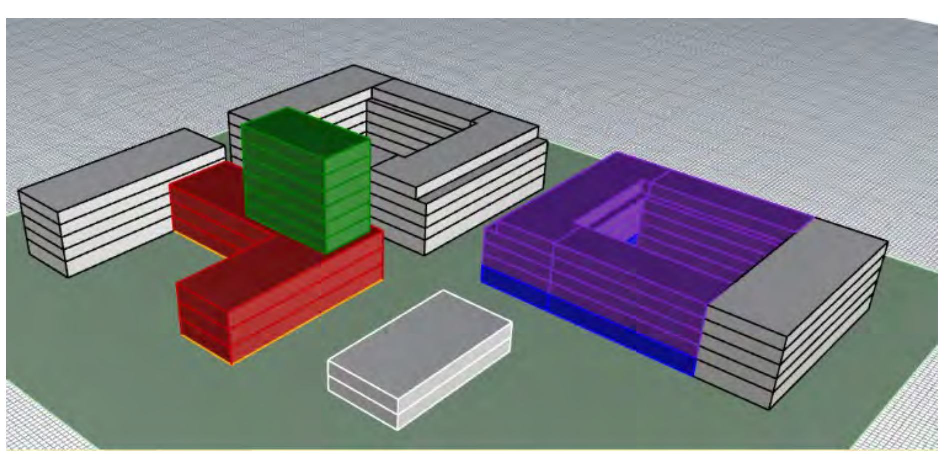
Bio-solar roofs

(Multiparameter optimization)

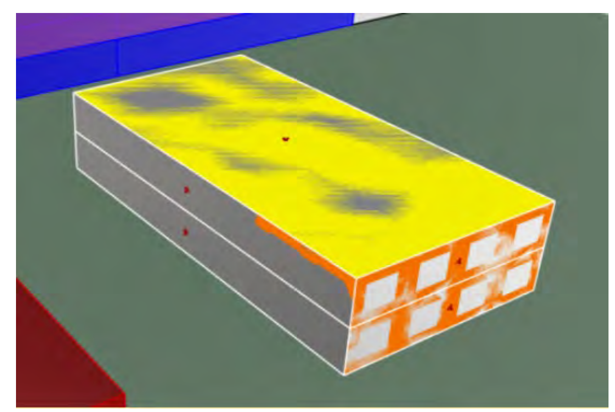
NEXT STEP: LOAD MATCHING

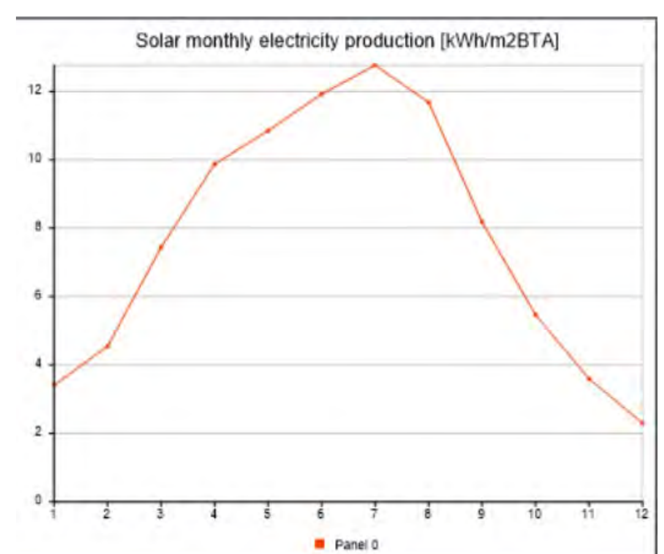
ENERGY USE
Energy use by building (hourly simulation)



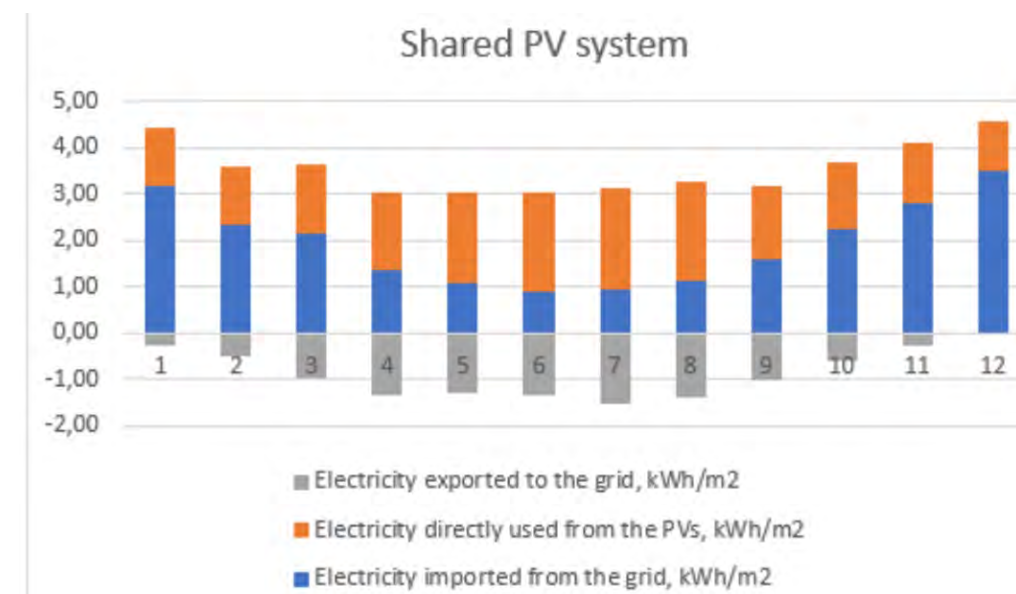


ENERGY PRODUCTION
Identification of areas suitable for PVs
Energy production by building (hourly simulation



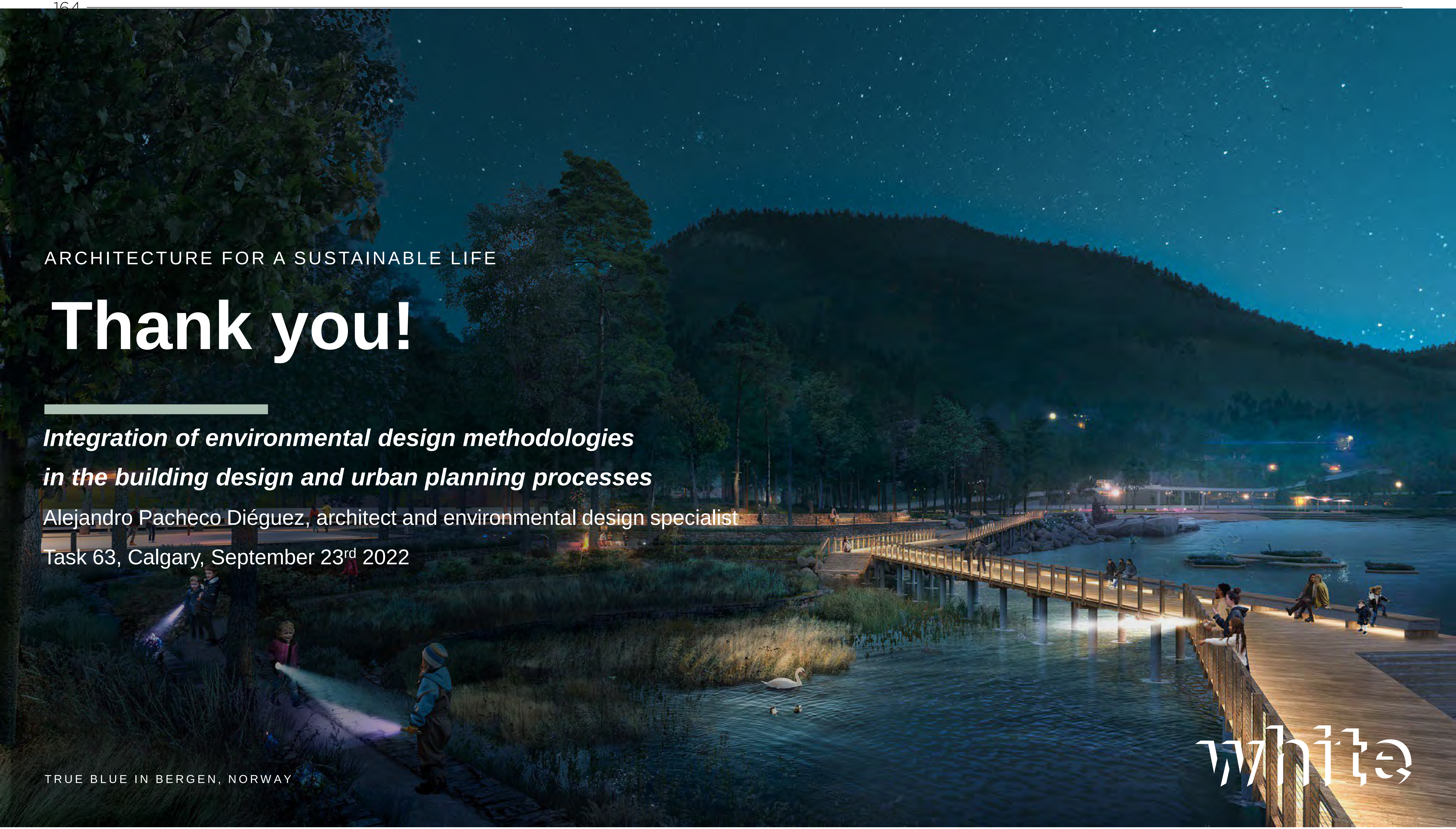


LOAD MATCHING
Load matching (separate PV systems by building or common system)



LESSONS LEARNED

- Time well invested (saves time later on)
- Important to align around the vision early on
- Understand motivations and use the right arguments


ARCHITECTURE FOR A SUSTAINABLE LIFE
Thank you!
Integration of environmental design methodologies
in the building design and urban planning processes
Alejandro Pacheco Diéguez, architect and environmental design specialist
Task 63, Calgary, September 23rd 2022
TRUE BLUE IN BERGEN, NORWAY
white

Integration of environmental design methodologies in the building design and urban planning processes

Alejandro Pacheco Diéguez, architect and environmental design specialist
Task 63 meeting, Calgary, September 23rd 2022

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

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IEA Solar Heating and Cooling Programme
(group 4230381)

How to Boost Major Solar Projects in Building Environment: The Example of a Village in Geneva, Switzerland

Gilles Desthieux

The presentation discusses Switzerland's climate and energy policies and provides some background on the G2 Solar project in Greater Geneva. This is followed by a discussion of solar planning in Switzerland at the municipal level, and how it has been applied to the village of Aigues Vertes. The presentation concludes with a discussion about how solar planning can be applied to the building level.

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

How to boost major solar projects in building environment: the example of a village in Geneva, Switzerland

Gilles Desthieux, Professor (HES-GE/HEPIA)
IEA SHC Task 63 Seminar, Calgary, 23 September 2022

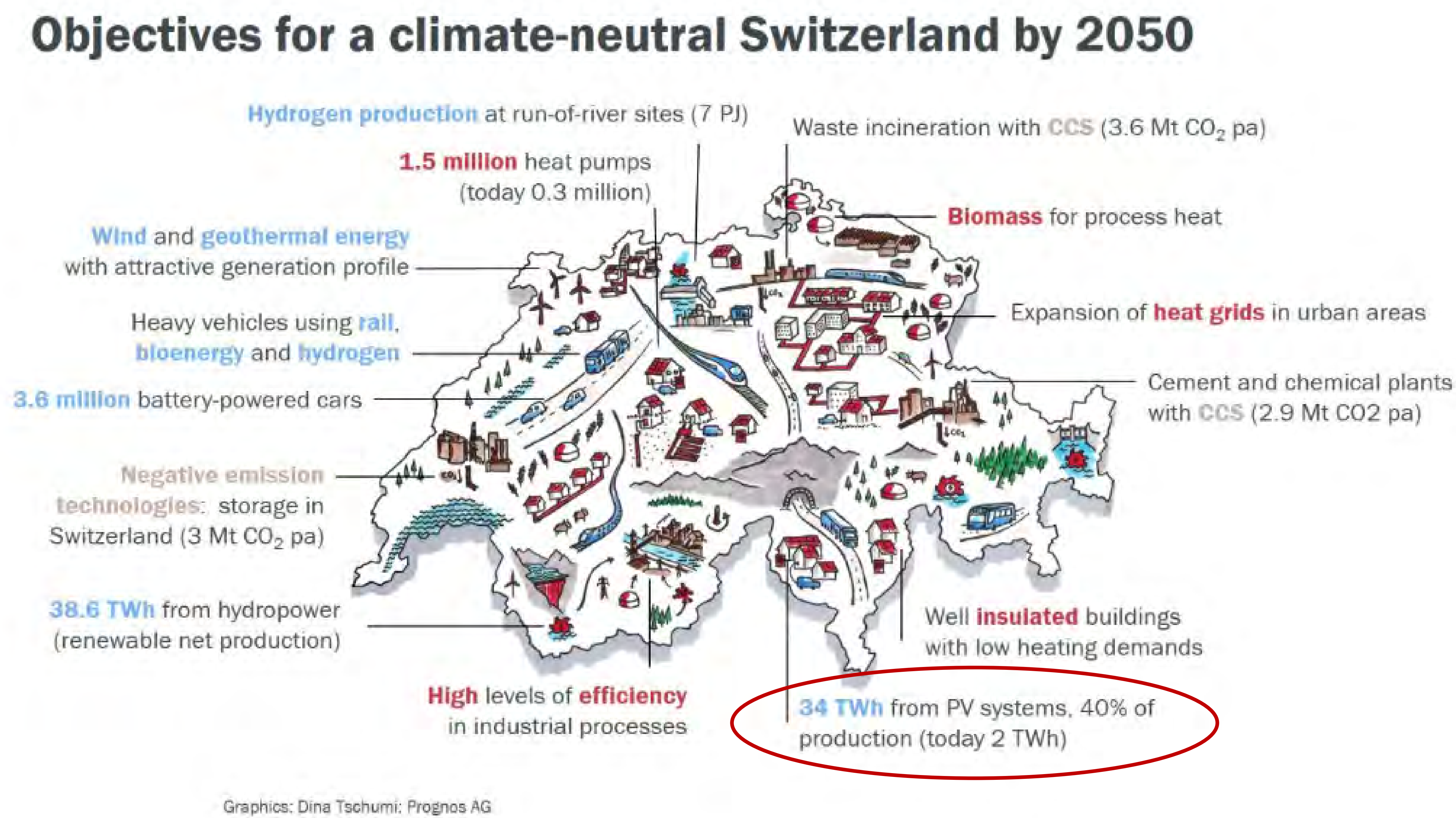
Hes·so // GENÈVE
Haute Ecole Spécialisée de Suisse occidentale

hepia
Haute école du paysage, d'ingénierie et d'architecture de Genève

Content

- Swiss climate and energy policy
- Background: solar cadaster in the Greater Geneva (G2 Solar project)
- Solar planning at municipal level
- Application to the *Aigues Vertes* village
- Application to building level

Swiss federal climate and energy policy



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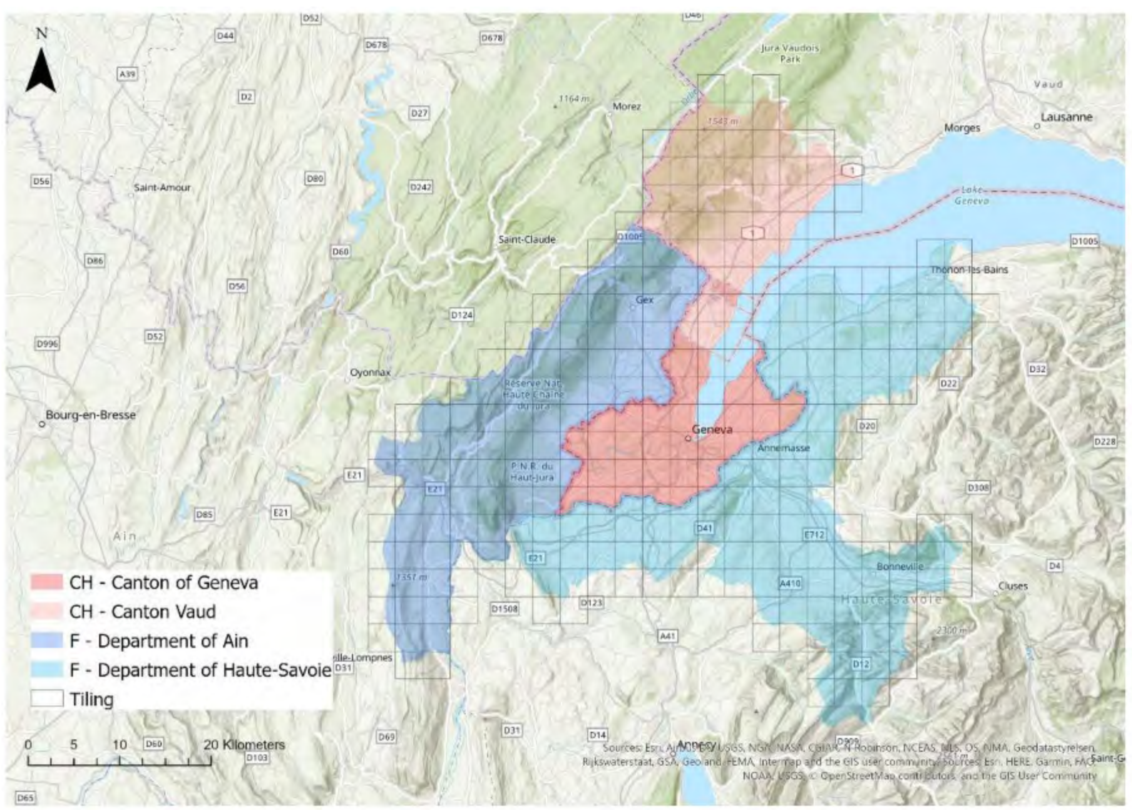
Solar cadaster in the Greater Geneva

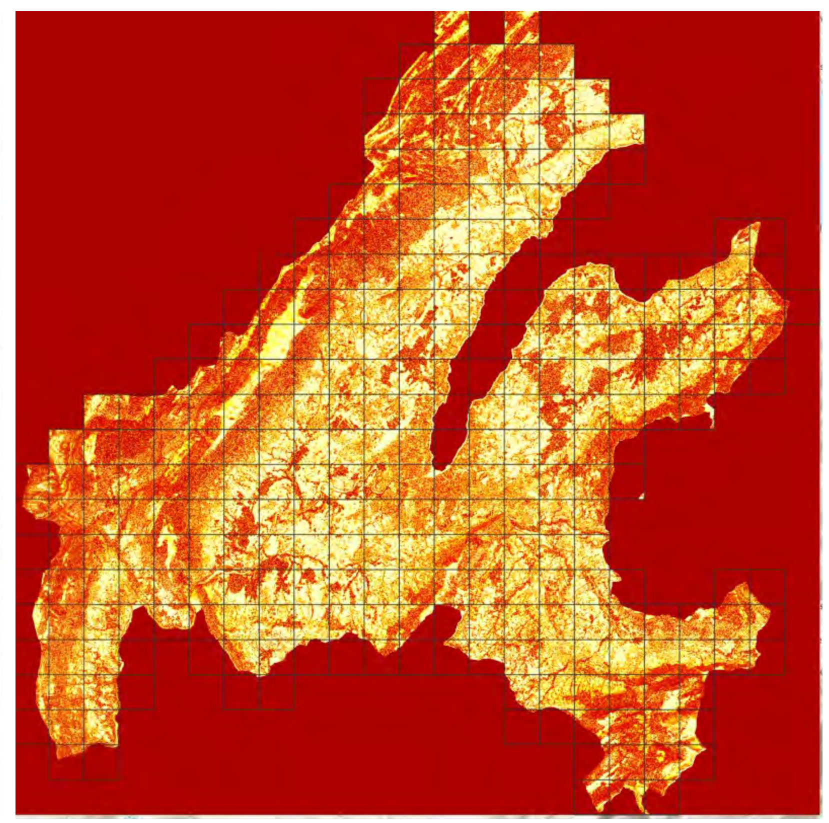
G2Solaire Interreg France - Suisse

Platform for boosting solar market in the Greater Geneva

2019 - 2022



Greater Geneva: 2 countries, 3 regions
total area: 2000 km2



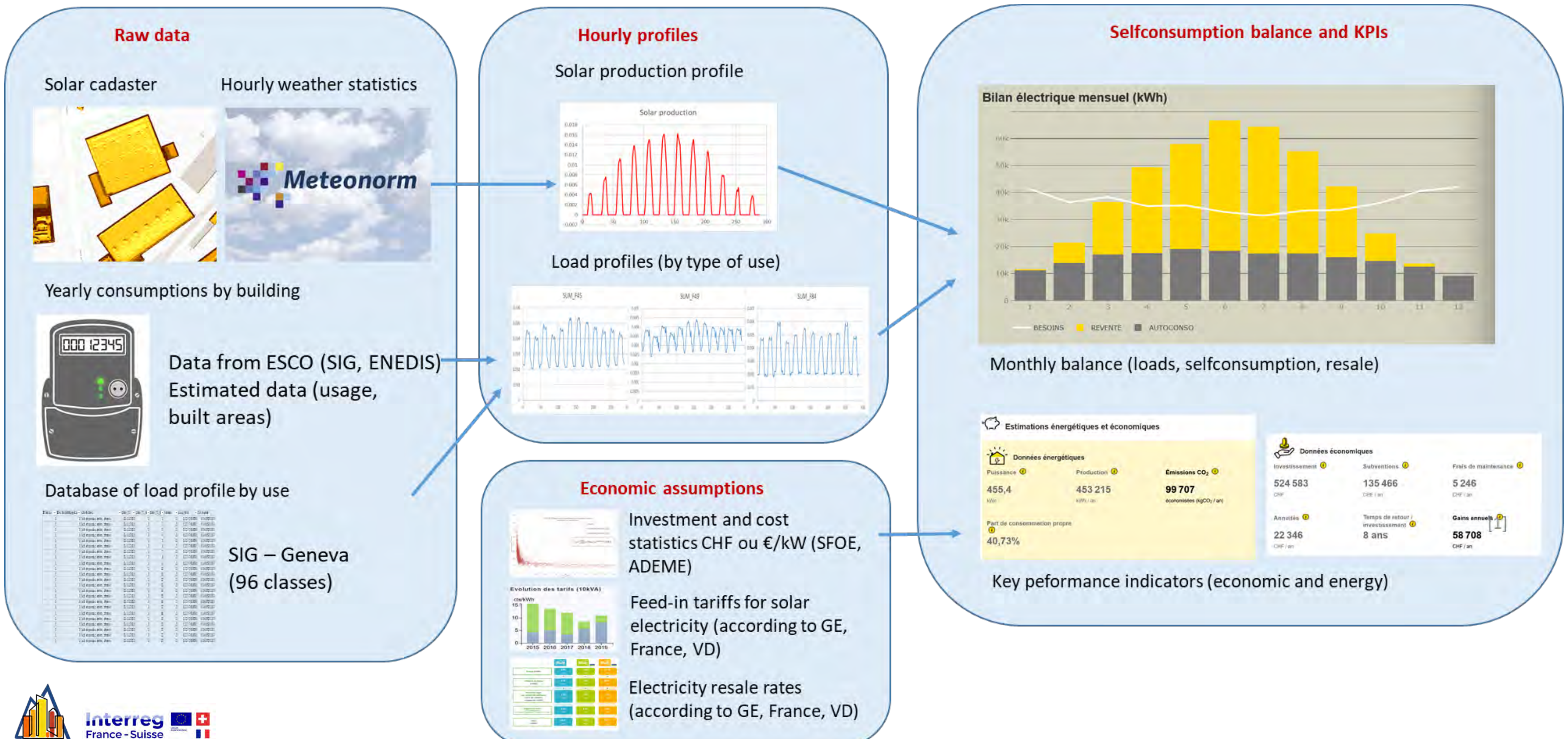
Yearly radiation output

Leaders:
- HEPIA (Switzerland)
- University of Savoie Mont-Blanc - USMB (France)

Partners:
- Switzerland: State of Geneva (OCEN, SITG, Grand Genève), State of Vaud (DIREN), SIG, Region of Nyon, arx iT
- France: INES, University of Lyon (CETHIL), Genevois Français, Innovales, Enedis, Caue-74, Terrinov

Selfconsumpion of solar PV: workflow

Simulation selfconsumption of each building of the Greater Geneva (265’000 buildings)



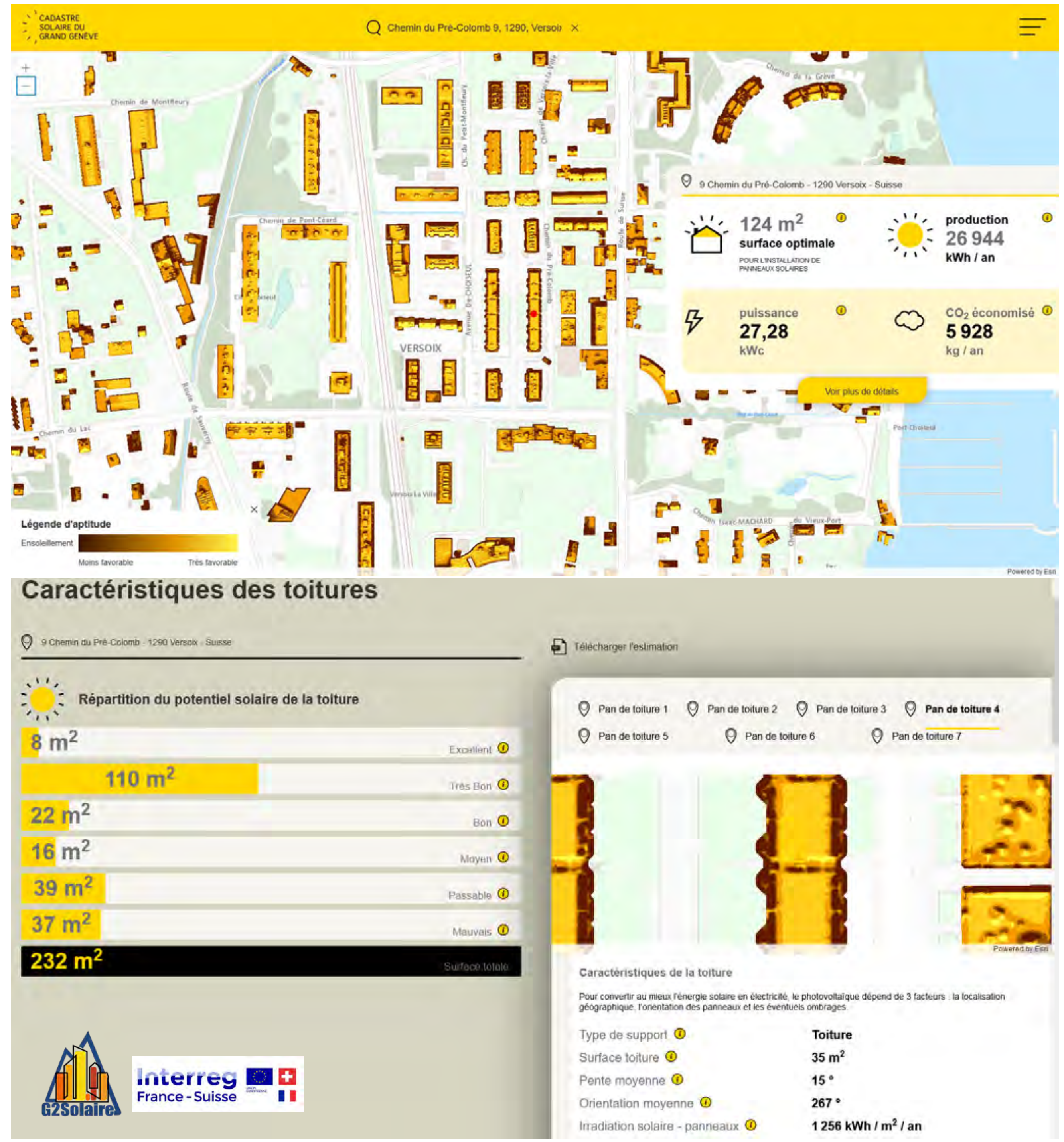
G2Solaire
Interreg France - Suisse

Web interface of the solar cadaster

Supports owners in the solar energy balance of their building
https://apps.sitg-lab.ch/solaire/

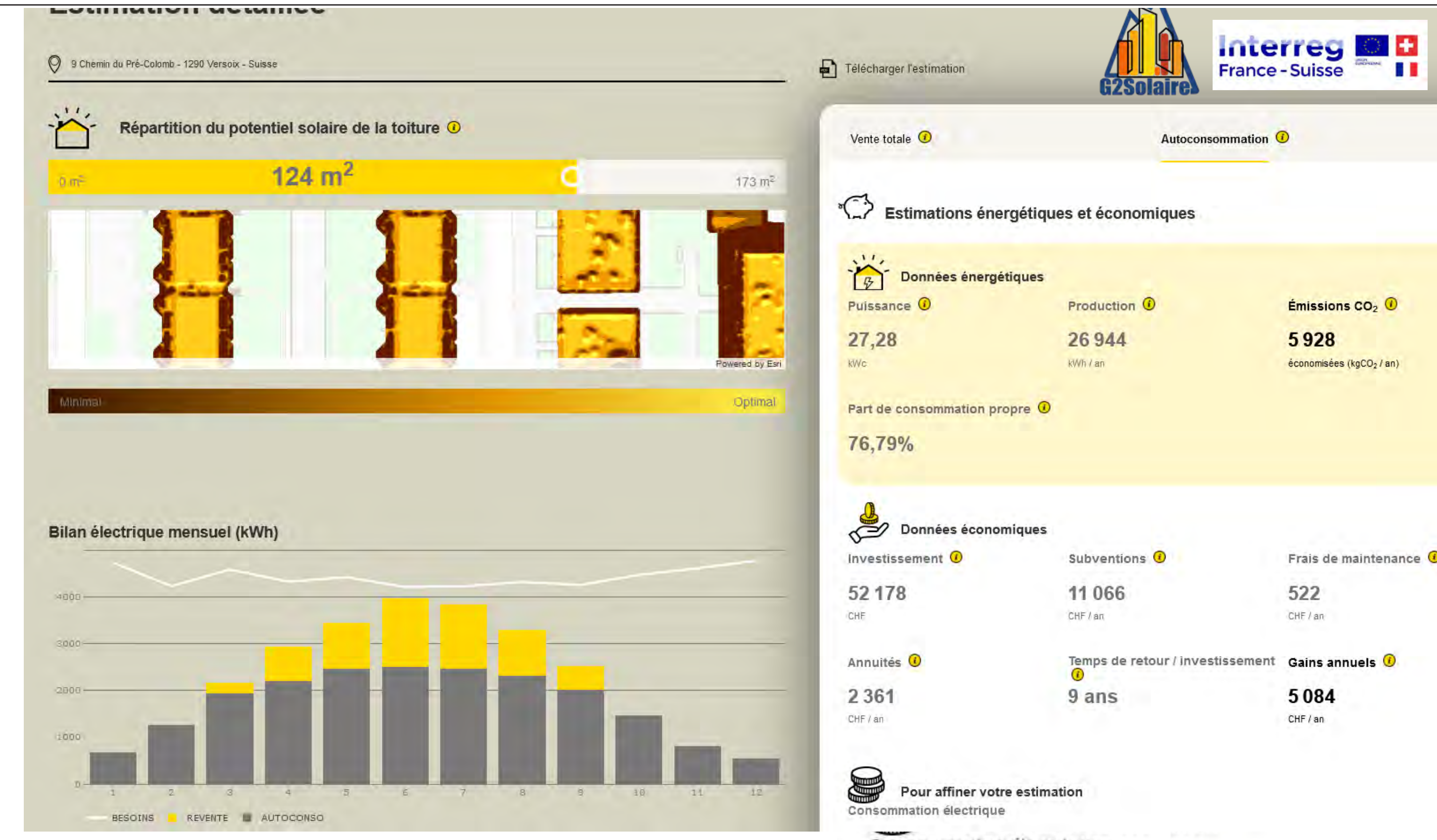
Key performance indicator

Building and roof geometry data



SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Web interface of the solar cadaster



Technical and financial estimation

Principle:

- Pre-calculated input data
- Online update by changing the cursor position
- And/or by providing information and data through the form

Online form to fill consumption data and refine simulation

Solar planning at municipal level: Bernex (Geneva). Application to the village of Aigues Vertes.

Bernex: 10'300 inhabitants

Peripheral commune of Geneva, mainly rural, intense urbanization process in progress

Study funded by:

Commune de Bernex

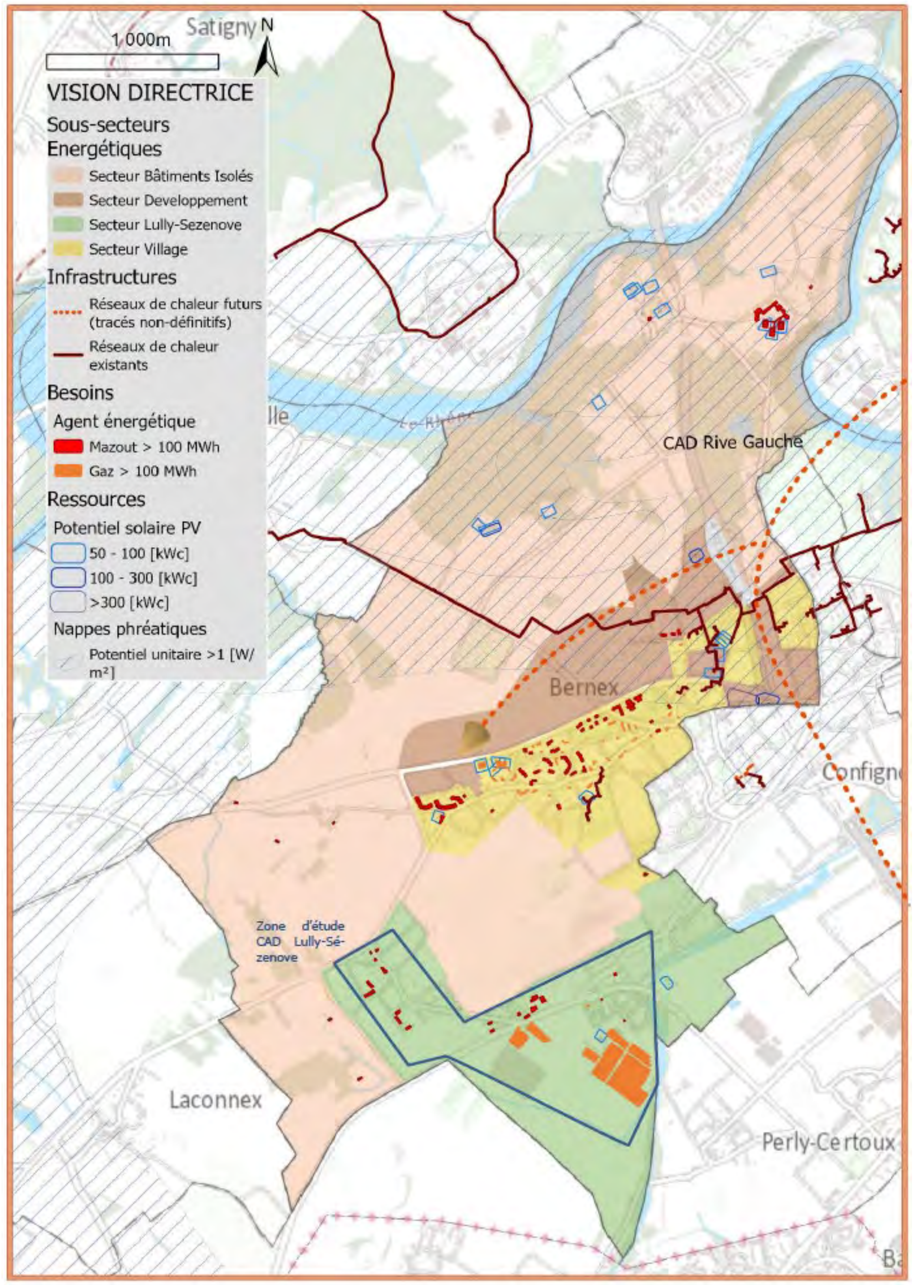
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

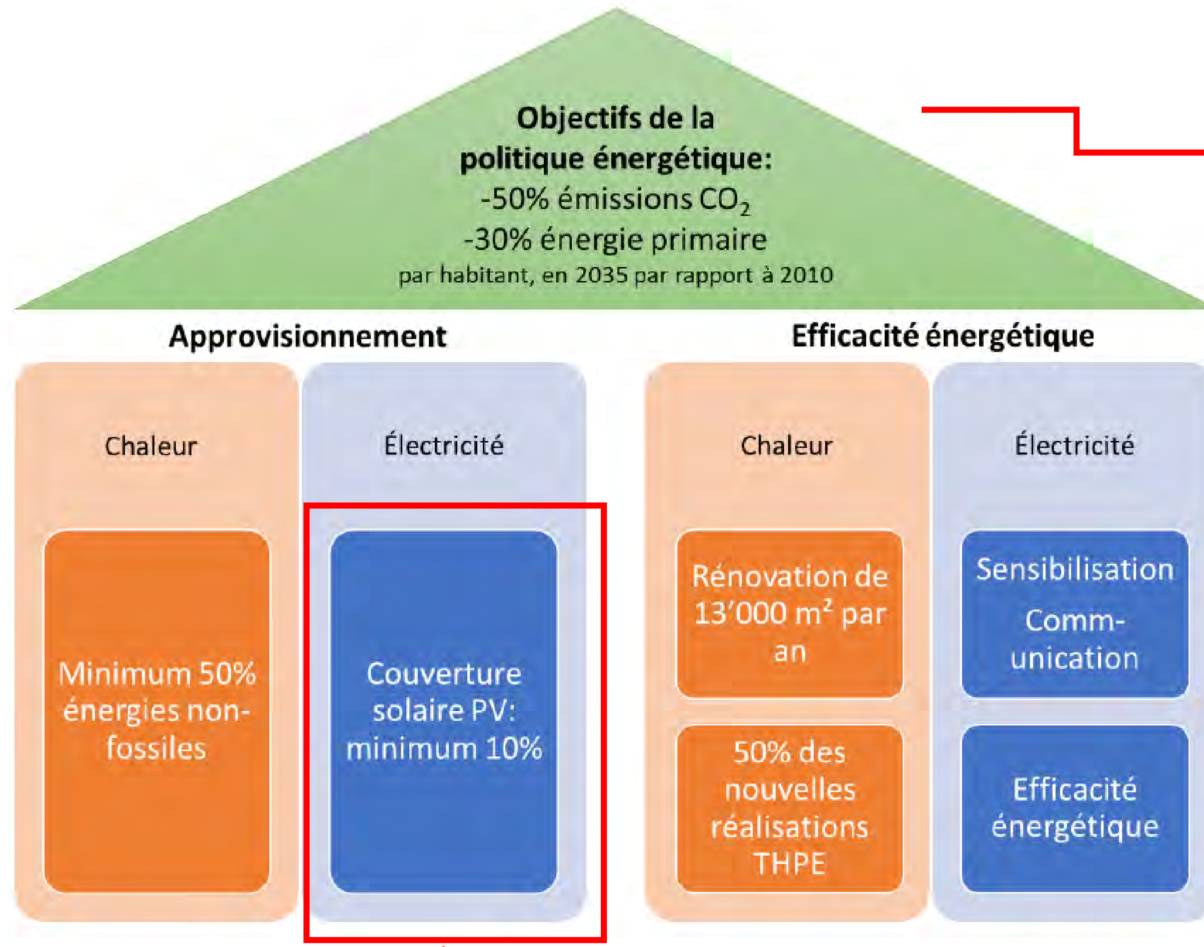
Swiss Federal Office of Energy

Conducted by:

AMSTEIN + WALTHERT

Background: Energy master plan of Bernex (2020)





Goals
(CO_2, supply, efficiency)

Supply of electricity consumption by at least 10% PV solar

=> speed up solar installations in the municipality
(targeting buildings with high potential)

Selection of best buildings for feasibility study

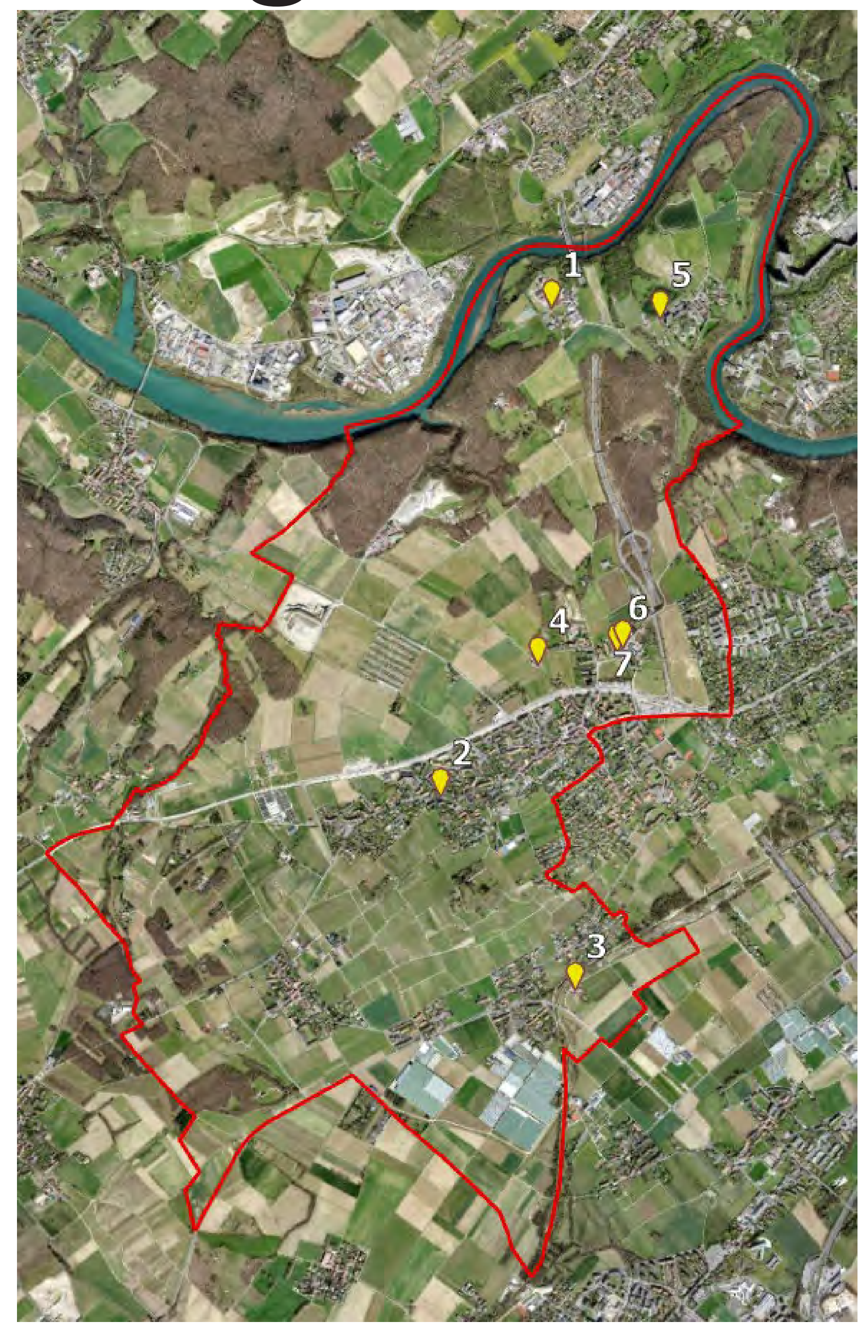
EGID	SUM_E_MO_	Epoqu_Cor	CO2_evite	Surf_Toit	CL_SI	ConsEl_kV	b_ElecPV_	b_ElecPV_	b_ConsPr	b_Autosu	b_TF	ADRESSE	%_Couv_T
1001941	363	1981-1985	155'484	3'407	4	433'666	198'558	164'721	55%	46%	6	Chemin de Saule 120	1.1%
295071893	290	1971-1980	124'099	2'290	10	233'428	101'616	188'336	35%	44%	6	(Châtillon)	1.9%
295040313	273	2001-2005	116'767	2'090	2	60'515	22'050	250'769	8%	36%	9	(Aigues Vertes)	2.7%
295094723	208	non connu	89'130	1'159	2	120'785	40'736	167'511	20%	34%	8	(Chemin des Rouettes 30)	3.3%
295097096	193	1981-1985	82'655	2'070	2	241'472	70'150	122'970	36%	29%	8	(Chemin des Blanchards 41)	3.9%
1001751	146	1961-1970	62'514	1'266	8	255'664	102'944	43'116	70%	40%	6	(Hôpital de Loëx)	4.3%
1001749	142	Avant 1919	60'743	1'253	8	255'664	101'911	40'012	72%	40%	6	(Hôpital de Loëx)	4.8%
1001744	142	1961-1970	60'570	1'297	8	255'200	101'688	39'831	72%	40%	6	(Hôpital de Loëx)	5.2%
2034500	130	1971-1980	55'432	1'075	9	28'883	13'904	115'609	11%	48%	10	Chemin des Suzettes 77	5.6%
295095262	124	non connu	52'957	1'188	4	70'448	37'949	85'782	31%	54%	8	(Route de Chancy)	5.5%
295078241	122	1961-1970	52'391	1'078	4	131'716	62'028	60'380	51%	47%	8	(Ecole de Lully)	5.9%
1001747	121	1919-1945	51'945	1'681	8	846'916	121'367	-	100%	14%	6	(Hôpital de Loëx)	6.3%
295101734	120	non connu	51'378	1'060	10	70'350	31'803	88'240	26%	45%	9	Route de l'Aire 111	6.6%
295094961	108	1946-1960	46'421	1'141	3	364'346	101'010	7'452	93%	28%	6	(Hôpital de Loëx)	6.9%
1001732	103	1986-1990	44'160	1'102	1	57'734	19'569	83'608	19%	34%	9	(Aigues Vertes)	7.2%
295111431	101	2006-2010	43'298	968	4	45'186	25'048	76'115	25%	55%	9	Chemin du Signal 19	7.5%
2034588	100	1971-1980	42'975	1'331	4	183'295	72'746	27'662	72%	40%	7	Route d'Aire-la-Ville 22	7.8%
295102688	100	1961-1970	42'862	939	4	61'710	32'904	67'241	33%	53%	9	(Ecole de Lully)	8.1%
295094953	99	non connu	42'244	834	10	74'772	32'843	65'858	33%	44%	8	(Chemin Lagnon)	8.4%
295093815	93	1961-1970	39'787	653	10	19'314	9'331	83'630	10%	48%	10	Route de Chancy 330	8.7%
295093816	93	1961-1970	39'712	652	10	60'568	27'098	65'687	29%	45%	9	(Chemin de Chante-Merle)	9.0%
295072931	85	1996-2000	36'345	680	10	71'422	30'885	54'033	36%	43%	10	(Chatillon)	9.2%
295100898	84	1971-1980	36'142	583	10	16'214	7'857	76'588	9%	48%	11	Chemin du Clos 15	9.5%
2034448	81	1961-1970	34'852	829	1	73'749	23'152	58'277	28%	31%	9	Rue de Bernex 390	9.7%
295009969	80	Avant 1919	34'415	605	10	174'616	59'072	21'337	73%	34%	8	Chemin des Cornaches 1	9.9%
1002521	79	1971-1980	33'922	1'022	11	133'394	39'427	39'831	50%	30%	9	Route de Soral 152	**10.2%**
295070695	77	non connu	33'088	814	10	81'874	33'791	43'518	44%	41%	8	(Chemin des Abarois 8)	10.4%
1001742	77	1981-1985	32'751	582	1	72'576	22'547	53'973	29%	31%	10	(Aigues Vertes)	10.6%
2034503	76	1986-1990	32'632	896	5	112'514	43'787	32'455	57%	39%	8	Route de Pré-Marais 26	10.9%
1001734	76	Avant 1919	32'349	568	1	45'084	15'148	60'433	20%	34%	10	(Aigues Vertes)	11.1%
1001738	70	1961-1970	30'074	569	1	34'240	11'783	58'485	17%	34%	12	(Aigues Vertes)	11.3%
2034446	70	1971-1980	30'041	568	9	170'806	55'427	14'763	79%	32%	7	Route du Merley 1	11.5%
295103984	70	1986-1990	29'752	670	10	104'300	39'309	30'204	57%	38%	9	(Aigues Vertes)	11.7%
295071750	68	1946-1960	29'228	521	10	11'398	5'555	62'735	8%	49%	12	Chemin de la Tuilière-Foëx 1	11.9%
1001775	66	1961-1970	28'201	656	8	624'660	65'889	-	100%	11%	7	Chemin du Stand 2	12.1%
295102683	63	non connu	27'123	459	10	3'830	1'924	61'449	3%	50%	12	Chemin de Sur-Beauvent 70	12.3%
295071665	62	1971-1980	26'471	597	8	216'379	60'744	1'105	98%	28%	8	(Rue de Bernex 340)	12.5%
1001733	58	1971-1980	25'022	545	1	41'210	13'542	44'920	23%	33%	11	(Aigues Vertes)	12.6%
295073641	58	1946-1960	24'698	737	9	42'098	18'586	39'119	32%	44%	11	(Route de Loëx)	12.8%
295009919	57	1946-1960	24'517	423	10	11'313	5'476	51'807	10%	48%	12	Route du Merley 46	13.0%
1002593	57	Avant 1919	24'514	780	2	13'003	4'732	52'544	8%	36%	11	Chemin des Curiades 4	13.1%
2034497	57	1986-1990	24'375	534	9	61'290	25'197	31'754	44%	41%	10	Route de Pré-Marais 58	13.3%
295071357	56	1961-1970	24'047	560	11	22'890	8'733	47'451	16%	38%	11	(Route dlAire-la-Ville 22)	13.5%
1001789	47	1961-1970	20'075	607	1	29'126	9'734	37'171	21%	33%	13	Chemin des Rouettes 27	13.6%
1002175	45	1971-1980	19'159	411	1	31'748	10'423	34'340	23%	33%	12	Bernex-en-Combes 12	13.8%
1001746	45	1961-1970	19'105	517	8	26'912	13'645	30'992	31%	51%	11	(Hôpital de Loëx)	13.9%
1002078	12	1971-1980	5'137	350	1	142'170	12'002	-	100%	8%	13	Rue de Bernex 248	13.9%
295071892	44	1971-1980	18'816	443	10	35'376	15'401	28'563	35%	44%	11		14.0%
295071662	44	1971-1980	18'728	407	8	75'855	30'641	13'116	70%	40%	9	Rue de Bernex 342	0.0%
295112230	44	2006-2010	18'689	709	10	72'563	26'621	17'045	61%	37%	9	Route de Soral 93	0.0%
295030021	43	2001-2005	18'565	357	1	32'413	10'554	32'822	24%	33%	12	Route de Pré-Marais 35	0.0%
1001903	43	1971-1980	18'552	667	1	35'366	11'338	32'009	26%	32%	11	Route du Merley 16	0.0%
1002072	42	1961-1970	18'103	357	1	26'536	8'857	33'439	21%	33%	12	Chemin Sous-le-T[illegible]t 26	0.0%

Ranking of buildings according to Solar cadaster

In green: best buildings covering 10% of municipal electricity demand

Contact and interviews with owners.

Feasibility solar study.



Studied buildings with potential:

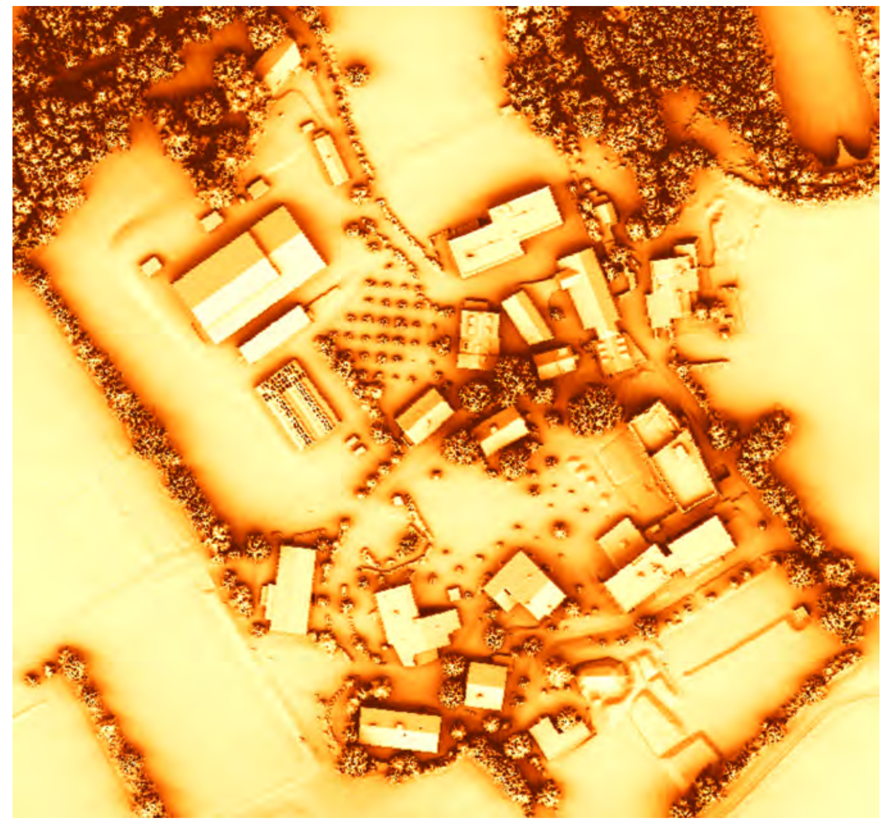
1. Hospital: 1000 kWp
2. Medical facility: 220 kWp
3. Farm: 34 kWp
4. Farm: 50 kWp
5. *Aigues Vertes*: 1000 kWp
6. Collective housing: 120 kWp
7. Collective housing: 30 kWp

Total municipal electricity demand potentially covered at this stage: 8.5%

on going process!

Application to *Aigues Vertes*

Foundation Aigues Vertes
Care center for people with disabilities
Village of 16 buildings



Extract from the Greater Geneva solar cadaster

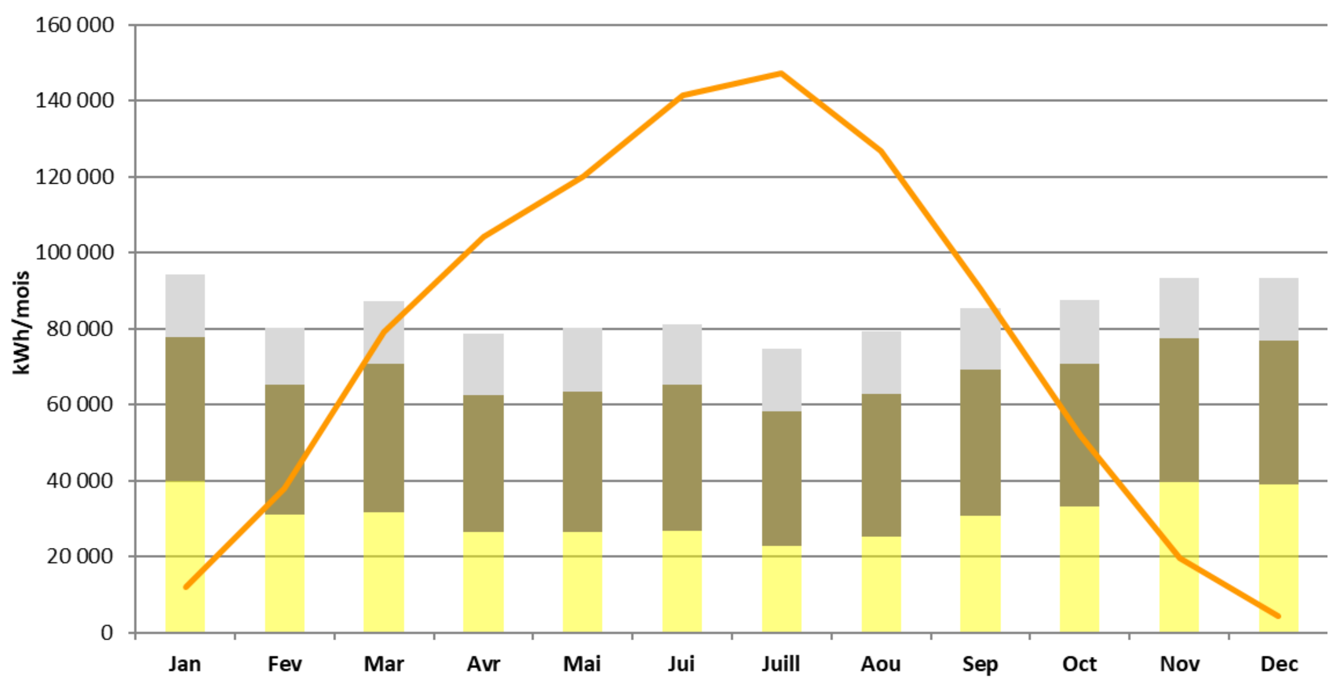
Electricity network
Medium voltage network
=> makes it easy to create a solar community

Roof surface analysis for solar installations

14 eligible roofs

Results

Monthly energy balance



Electricity consumption

- lighting
- devices
- technical installations

Solar electricity production

Result of the technical-economic study
(**case of solar community** for the entire site)

Installation data		Energy balance		Financial data	
Solar panel surface:		**Electricity consumption:**		**Investissement brut:**	
4'532	m^2	1'015	MWh/yr	910'430	CHF
Installed capacity:		**Selfconsumption rate:**		**Specific cost:**	
997	kWp	34%		913	CHF/kWp
Yearly production:		**Share injected into the grid:**		**Subsidies (Swiss + Commune):**	
935	MWh/yr	66%		274 940 + 20 000 = 294 940	CHF
Capacity by area:		**Self-sufficiency rate:**		**Annuel profit:**	
42	W/m^2 built area	31%		153'826	CHF/yr
109	W/m^2 ground area	**Share drawn from the grid:**		**ROI:**	
		69%		4.3	years

- ✓ Very high potential (~1 MWp)
- ✓ Medium-high selfconsumption rate (34%)
- ✓ Good return on investment: 4.3 years
- ✓ Economy of scale: ~900 CHF / kWp

Next steps toward concretization

- Decision pending by the Foundation Board to move towards a solar installation on the entire site
  - several small installations vs unique and global installation
- Support for the solar project process, steps:
  - In situ surveys, ability of the roofs
  - Confirmation of potential and detailed analysis
  - Call for tenders from installers, awarding of contracts
  - Realization and monitoring of performance

Building level including facade analysis

Meyrin Cité

Peripheral district of Geneva (close to the CERN)

Collective housing building neighborhood

Study funded by:

Hes·so Haute Ecole Spécialisée de Suisse occidentale

SIG

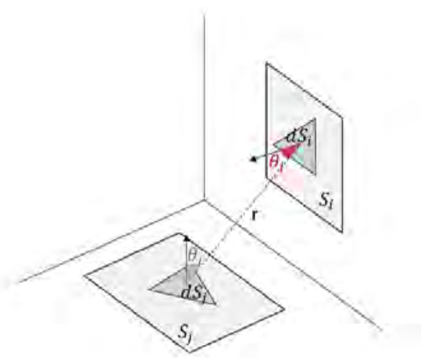
Conducted by:

hepia Haute école du paysage, d'ingénierie et d'architecture de Genève

HEIG VD

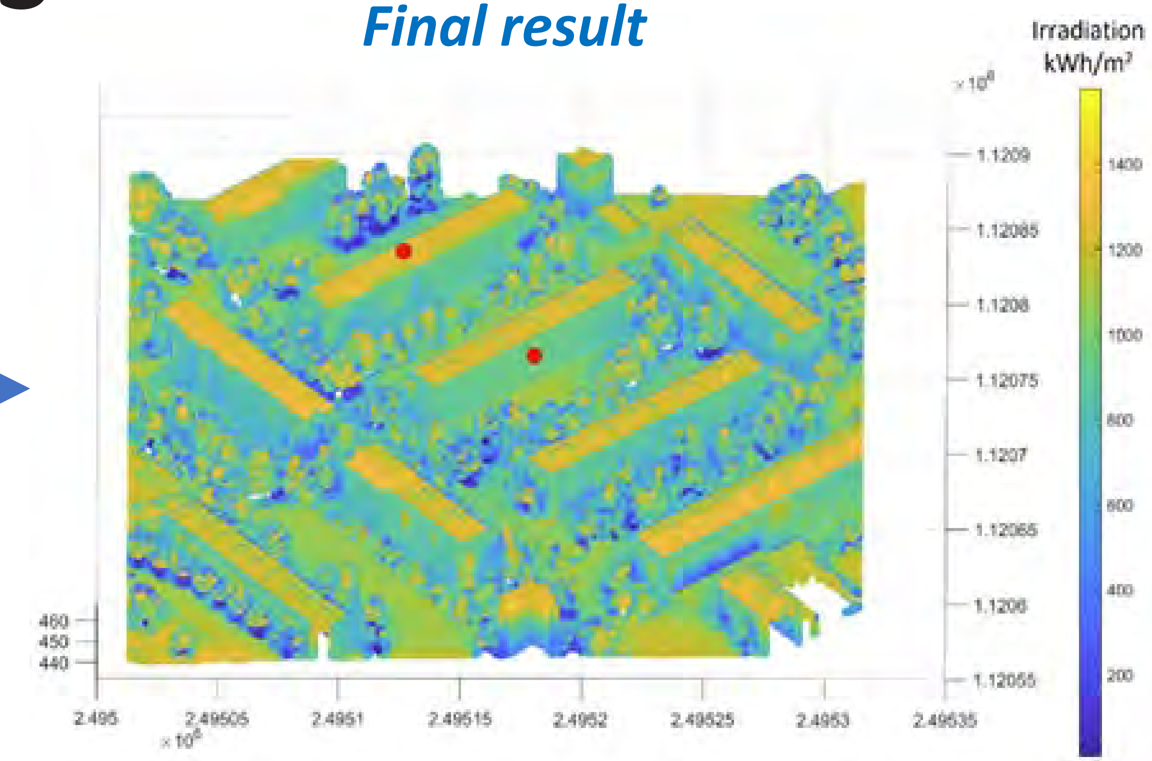
Workflow: radiation and windows detection

CadSol model: Beam + Diffuse

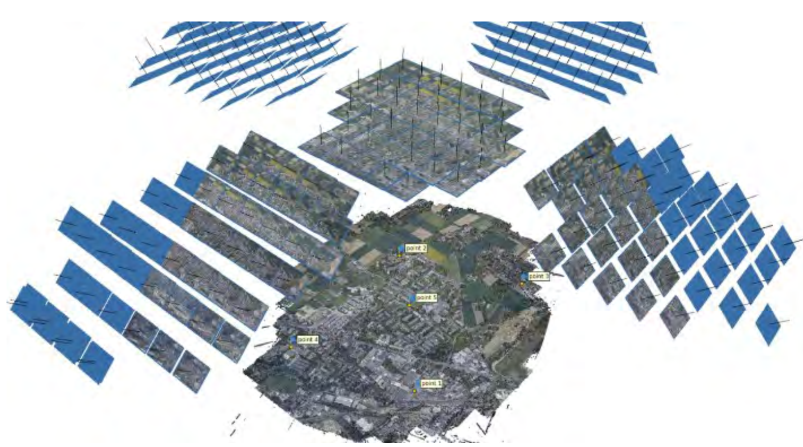


Radiosity: Reflection

Final result

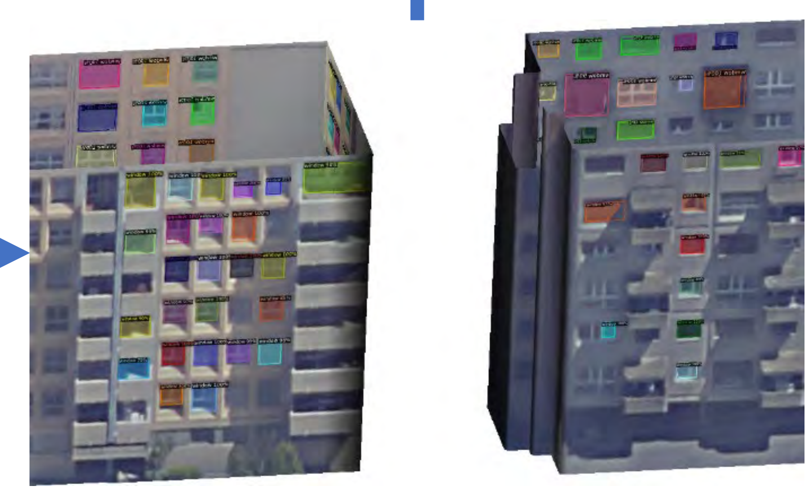


albedo



Oblique orthophotos processing with photogrammetry

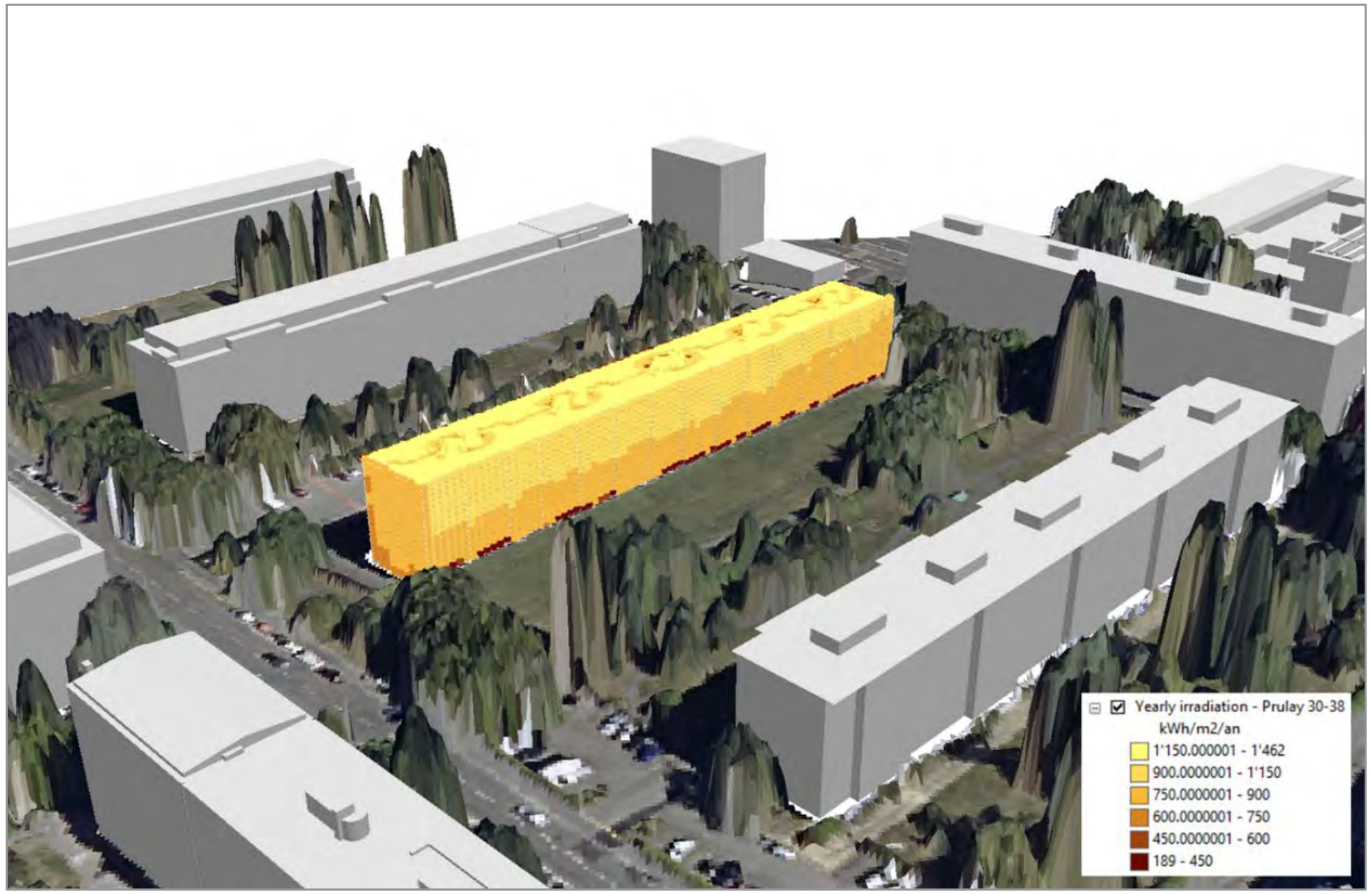
Digital twin



Automatic detection of windows using machine learning

Focus on a building groups

5 building entrances

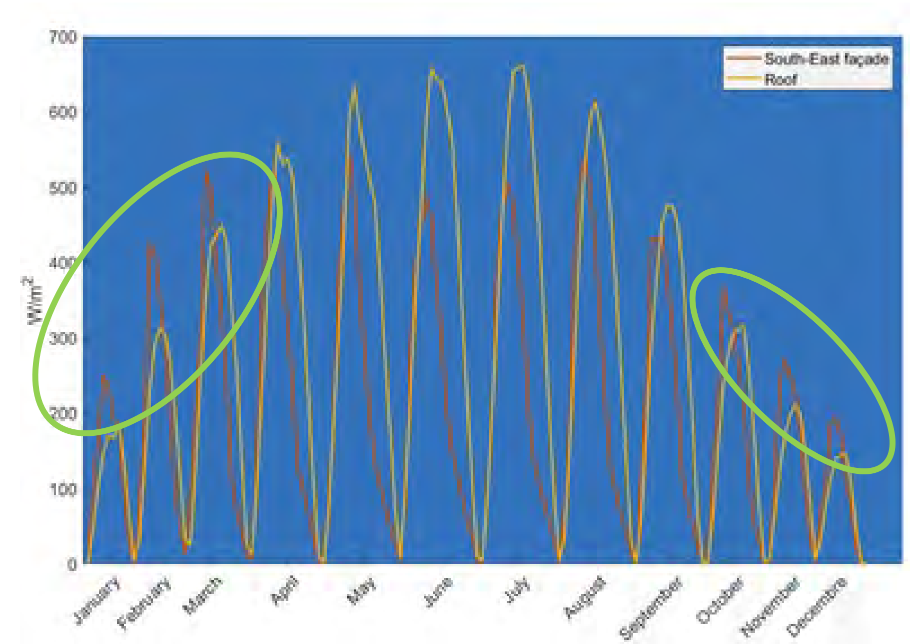


3D view: irradiation outputs, 3D building model, orthophoto

	ROOF	South-West FACADE	South-East FACADE
Total area (m^2)	2’128	206	1’445
Windows area (m^2)	-	5	850
Productive area (m^2)*	1’770	157	427

*irradiation > 800 kWh/m^2/yr & no window

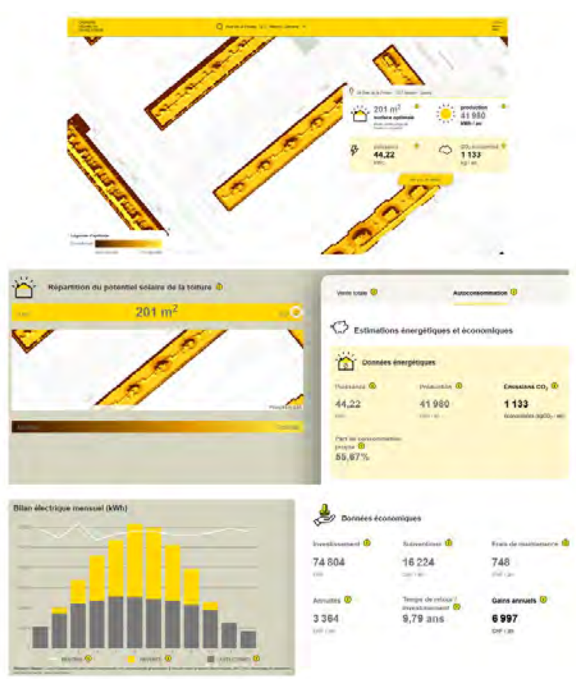
Surface balance



Irradiance facade > roof
October -> March

Monthly irradiation balance on roof and south facade

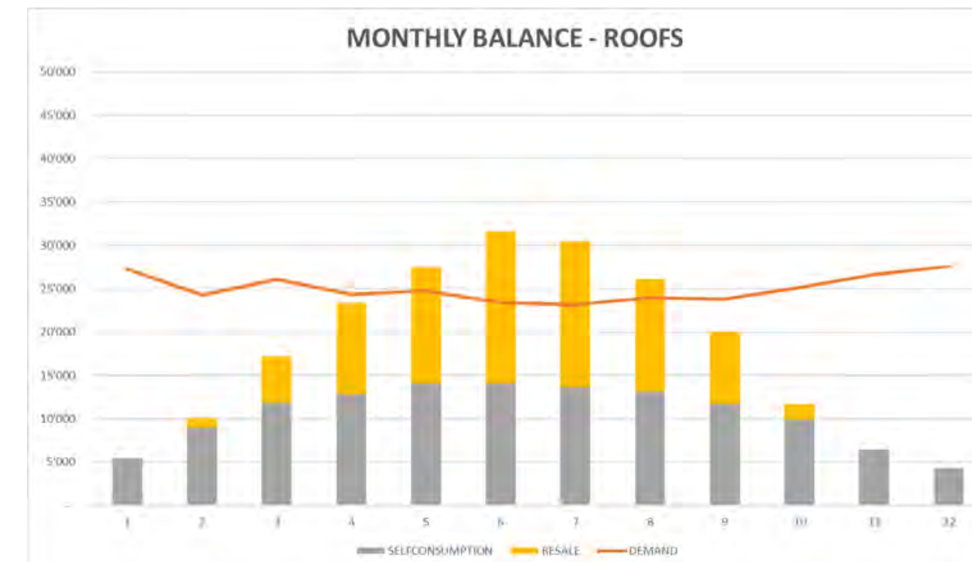
Energy balance with and without facade

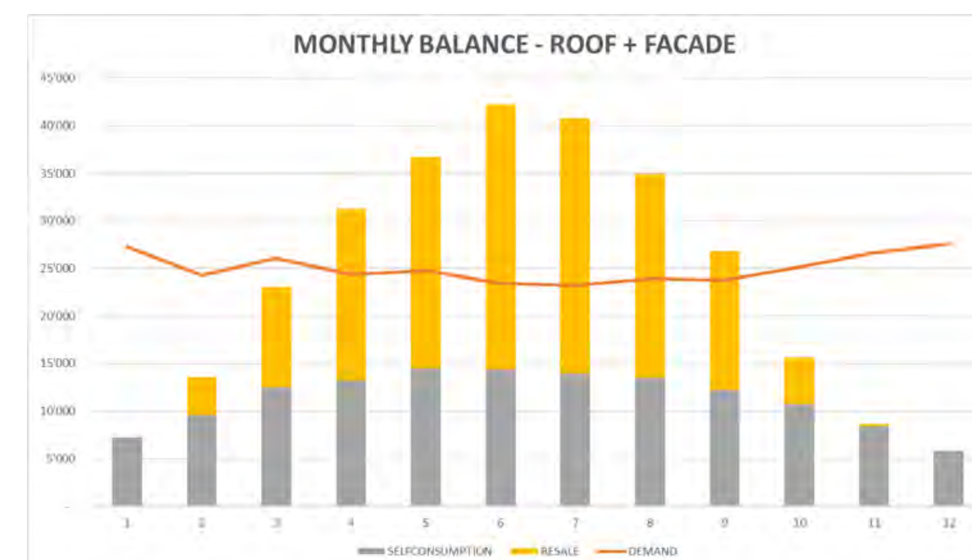


Solar Cadaster
+
Multi-building selection
Facade

	Unit	ROOF only	ROOF + FACADE
PV panels area	m2	1’025	1’592
Power	kWp	226	339
Production	kWh/yr	214'555	286’746
Self-consumption	%	59	47
Investment	CHF	290’438	410’282
Unit price	CHF/kWp	1’285	1’210
Subsidies	CHF	68’940	101’710
Yearly incomes	CHF/yr	23’872	27’110
ROI	yr	6.8	7.8

Contribution of the facades: +30% in kWh
Energy demand coverage in winter (Dec to Feb):
- 25% roof only
- 30% roof + facade





Thank you for your attention

for any question:

gilles.desthieux@hesge.ch

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

www.iea-shc.org

@IEASHC

IEA Solar Heating and Cooling Programme (group 4230381)

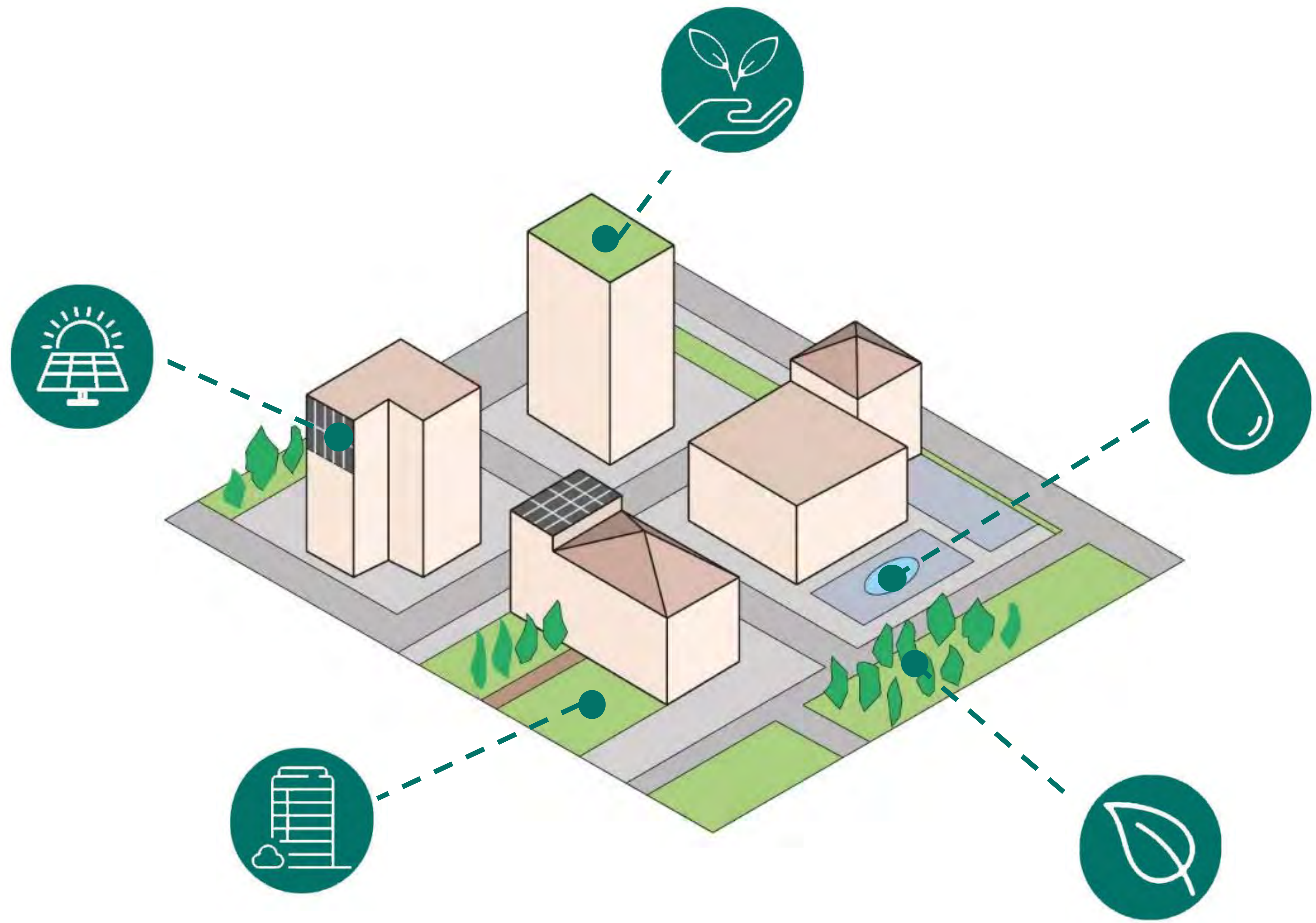
Sustainable and Climate Resilient Solar Neighborhoods
Silvia Croce

The presentation begins with a discussion of the use of urban surfaces in solar neighborhoods, which is followed by an introduction to a structured approach to support the definition of urban surface areas. This is followed by a case study in Bolzano, Italy, which investigates the application of this approach. The presentation concludes with a discussion about what can be learned from these examples and what future developments may hold.

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Sustainable and climate resilient Solar Neighborhoods

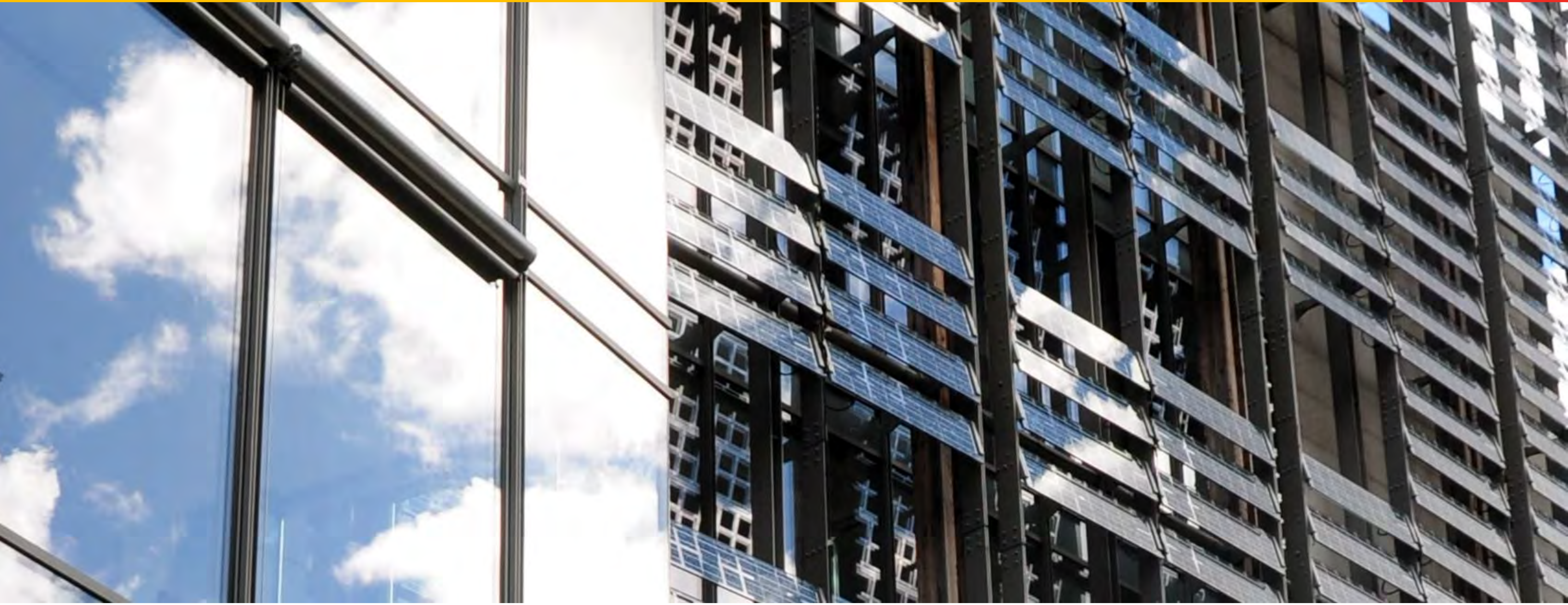
Silvia Croce, PhD – Institute for Renewable Energy, Eurac Research (Italy)
Seminar on Solar Neighborhoods, Calgary, 23 September 2022



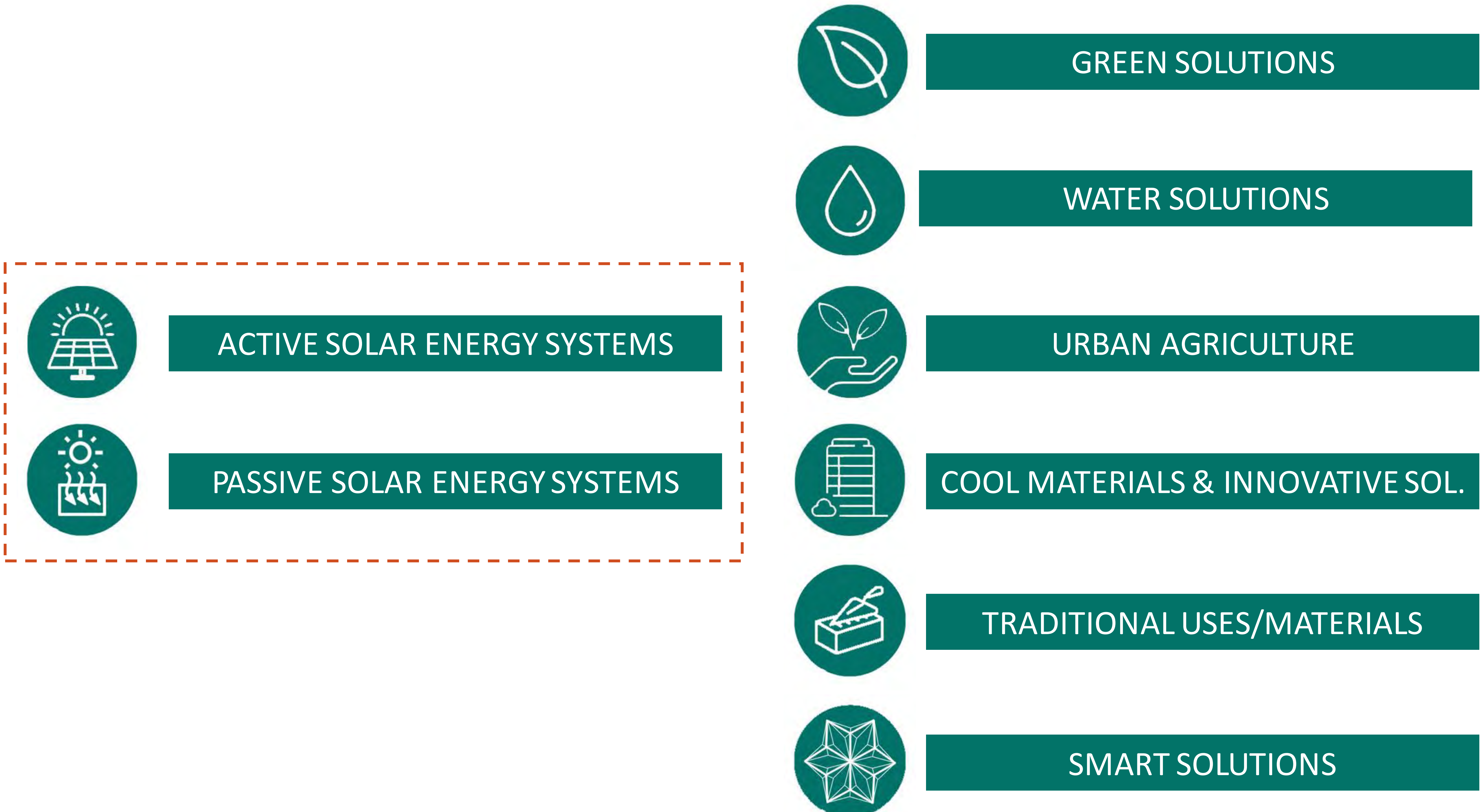
Outline

1. Urban surface uses in Solar Neighborhoods
2. A structured approach to support the definition of urban surface uses
3. Application to case studies in Bolzano (Italy)
4. Lessons learned & Future developments

Urban surface uses in Solar Neighborhoods

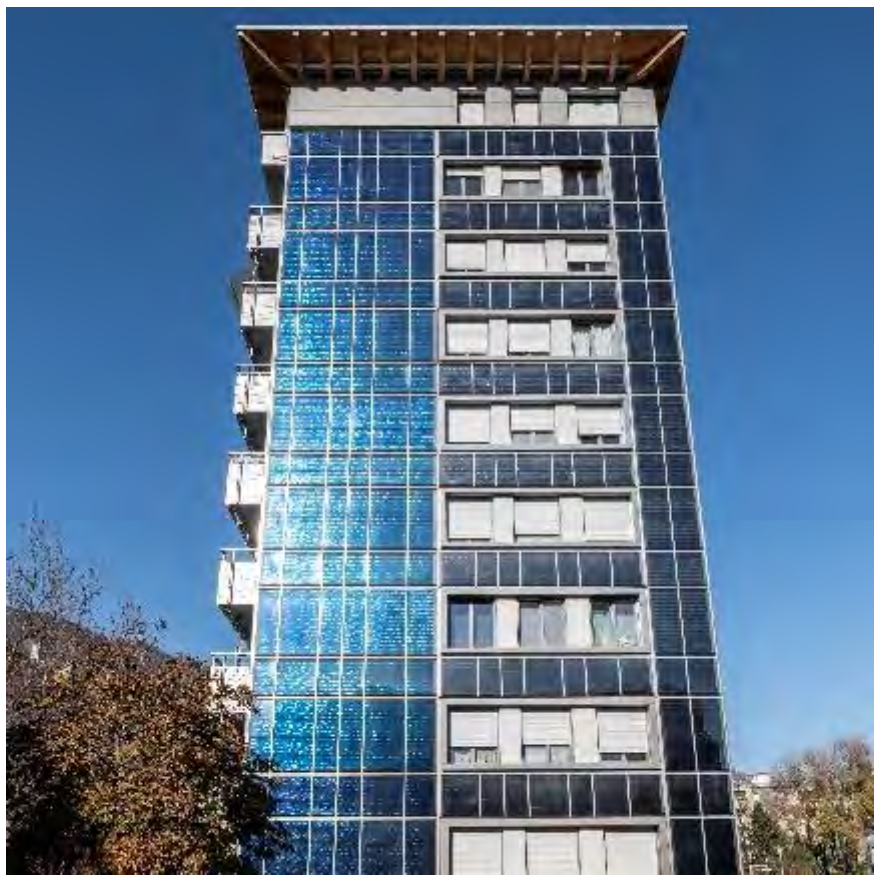


Urban surface uses in Solar Neighborhoods



Urban surface uses

Active solar energy systems



Energy systems for the building envelope

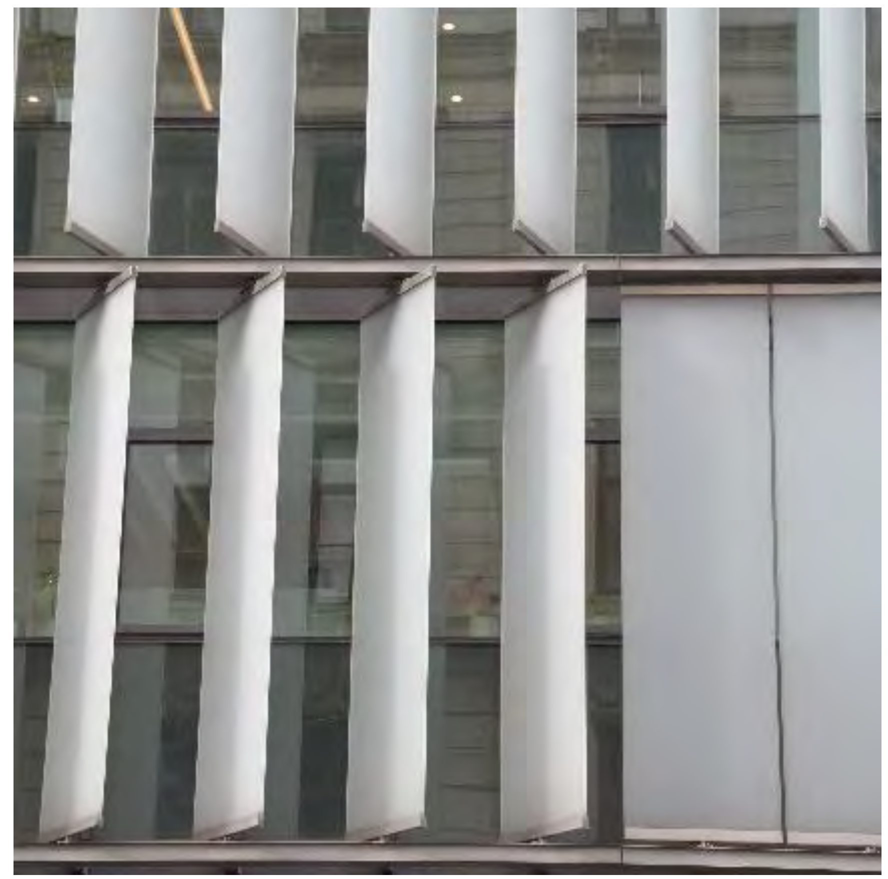
Energy systems for the ground surfaces

Energy systems for urban features

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Urban surface uses
Passive solar energy systems

Passive solar heating



Passive solar cooling

Daylight control

Urban surface uses

Green solutions

Vegetation on ground

Green building solutions

Innovative technological solutions

Urban surface uses
Water solutions

Water bodies

Evaporative techniques

Water squares

Urban surface uses
Urban agriculture

Ground-based agriculture

Building-integrated agriculture

Other forms

Urban surface uses

Cool materials & Innovative solutions

Highly reflective and emissive materials

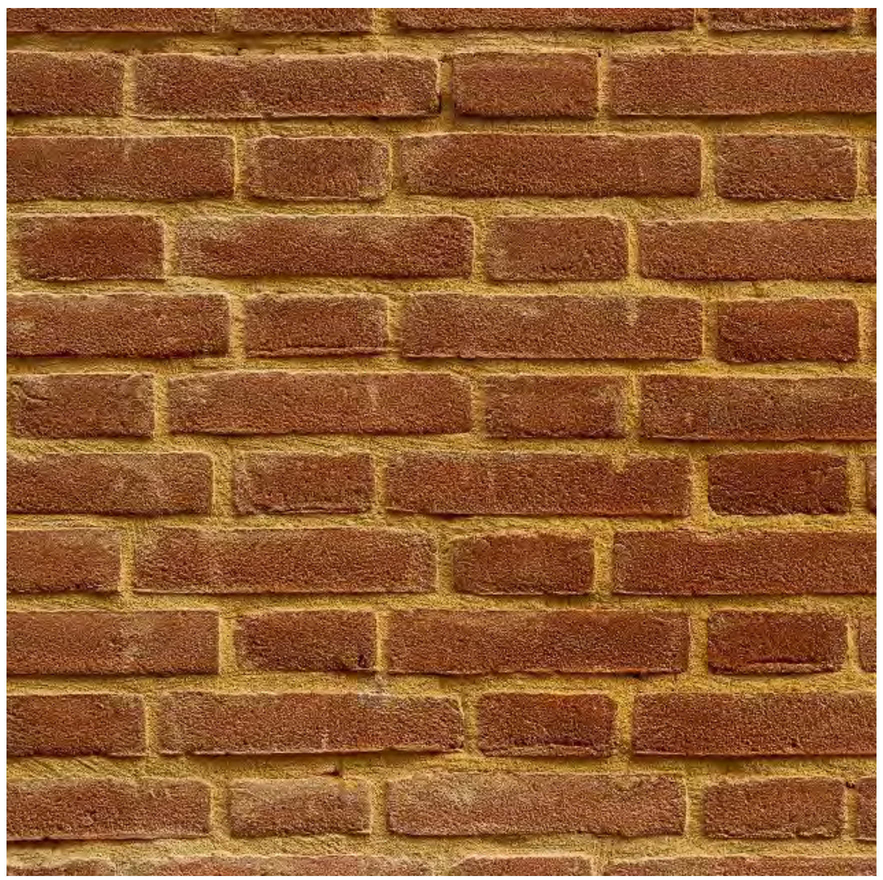
Innovative materials with combined properties

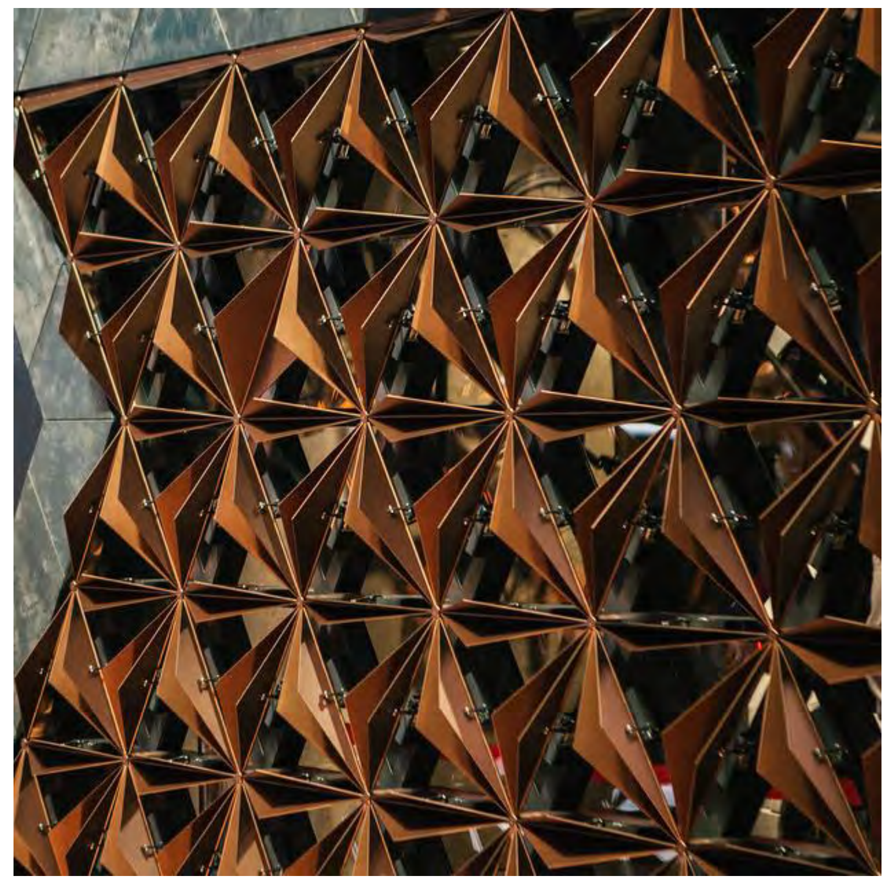
Evaporative surfaces

Urban surface uses

Traditional uses

Smart solutions





Kinetic / Responsive surfaces

Animation and illumination technologies

Potential synergies

Solar active energy systems integrated to other solutions

Bio-solar roofs

Multifunctional facades

Productive facades

Urban surface uses: which benefits?

The urban surfaces are a key resource to tackle issues related to urbanization and the correlated effects of climate change

SUSTAINABILITY

Renewable energy production

Fresh-water availability

Food provision

CLIMATE RESILIENCE

Urban climate management

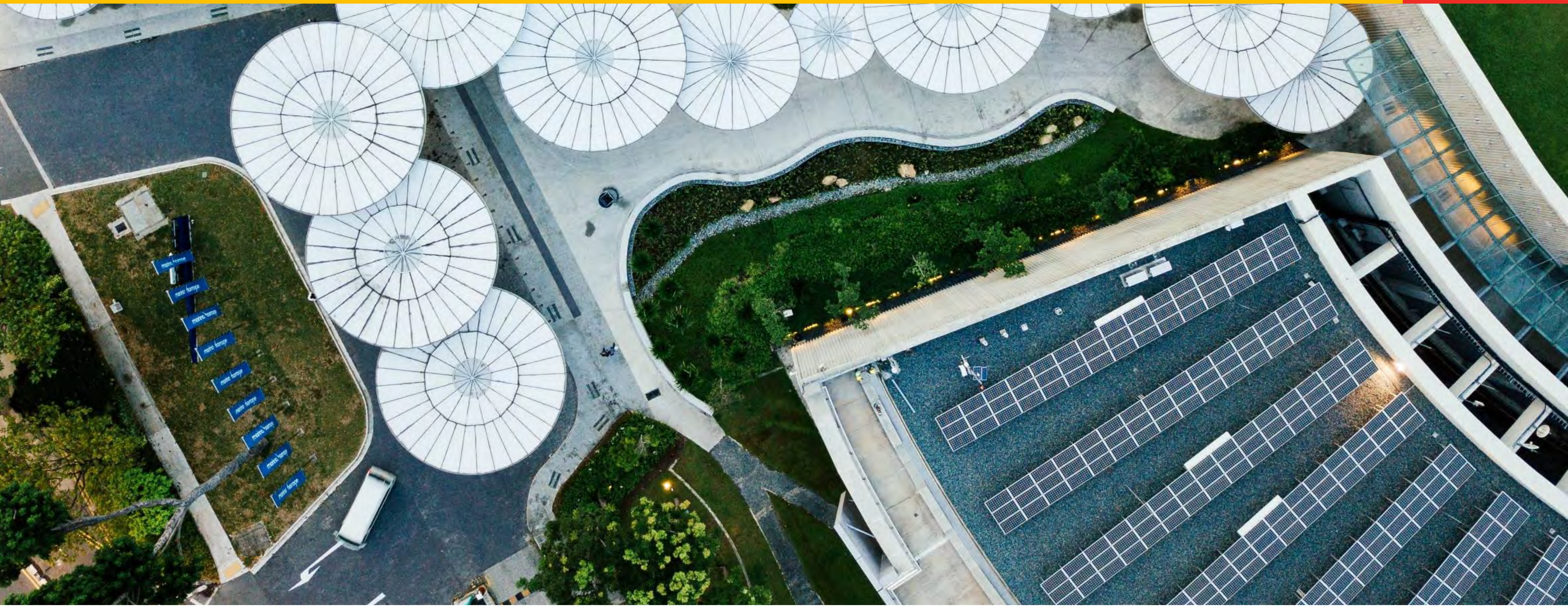
Habitats & biodiversity preservation

Water management

Air quality amelioration


SHC
Surface Uses in Solar Neighborhoods
Definition of the most suitable surface uses to prevent conflicts and create synergies
IEA SHC TASK 63 | SOLAR NEIGHBORHOOD PLANNING
Technology Collaboration Programme
ST / BIST
WINDOWS / GLAZED WALLS & ROOFS
4.3 Passive solar energy systems

A structured approach to support the definition of urban surface uses



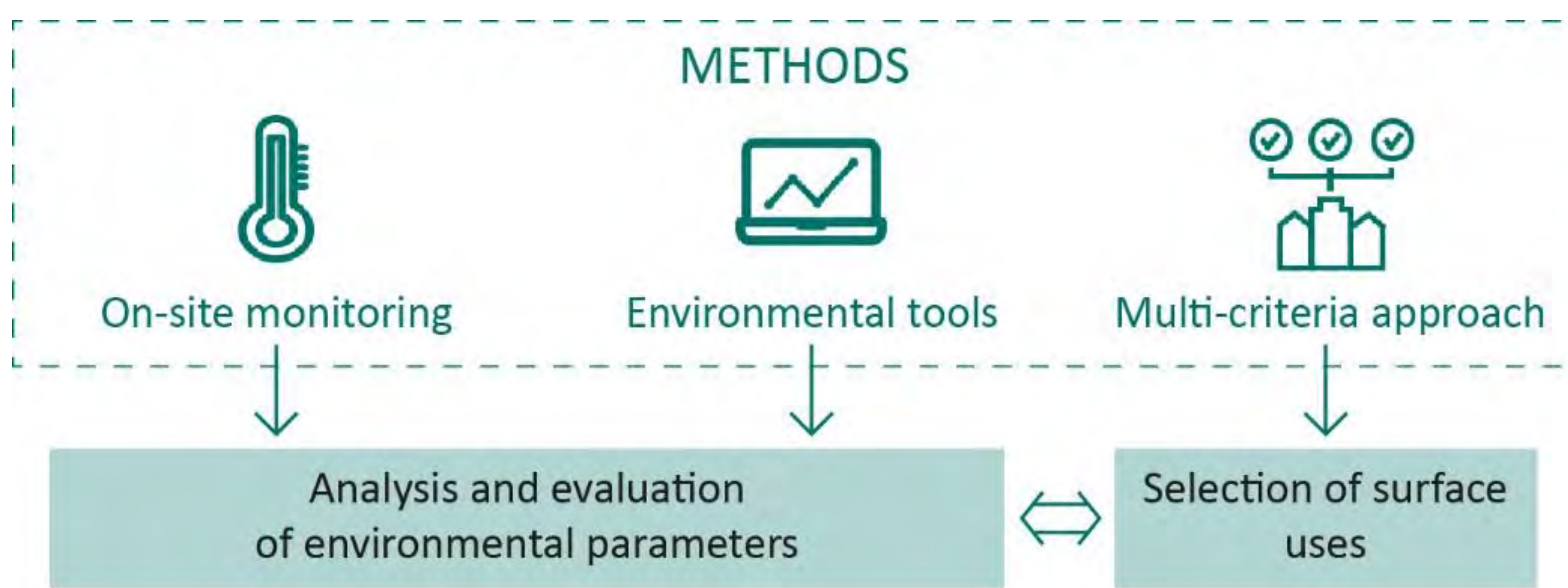
A structured approach to support the definition of urban surface uses

Common approaches to urban surfaces use:

- **Sectorial** → focused on single solutions and on pursuing single objectives
- **Bi-dimensional** → disregarding the three-dimensional complexity of the built environment

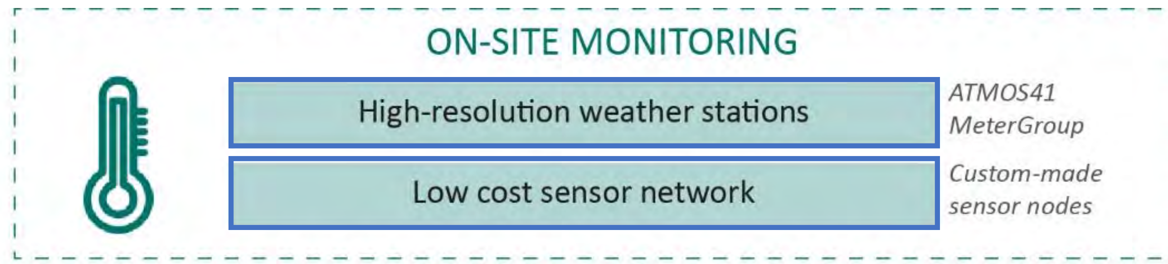
A **structured approach to support urban planners and municipal decision makers** in the definition of urban surface use patterns is developed and tested.

The proposed workflow addresses the **design of urban surface** uses by means of both **quantitative and qualitative data**, taking into consideration the **complex and multi-disciplinary nature of the problem**.



A structured approach to support the definition of urban surface uses

On-site monitoring



High-resolution weather stations

Low-cost sensor nodes

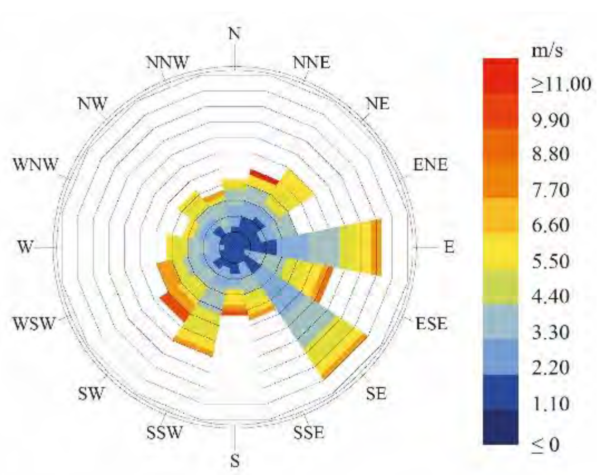
A structured approach to support the definition of urban surface uses

Environmental tools

ENVIRONMENTAL TOOLS

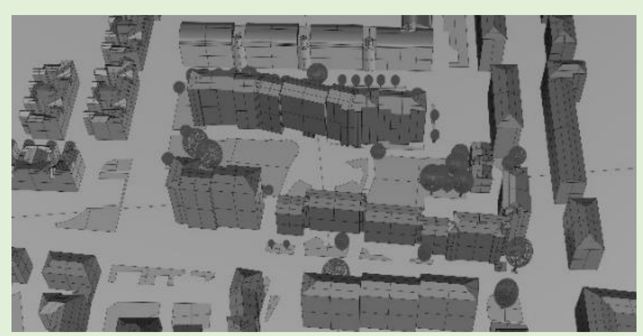
Local climate conditions characterization	*Climate consultant* *Ladybug for GH*
Microclimate analyses	*ENVImet* *Dragonfly for GH*
Solar analyses	*DIVA for Rhino*

City scale



Ladybug for GH
Weather data

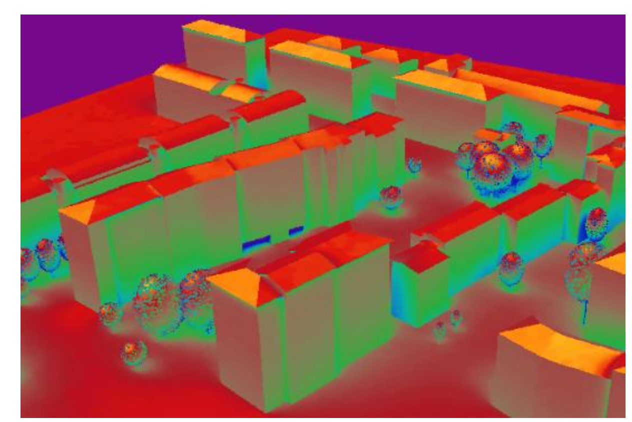
3D + Parametric Modelling



Rhinoceros +
Grasshopper

District scale

Solar Analyses



DIVA for Rhino
Honeybee

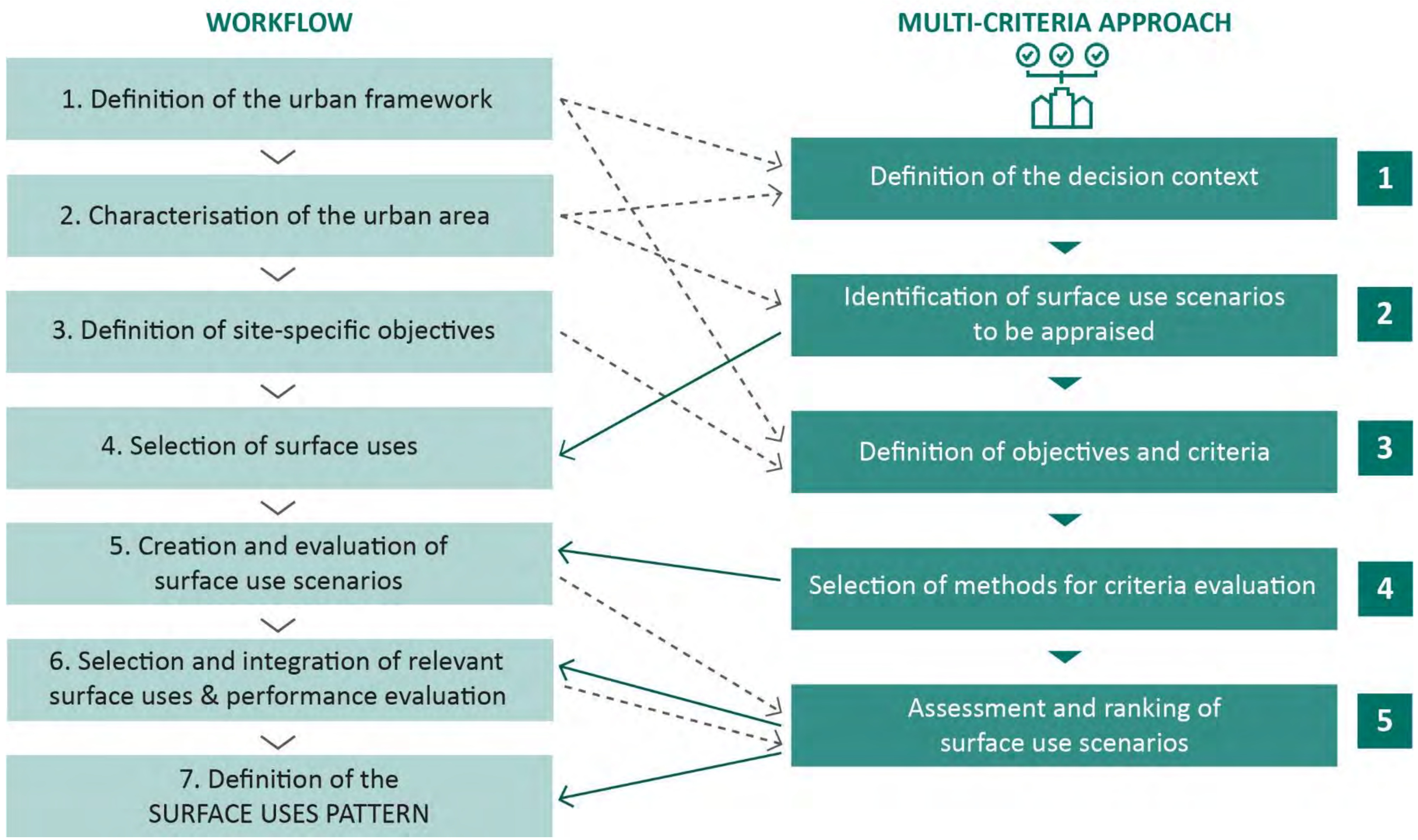
Microclimate Analyses

ENVImet
Grasshopper workflow

A structured approach to support the definition of urban surface uses

Multi-criteria approach

Decisions on the use of urban surfaces require a method able to include **various, often conflicting decision factors**, as well as to consider the **preferences of the stakeholders**.



Application to case studies in Bolzano (Italy)

Case studies in Bolzano

Via Brescia-Palermo

Residential area

Bolzano South

Industrial mixed-use area

Sinfonia

Sinfonia in Bolzano: major actions

The European project SINFONIA is a **six-year initiative** to **deploy large-scale**, **integrated** and **scalable energy solutions** in mid-sized European cities, which reached its finish in June 2020.

1

Credits: Alperia

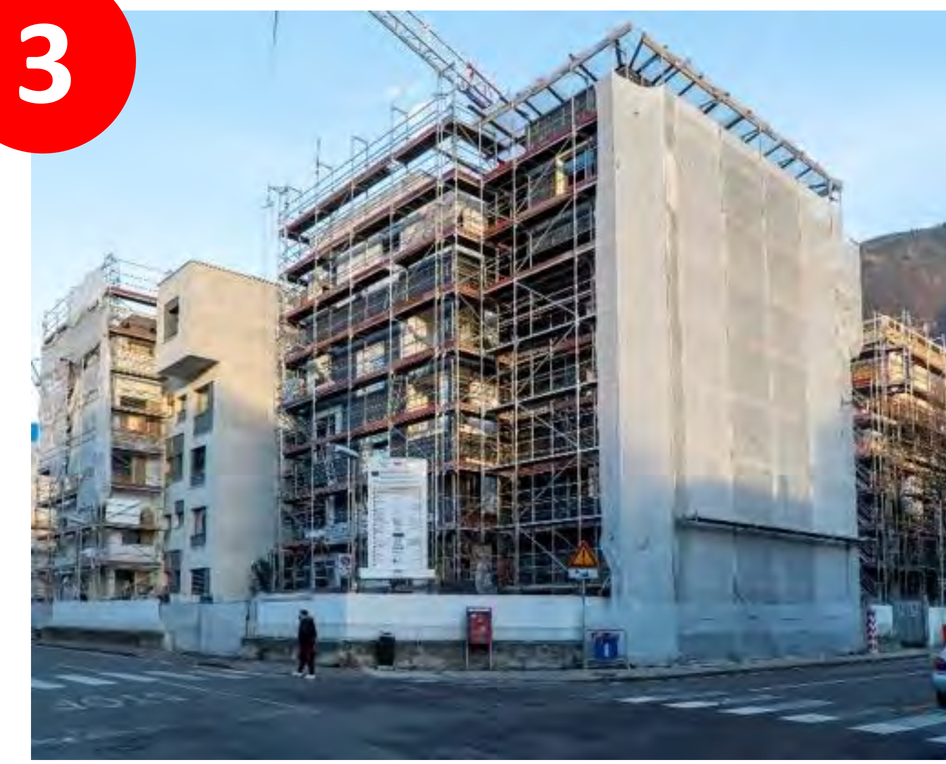
Enhancement of district heating system: extension and optimization

2

Credits: Comune di Bolzano

Infrastructure for mobility and services: sensors, smart points and interactive totems

3



Credits: Eurac Research

Large scale refurbishment of social housing: 5 building complexes, > 40.000 m^2

Application of the methodology to the case study

Bolzano

Geography and local climate conditions

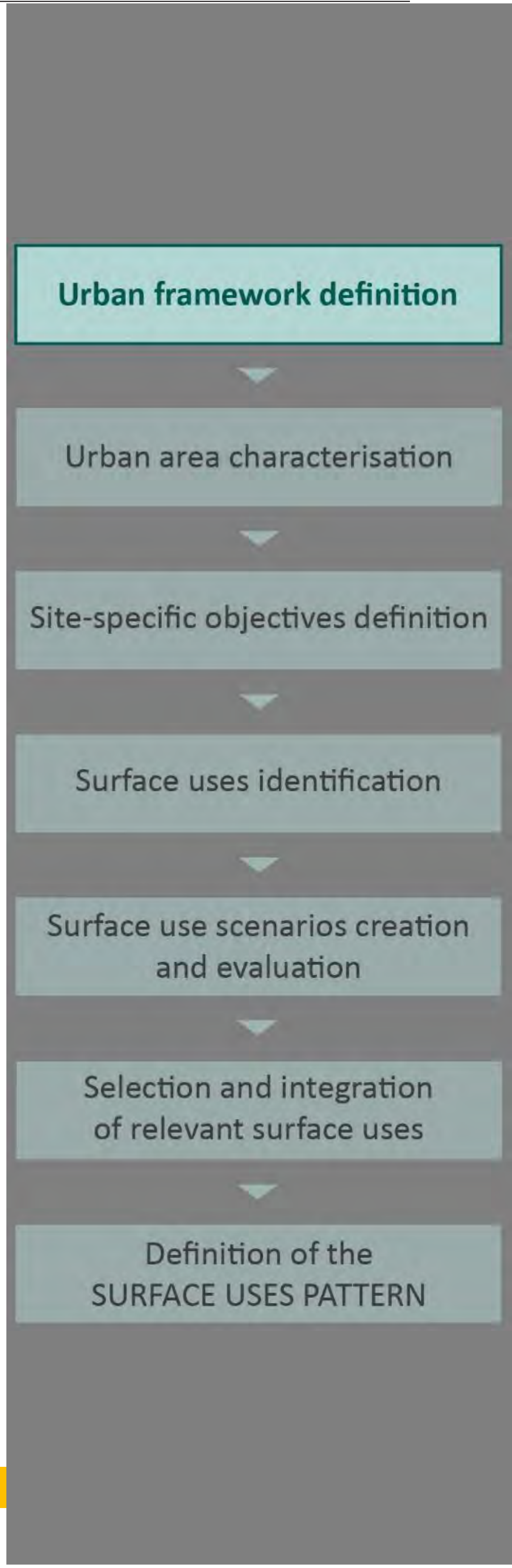
- Increase in the mean annual air temperature
- Summer heatwaves
- Urban Heat Island
- Intense precipitation phenomena → flooding

Urban governance and planning

- Sustainable Energy and Climate Action Plan (2020)
- Building Impact Reduction Index (RIE)

↓

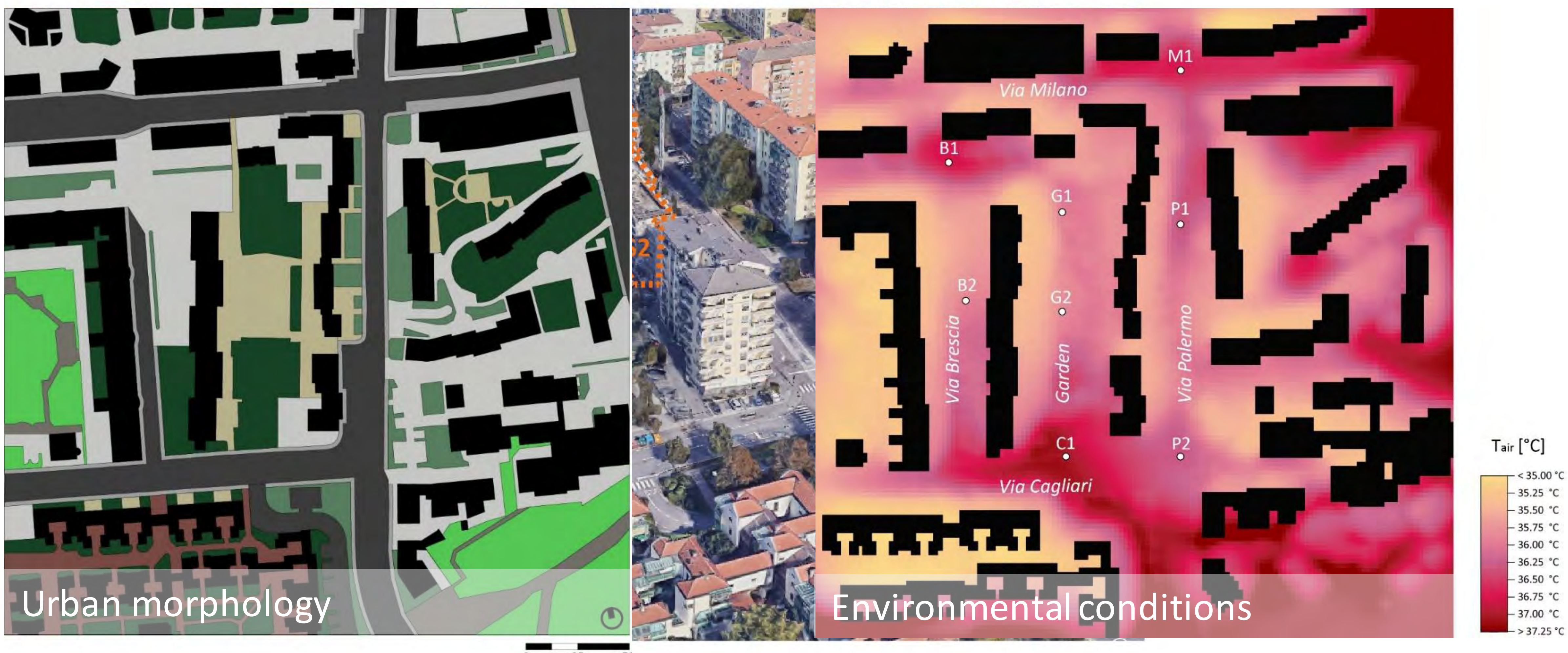
Citi-scale objectives



Urban area characterisation

Via Brescia-Palermo is one of the five **residential areas** in Bolzano involved in the Smart Cities European project Sinfonia.

The district includes two social housing building blocks refurbished in the Sinfonia framework, and the nearby residential buildings



Air temperature distribution at 1 m a.g.l. at 15:00

Urban framework definition

Urban area characterisation

Site-specific objectives definition

Surface uses identification

Surface use scenarios creation and evaluation

Selection and integration of relevant surface uses

Definition of the SURFACE USES PATTERN

Site-specific objectives

Resulting from:
- City-specific objectives
- Results of urban area characterisation
- SINFONIA project

GENERAL OBJECTIVES		*SITE-SPECIFIC OBJECTIVES*
PRIMARY OBJECTIVES		
Urban climate regulation	1	Reduce summer overheating and UHI Improve human thermal comfort conditions
Habitats and biodiversity preservation	2	Preserve the vegetated areas and increase their surface
Energy self-reliance	3	Produce renewable energy by active systems
SECONDARY OBJECTIVES		
Urban water management	4	Increase the share of permeable surfaces to reduce floods
Air quality amelioration	5	Reduce pollutants and ghg emissions

- Urban framework definition
- Urban area characterisation
- **Site-specific objectives definition**
- Surface uses identification
- Surface use scenarios creation and evaluation
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- Definition of the SURFACE USES PATTERN

Surface uses identification

Based on the morphological and environmental characterisation, and the site-specific objectives, **four different scenarios of surface use have been identified and tested**.

- Green scenario
- Water scenario
- Cool scenario
- Energy systems scenario

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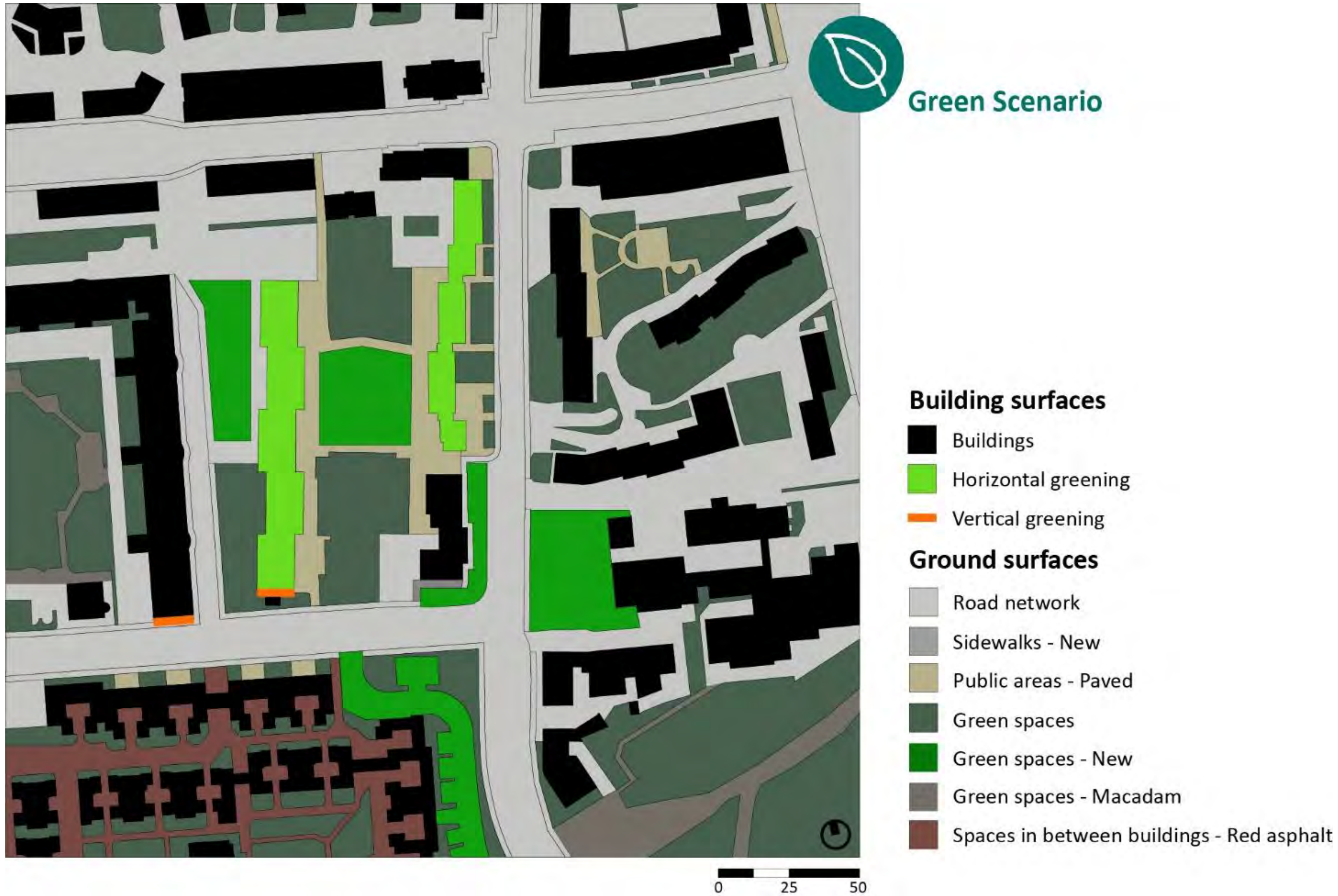
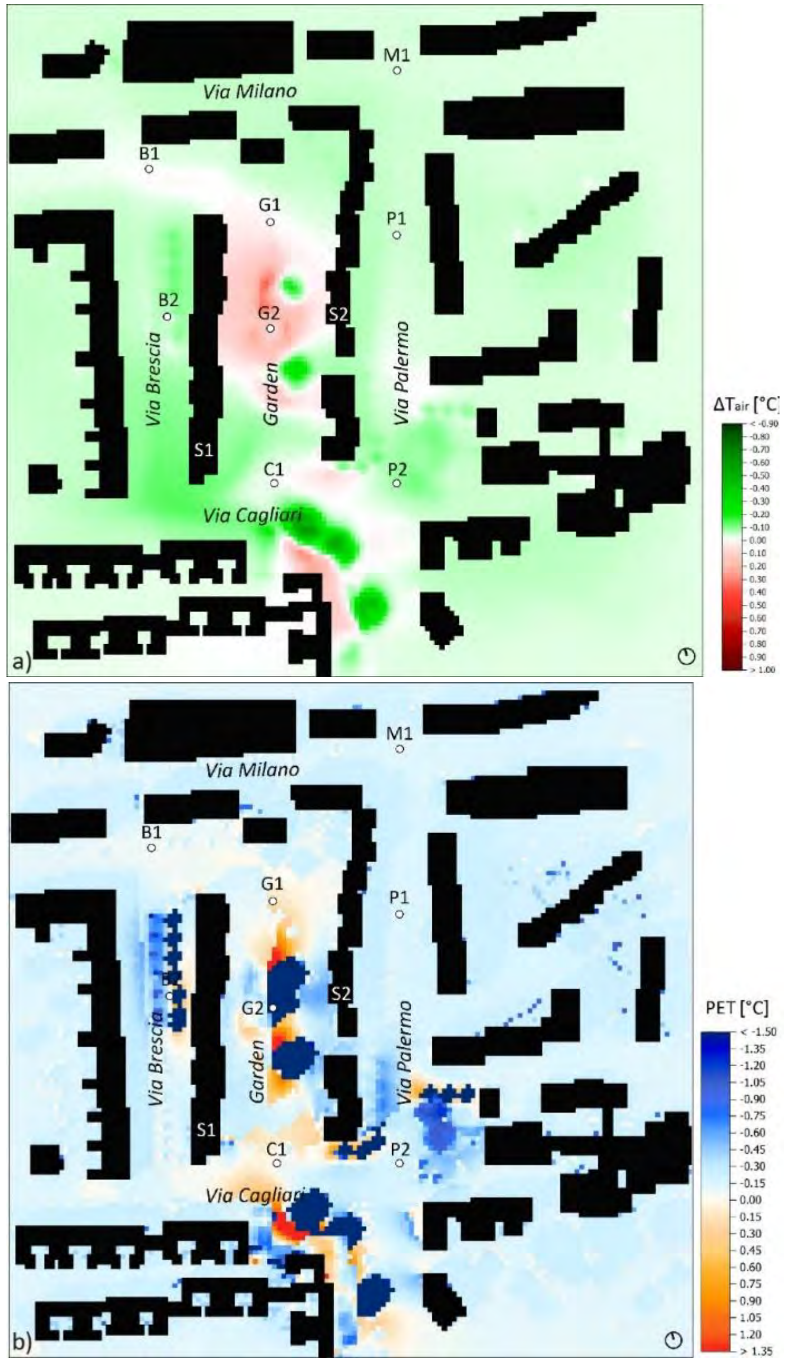
Definition of the SURFACE USES PATTERN

Surface use scenarios: Green



ΔT_{air} = - 0.10 °C
In Garden: increase up to + 0.30 °C
+ 7% vegetated fraction



Air temperature and PET distribution at 1 m a.g.l.
Absolute difference between Baseline and simulated scenario

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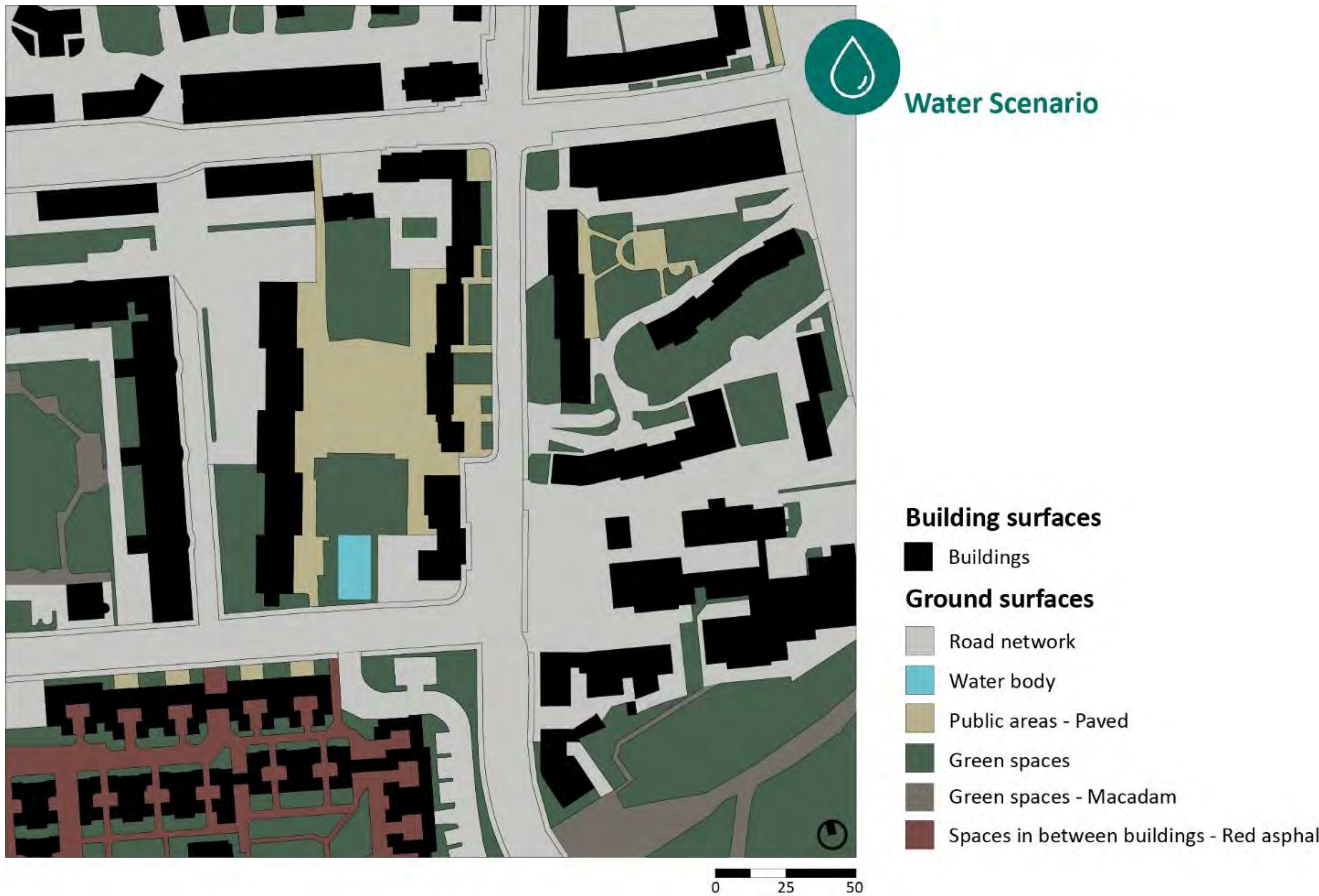
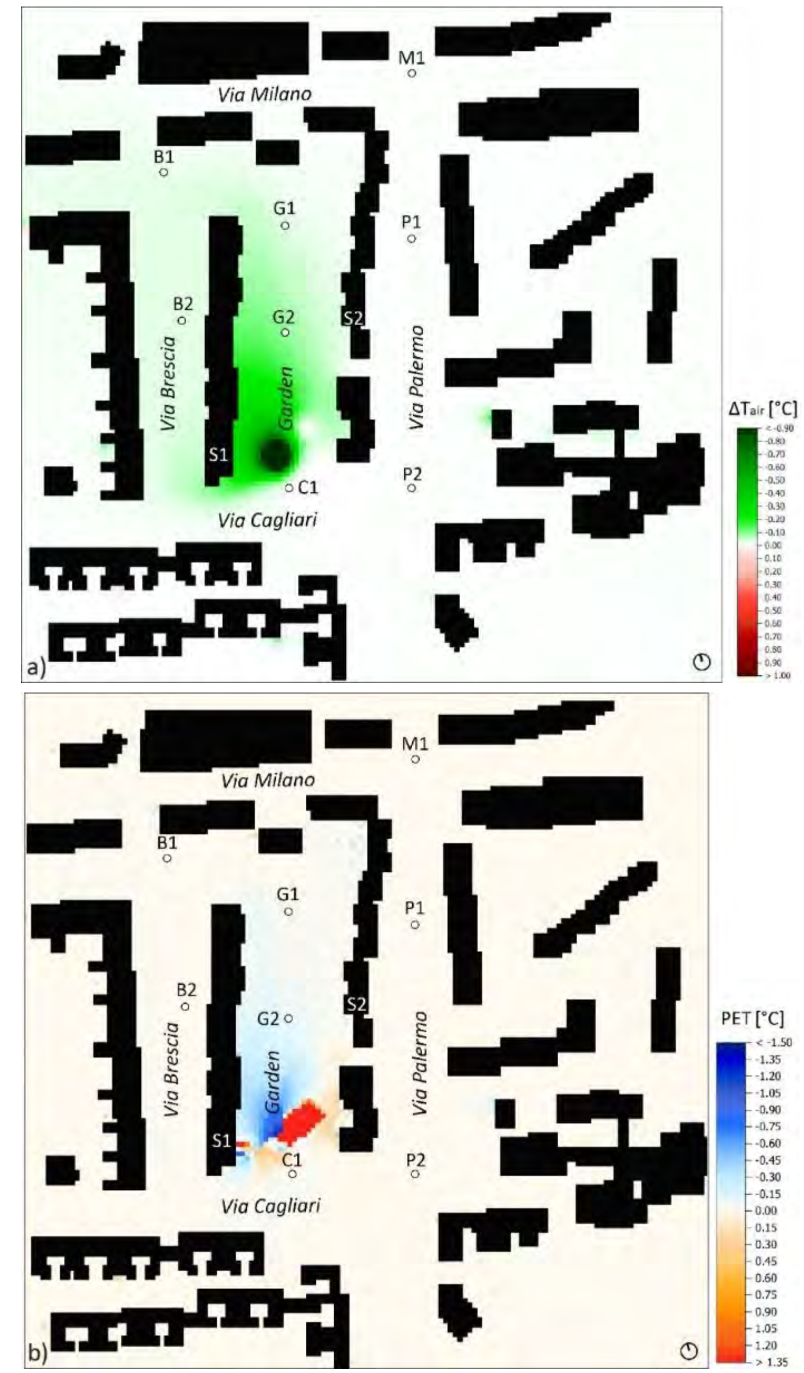
Definition of the SURFACE USES PATTERN

Surface use scenarios: Water



ΔT_{air} = - 1.0 °C limited to the proximity to water body
In the district, ΔT_{air} = - 0.07 °C (negligible)



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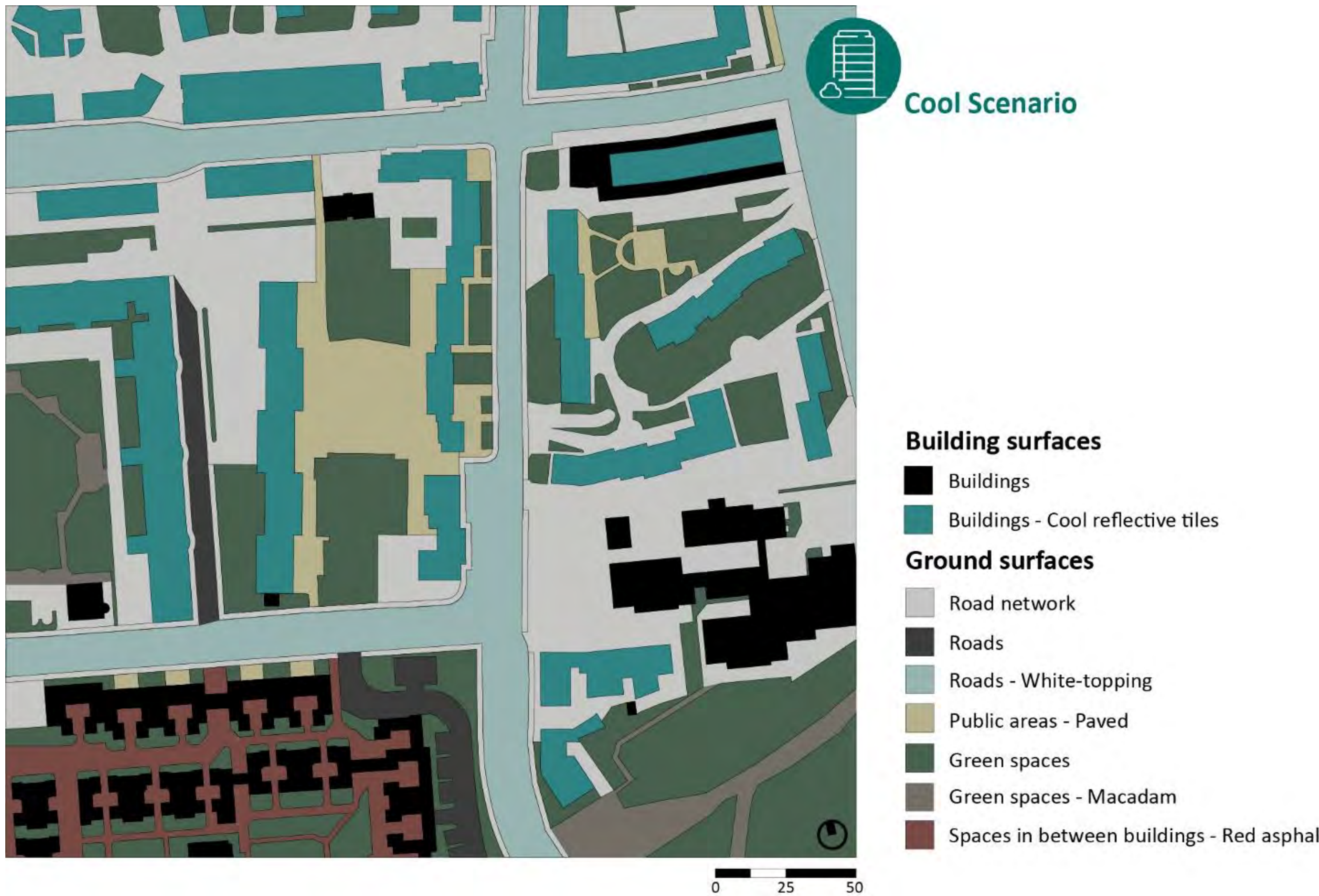
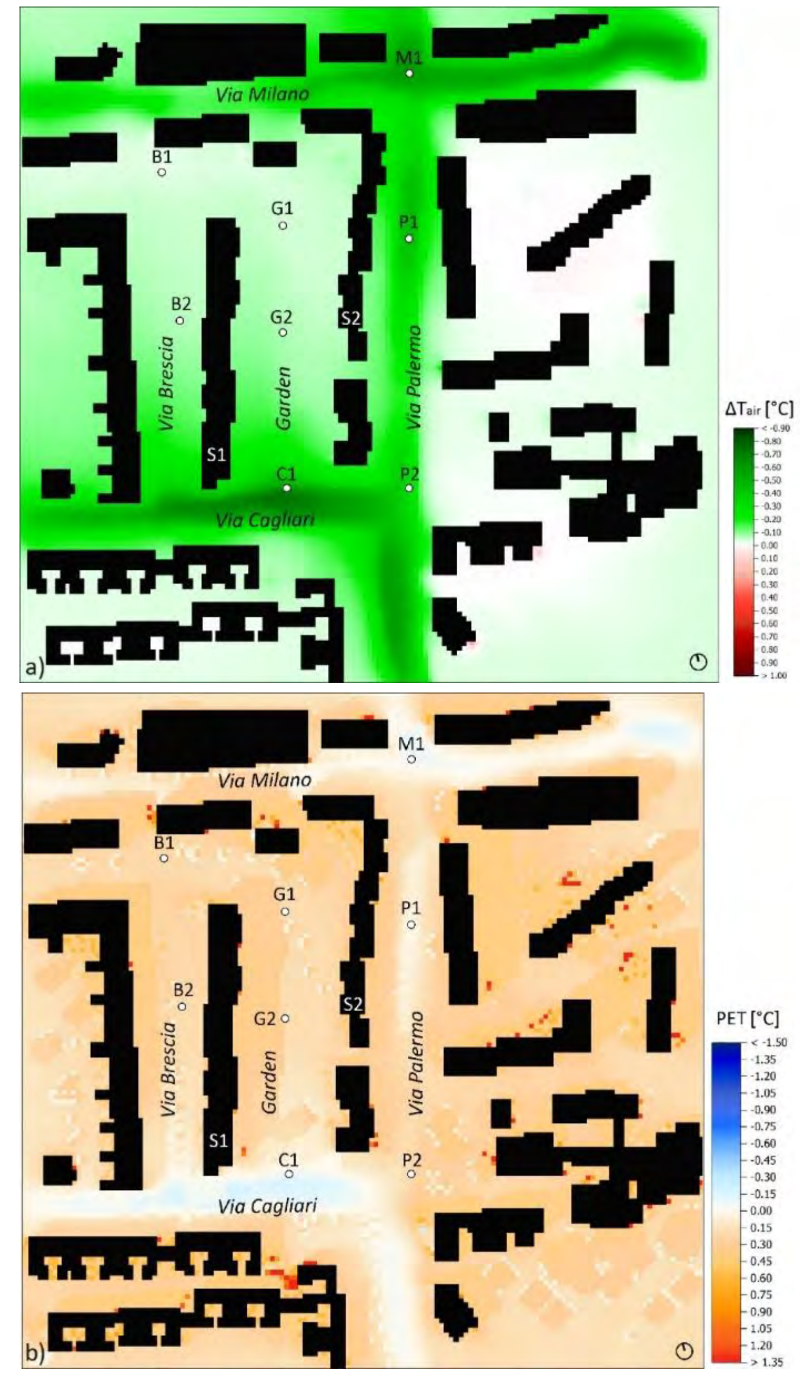
Surface use scenarios: Cool



ΔT_{air} = - 0.15 °C
Δ PET = + 0.04 °C (negligible increase)



Air temperature and PET distribution at 1 m a.g.l.
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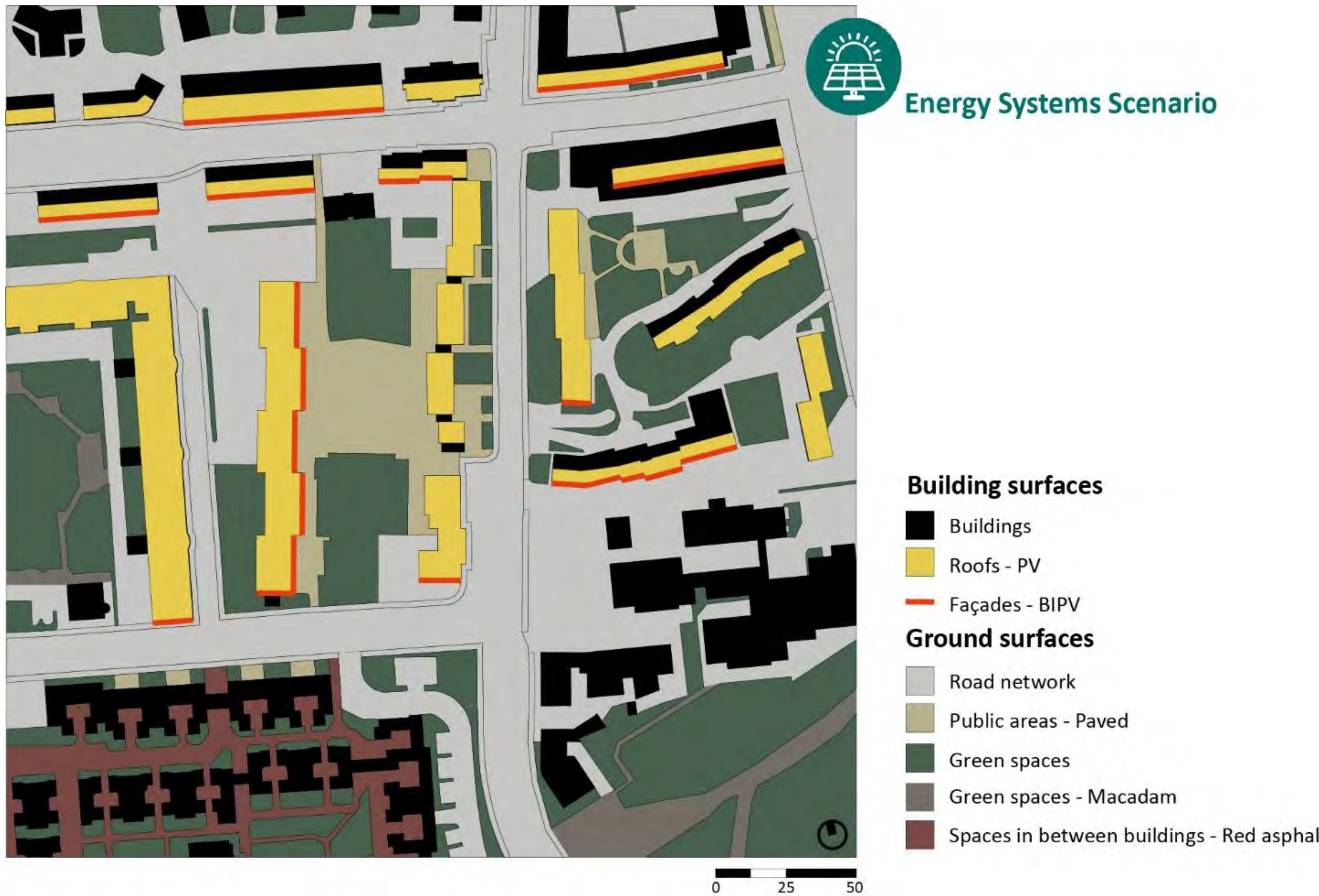
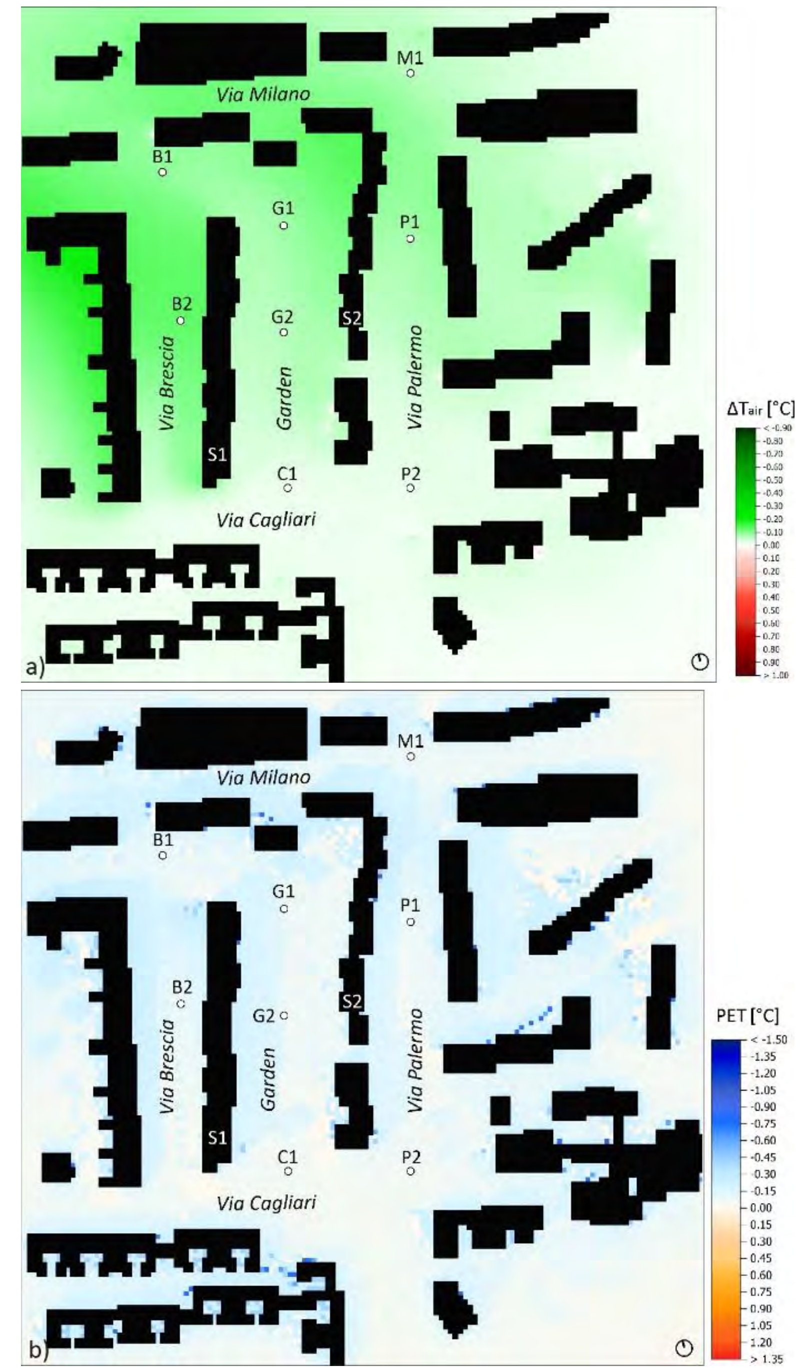
Surface use scenarios: Energy systems



ΔT_{air} = - 0.03 °C
10˙205 m² of building envelope surfaces suitable for the installation of solar systems



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Scenarios' performance evaluation

Performance matrix: level of contribution of the surface use scenarios to site-specific objectives

	Site-specific objectives	Surface use scenario			
1	Urban climate regulation: *Reduce summer overheating and UHI*	partially positive	partially positive	positive	partially positive
1	Urban climate regulation: *Reduce summer overheating and UHI during hottest hours*	partially positive	partially positive	partially positive	partially positive
1	Urban climate regulation: *Improve human thermal comfort conditions*	positive	partially positive	partially negative	partially positive
1	Urban climate regulation: *Improve human thermal comfort conditions during hottest hours*	positive	partially positive	partially negative	partially positive
2	Urban habitats and biodiversity preservation: *Preserve vegetated areas and increase their surface*	positive	partially negative	partially negative	partially negative
3	Energy self-reliance: *Produce renewable energy by active systems*	neutral	neutral	neutral	positive
4	Urban water management: *Increase the share of permeable surfaces*	positive	partially negative	neutral	neutral
5	Air quality amelioration: *Reduce pollutants and ghg emissions*	positive	neutral	partially positive	partially positive

Contribution: negative, partially negative, neutral, partially positive, positive

- Urban framework definition
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Surface Use Pattern

	Site-specific objectives	Surface use scenario			
1	Urban climate regulation: *Reduce summer overheating and UHI*	partially positive	partially positive	positive	partially positive
1	Urban climate regulation: *Reduce summer overheating and UHI during hottest hours*	partially positive	partially positive	partially positive	partially positive
1	Urban climate regulation: *Improve human thermal comfort conditions*	positive	partially positive	partially negative	partially positive
1	Urban climate regulation: *Improve human thermal comfort conditions during hottest hours*	positive	partially positive	partially negative	partially positive
2	Urban habitats and biodiversity preservation: *Preserve vegetated areas and increase their surface*	positive	partially negative	partially negative	partially negative
3	Energy self-reliance: *Produce renewable energy by active systems*	neutral	neutral	neutral	positive
4	Urban water management: *Increase the share of permeable surfaces*	positive	partially negative	neutral	neutral
5	Air quality amelioration: *Reduce pollutants and ghg emissions*	positive	neutral	partially positive	partially positive

Contribution: negative, partially negative, neutral, partially positive, positive

Selected of solutions for the integration of the Surface Use Pattern (SUP)

1 Green solutions

2 Energy systems

3 Cool materials

Urban framework definition

Urban area characterisation

Site-specific objectives definition

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Definition of the SURFACE USES PATTERN

Surface Use Pattern

Urban framework definition

Urban area characterisation

Site-specific objectives definition

Surface uses identification

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Definition of the SURFACE USES PATTERN

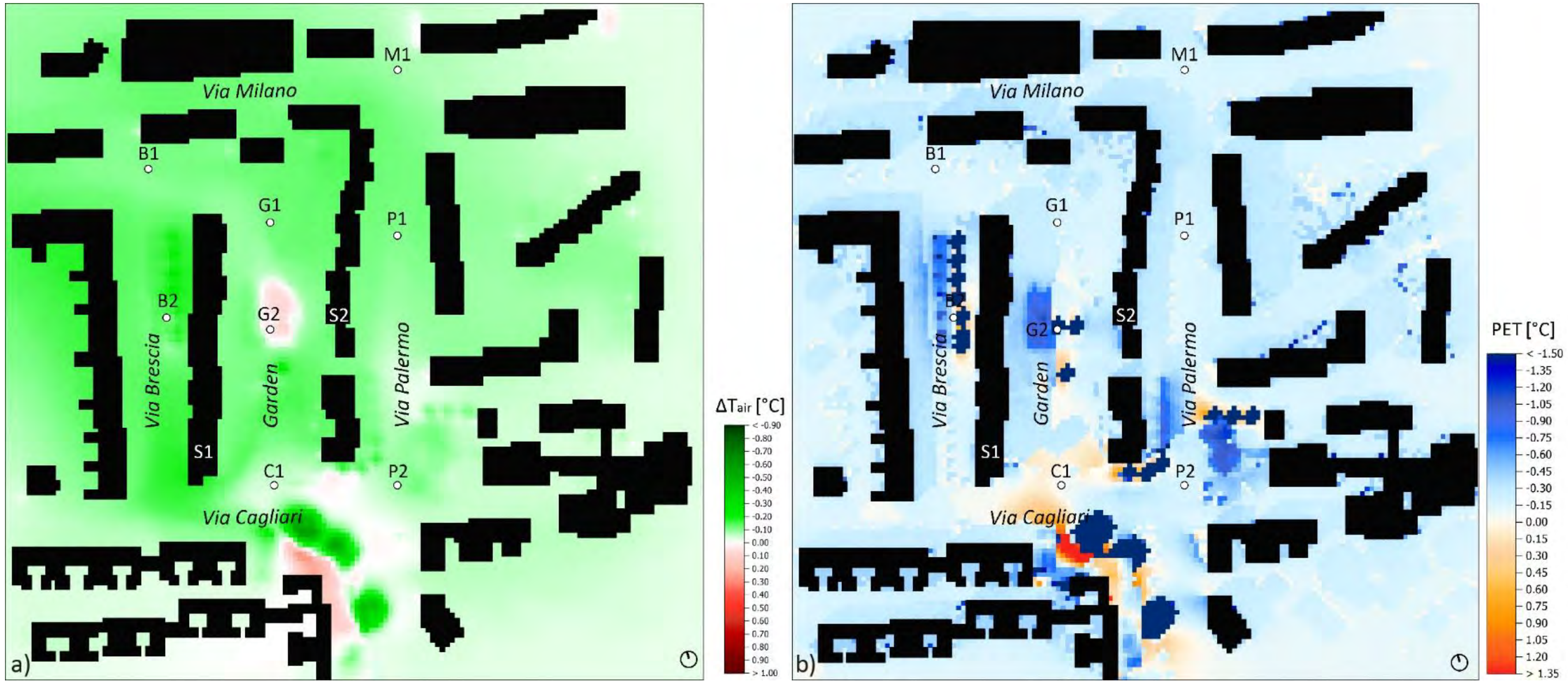
Surface Use Pattern

→ **Air temperature is reduced** in all hot spots - Average decrement up to - 0.12 °C

→ **Improvement of human thermal comfort** - PET average reduction - 0.15 °C

→ **Production of renewable energy is guaranteed through solar active systems** - corresponding annual solar potential of 10˙050 MWh/a

→ **Increased RIE** (4.55), and **+ 6% vegetated fraction**



Air temperature and PET distribution at 1 m a.g.l.
Absolute difference between Baseline and simulated scenario

- Urban framework definition
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- Selection and integration of relevant surface uses
- **Definition of the SURFACE USES PATTERN**

Surface Use Pattern

Urban framework definition

Urban area characterisation

Site-specific objectives definition

Surface uses identification

Surface use scenarios creation and evaluation

Selection and integration of relevant surface uses

Definition of the SURFACE USES PATTERN

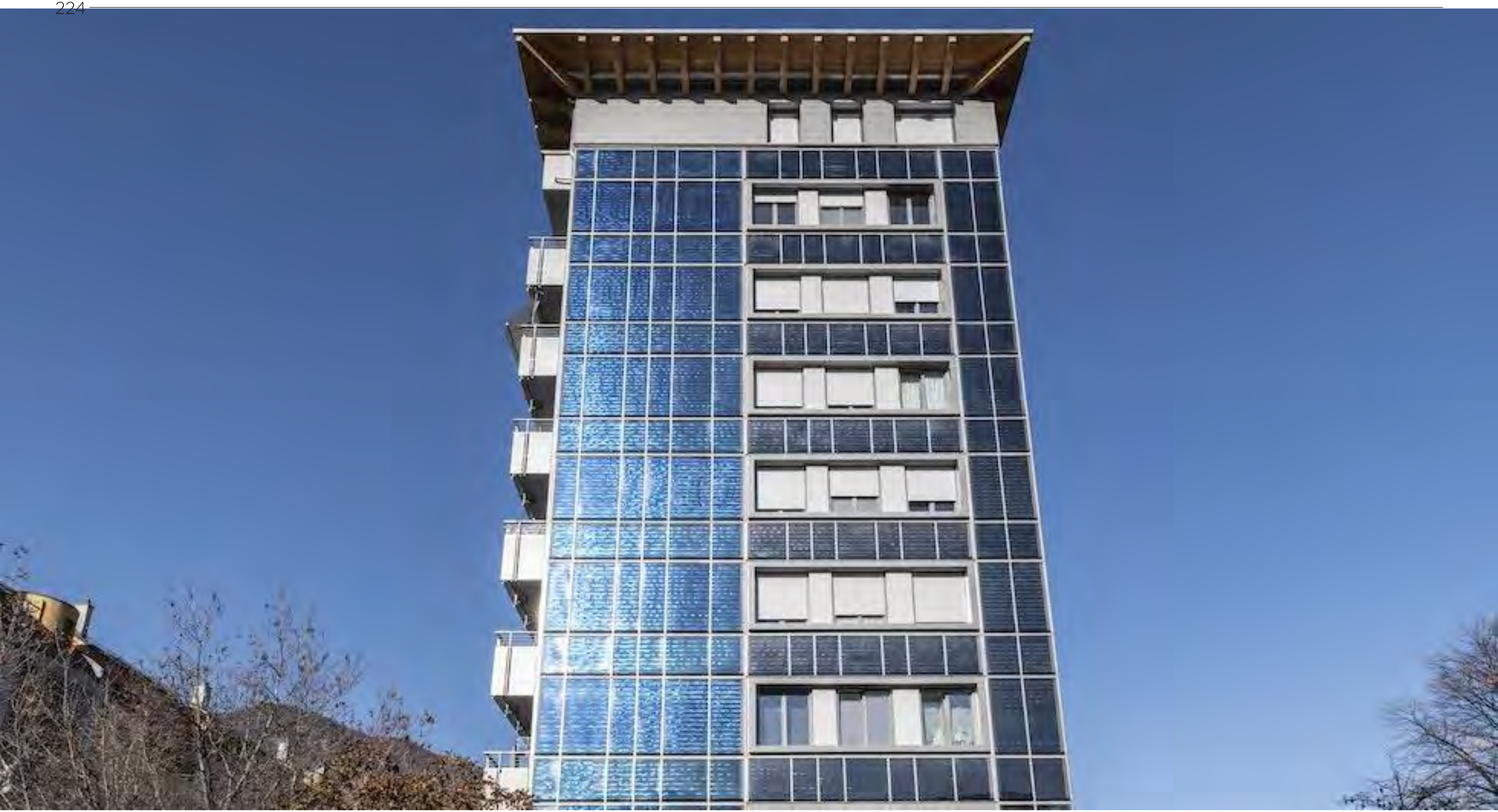
Sinfonia refurbishment interventions Via Brescia-Cagliari

220 kWh/m² year

Before refurbishment

48 kWh/m² year

After refurbishment



Via Brescia after refurbishment. Credits: Eurac Research

Sinfonia refurbishment interventions Via Palermo

204 kWh/m² year

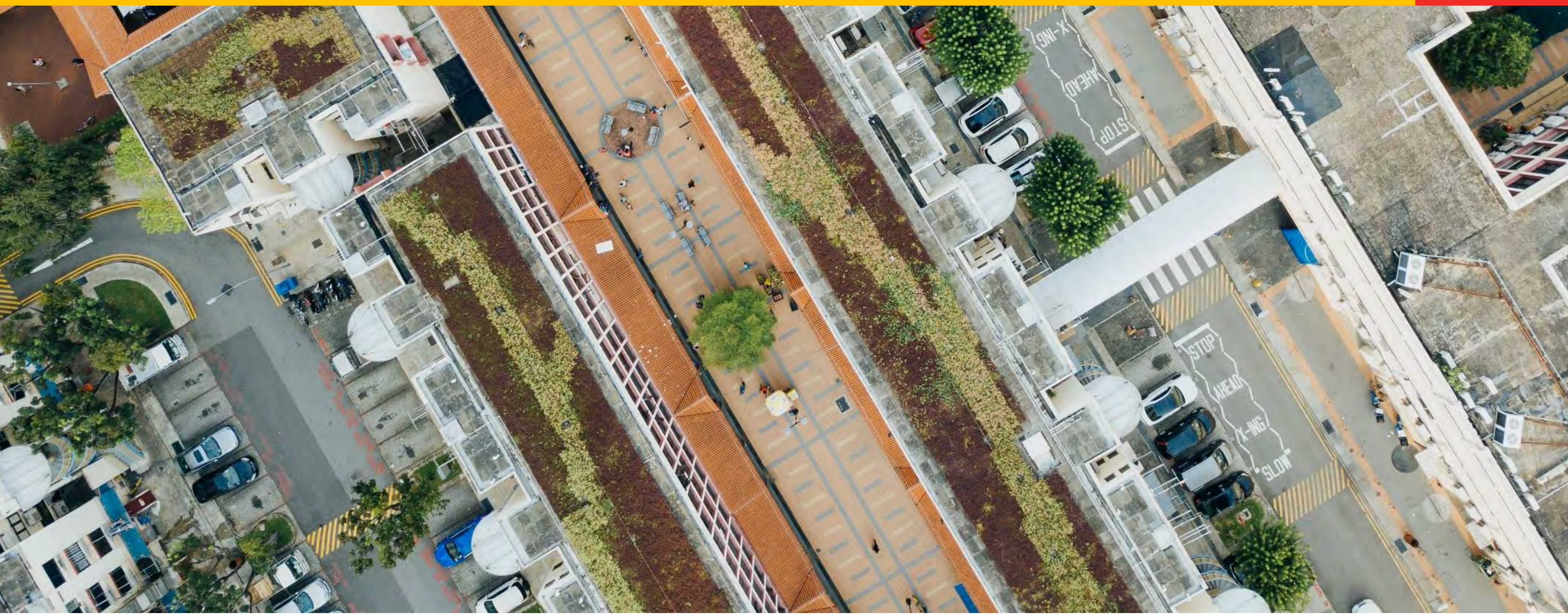
Before refurbishment

47 kWh/m² year

After refurbishment

Via Palermo after refurbishment. Credits: Eurac Research

Lessons learned & Future developments



Lessons learned

Urban surfaces uses can play a major role in the response and transformation toward **climate resilient and sustainable cities**.

- **City- and site-specific level characterisation** plays a **key role** in the definition of **responsive surface uses strategies**
- The **definition of surface uses** → requires **clear objectives**
  → is a **complex and multidisciplinary challenge**
  → is a **site-specific challenge**
- There is **no single best surface use** that meets all the objectives
- **Surface Use Pattern: variety is the key**

What's coming next?

JUST NATURE

- Bolzano & Merano (Italy)
- Existing urban areas
- Goal: just transition toward carbon neutral cities

ARV

- Trento (Italy)
- New development
- Goal: climate positive

Thank you for your attention!

Silvia Croce
Institute for Renewable - Eurac Research
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www.iea-shc.org

@IEASHC

IEA Solar Heating and Cooling Programme (group 4230381)

Solar-Driven Low-Carbon Communities: Drake Landing and Beyond

Lucio Mesquita

The presentation first introduces CanmetENERGY, the science and technology branch of Natural Resources Canada. This is followed by a discussion about solar district heating with seasonal borehole thermal storage. The presentation is focused on Drake Landing, a planned community in Okotoks, Alberta. While highlighting the merits of this solar community, the presentation also identifies some maintenance challenges and poses questions about the next steps in optimizing energy efficiency options for communities.

Natural Resources Canada | Ressources naturelles Canada

SOLAR-DRIVEN LOW-CARBON COMMUNITIES: DRAKE LANDING AND BEYOND

Lucio Mesquita

Seminar on Solar Neighborhoods – University of Calgary- September 23, 2022

CanmetENERGY
Leadership in ecoInnovation

Canada

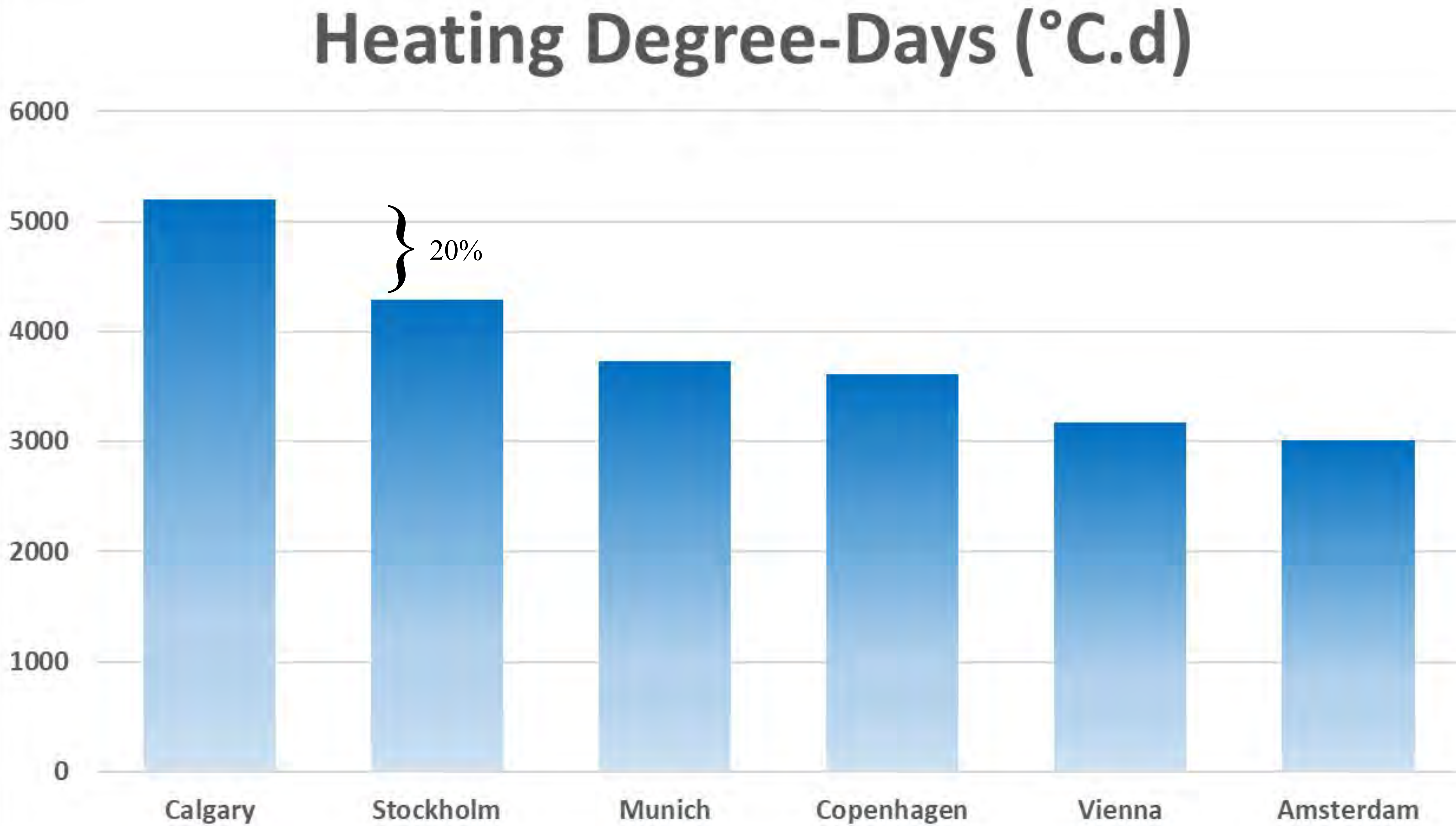
CanmetENERGY

Leadership in ecoInnovation

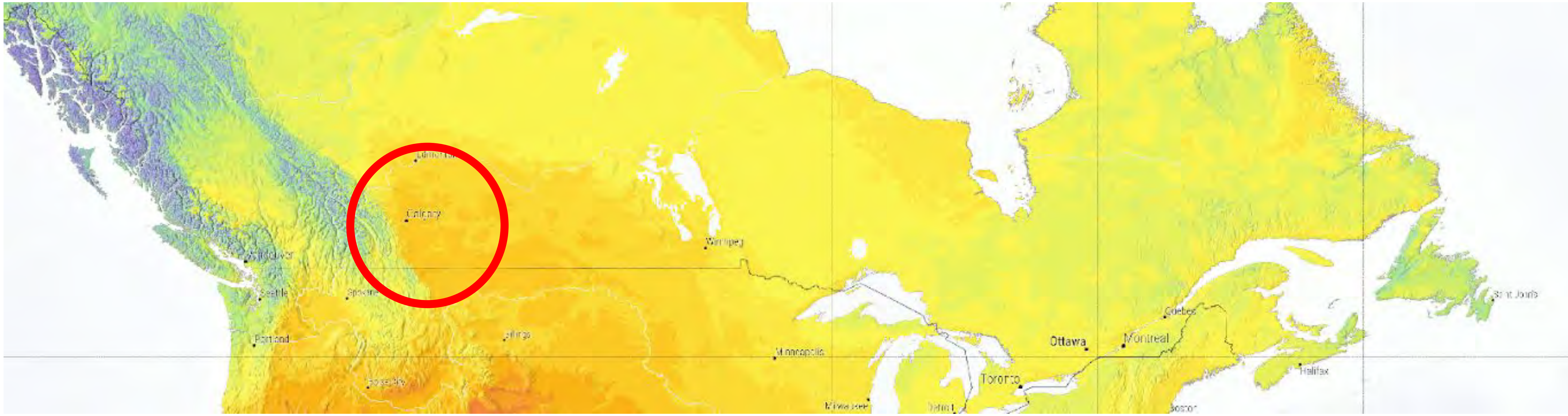
CanmetENERGY is the science and technology branch of Natural Resources Canada and operates three labs across Canada with over 450 scientists, engineers and technicians

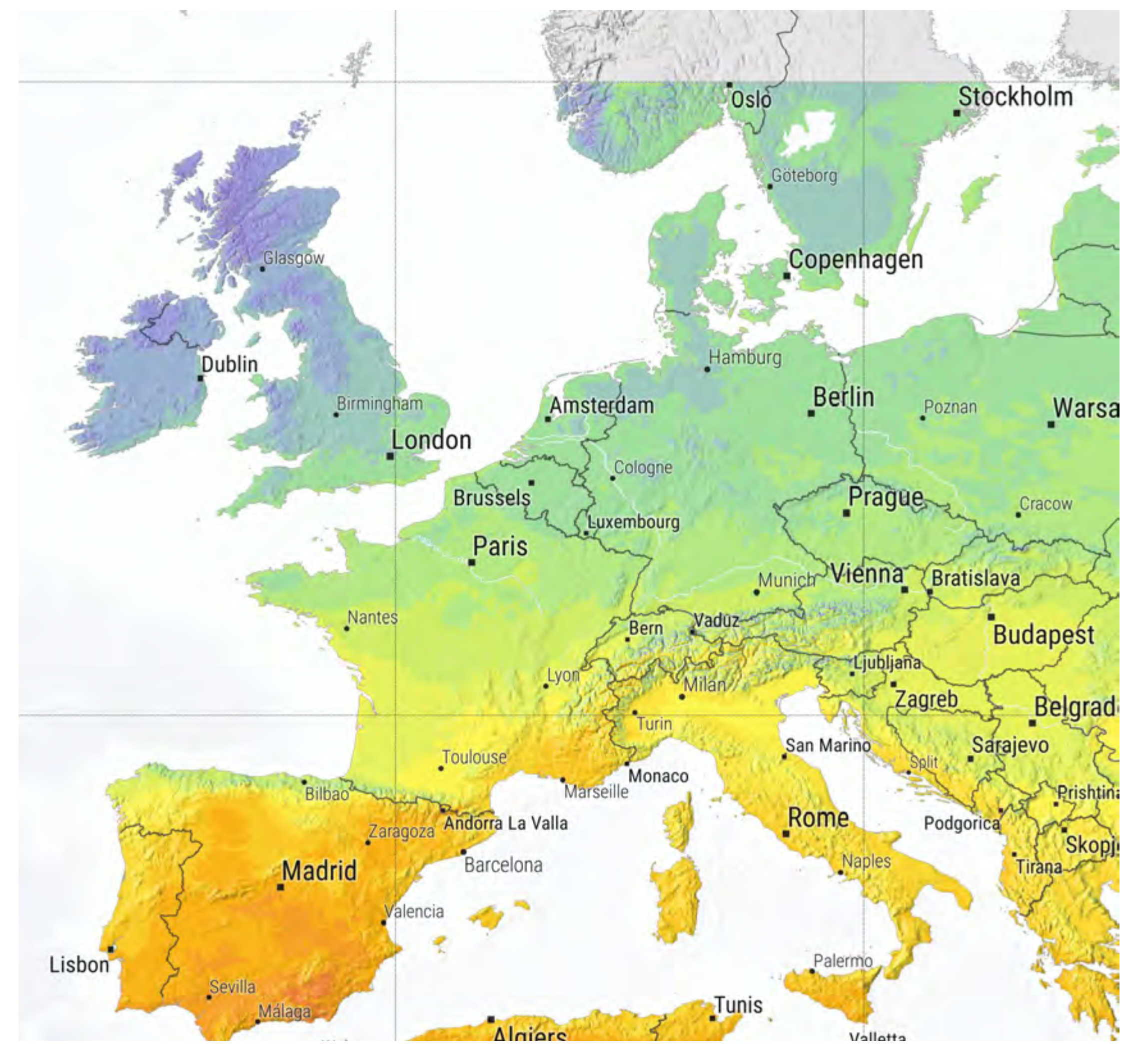
Solar District Heating with Seasonal BTES

DRAKE LANDING
SOLAR COMMUNITY
OKOTOKS


Heating Degree-Days (°C.d)
6000
5000
4000
3000
2000
1000
0
20%
Calgary
Stockholm
Munich
Copenhagen
Vienna
Amsterdam

5



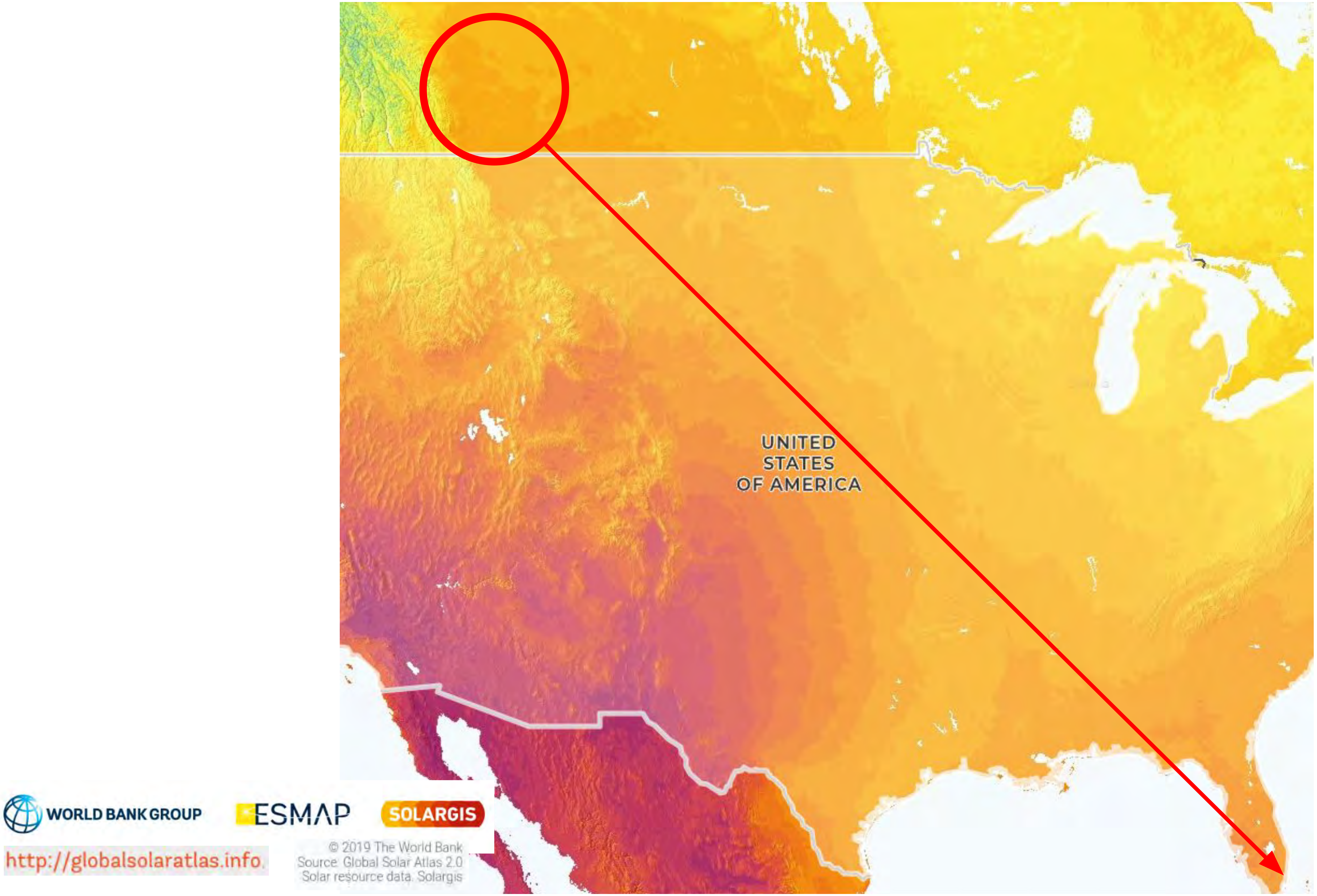


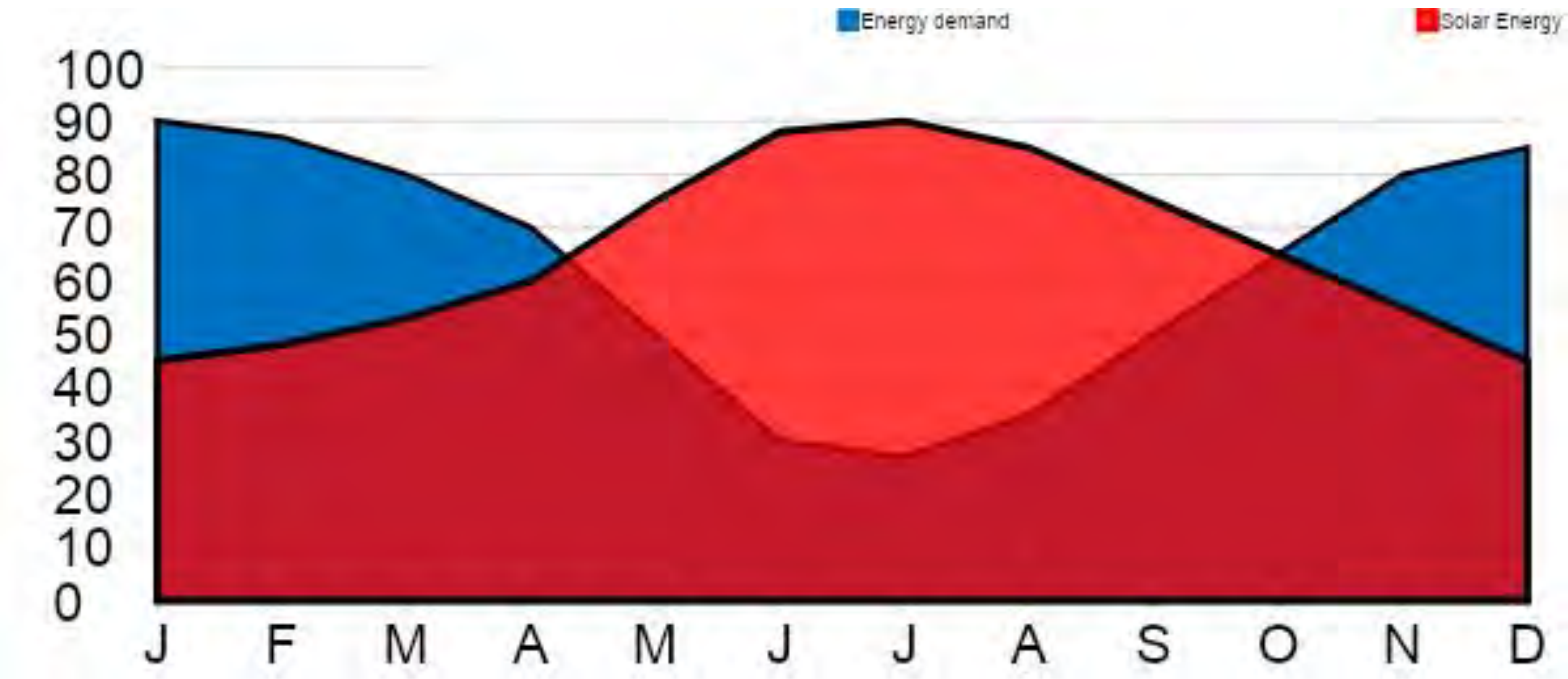
Approximately 50% more tilted irradiation than Stockholm, close to Madrid levels.

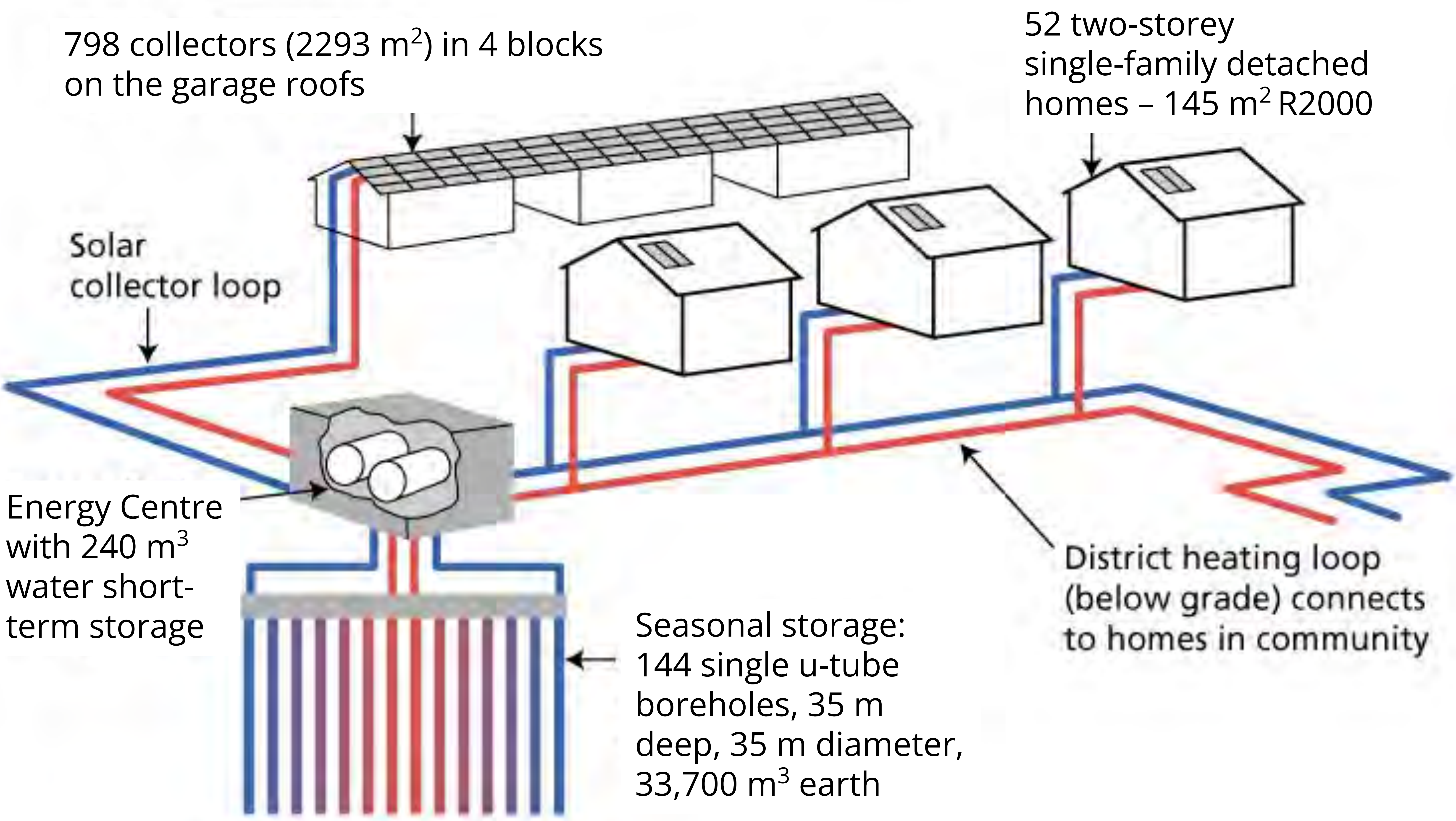
WORLD BANK GROUP ESMAP SOLARGIS

http://globalsolaratlas.info

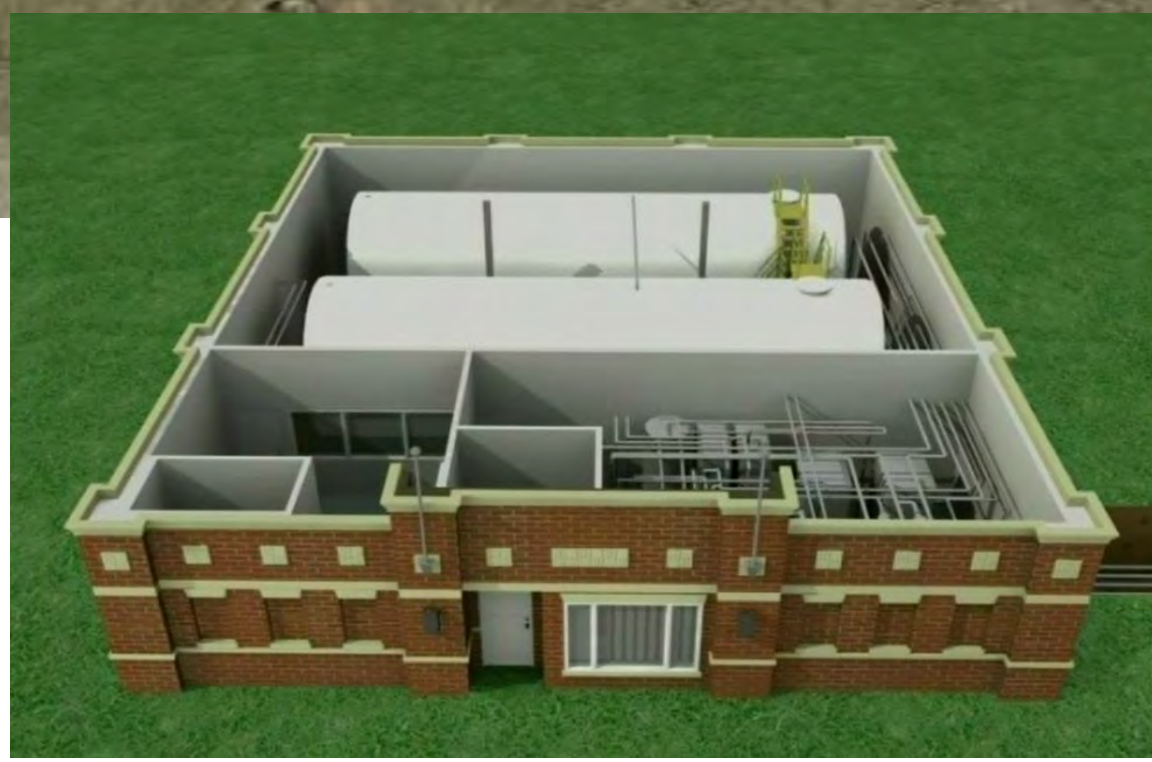
6

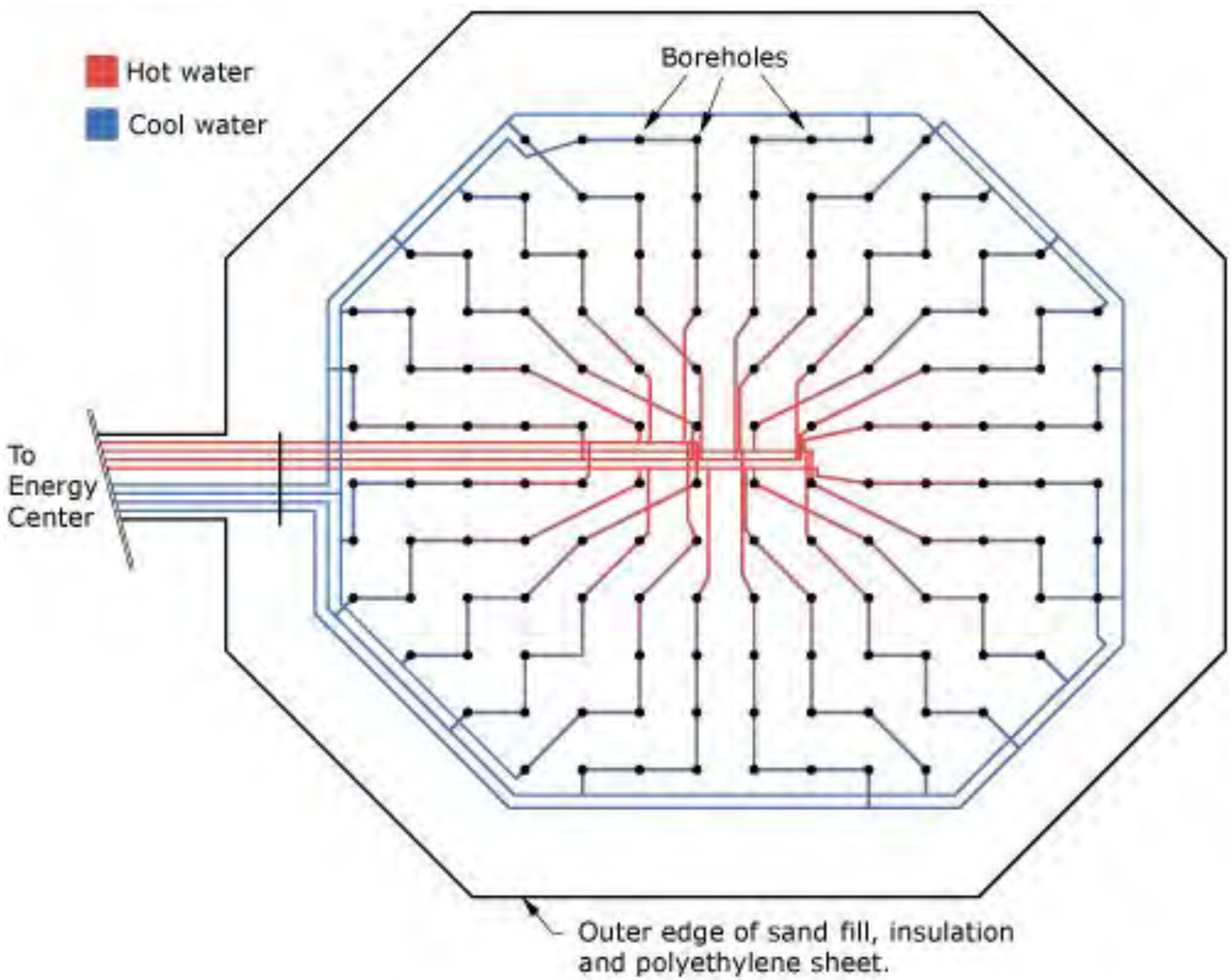

UNITED
STATES
OF AMERICA
WORLD BANK GROUP
ESMAP
SOLARGIS
http://globalsolaratlas.info
© 2019 The World Bank
Source: Global Solar Atlas 2.0
Solar resource data: Solargis

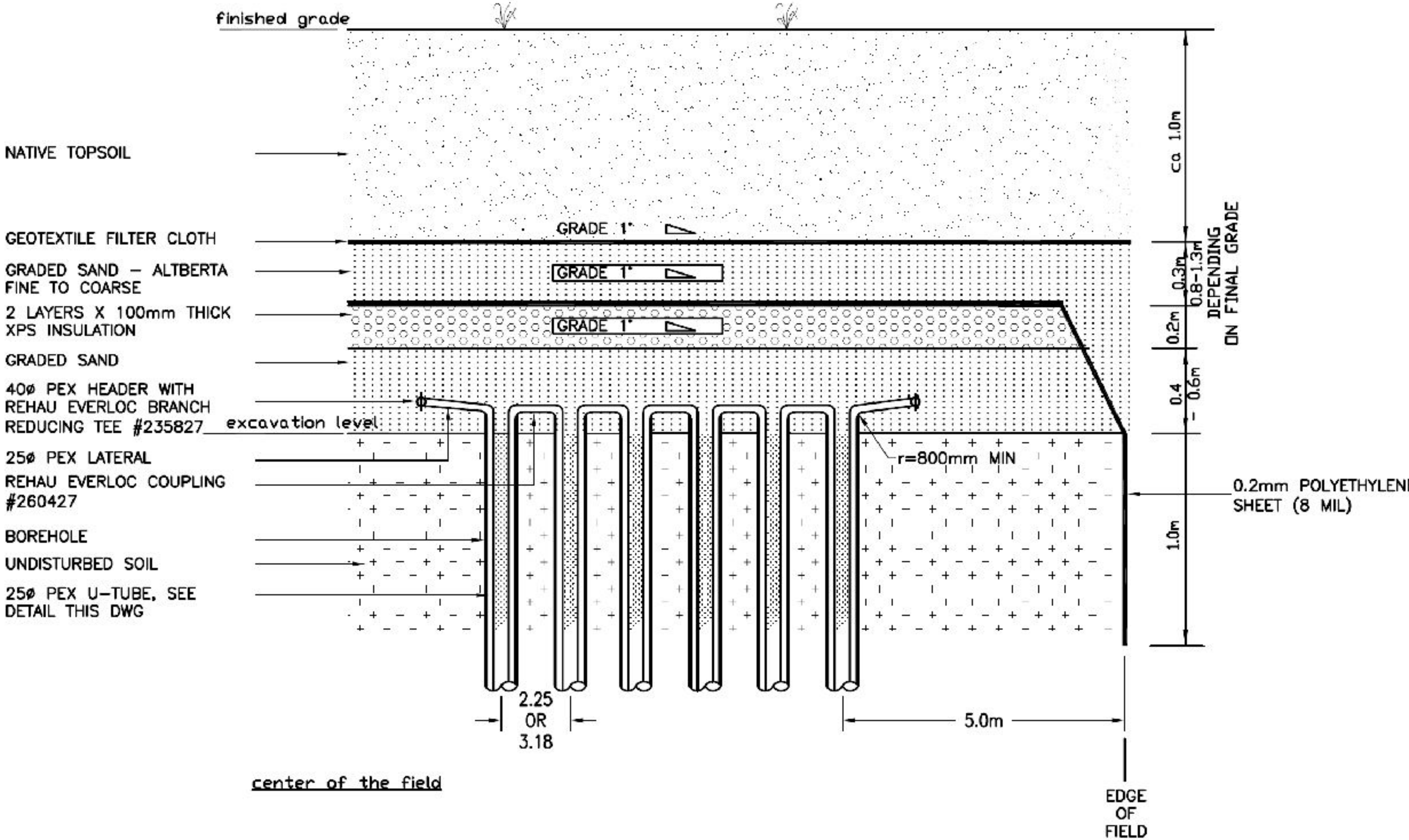

Energy demand
Solar Energy
100
90
80
70
60
50
40
30
20
10
0
J
F
M
A
M
J
J
A
S
O
N
D


798 collectors (2293 m2) in 4 blocks on the garage roofs
52 two-storey single-family detached homes – 145 m2 R2000
Solar collector loop
Energy Centre with 240 m3 water short-term storage
Seasonal storage: 144 single u-tube boreholes, 35 m deep, 35 m diameter, 33,700 m3 earth
District heating loop (below grade) connects to homes in community

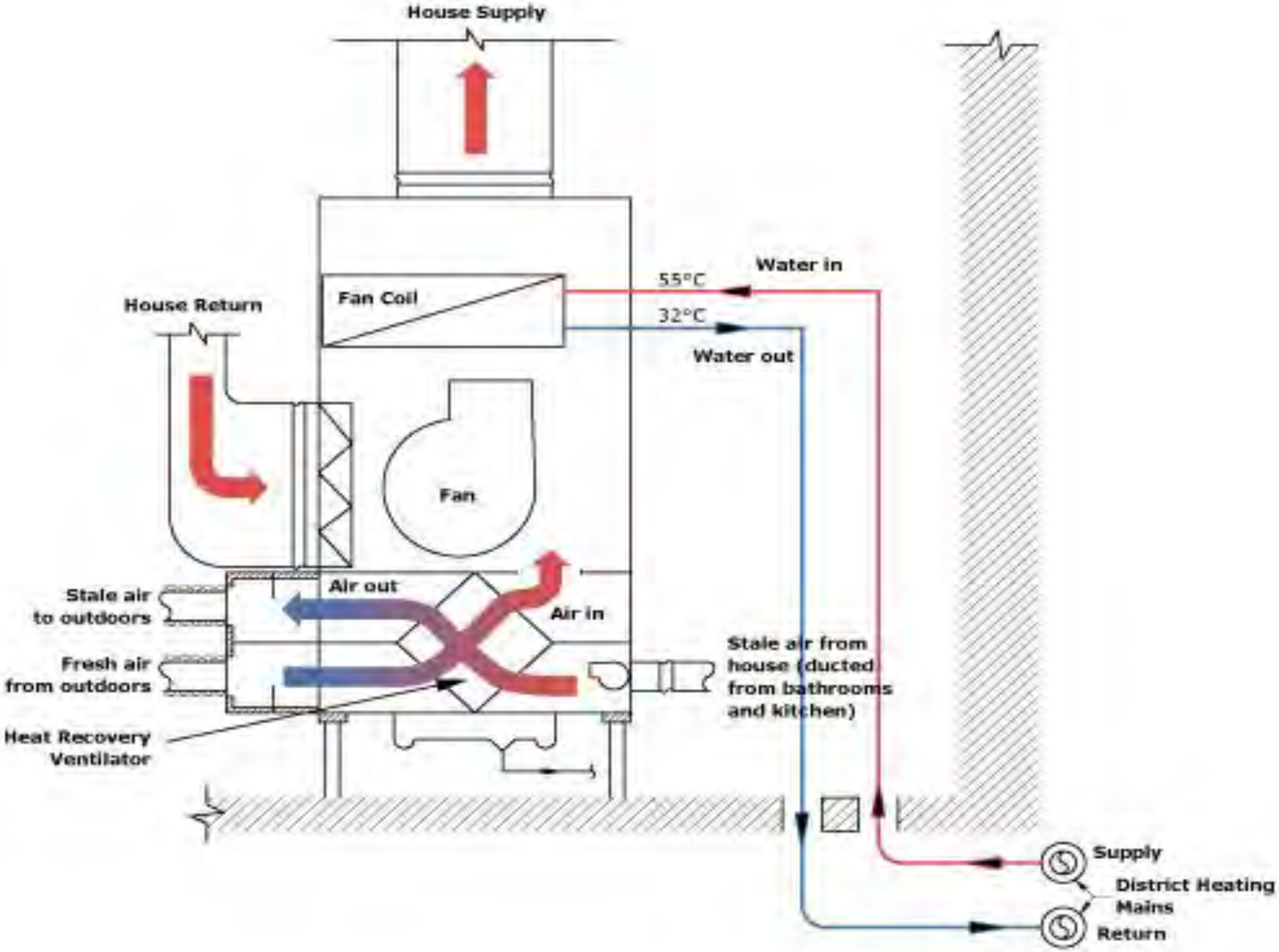
798 Single-Glazed Collectors - 2293 m^2 gross area




Hot water
Cool water
Boreholes
To Energy Center
Outer edge of sand fill, insulation and polyethylene sheet.


finished grade
NATIVE TOPSOIL
GEOTEXTILE FILTER CLOTH
GRADED SAND – ALTBERTA FINE TO COARSE
2 LAYERS X 100mm THICK XPS INSULATION
GRADED SAND
40ø PEX HEADER WITH REHAU EVERLOC BRANCH REDUCING TEE #235827
excavation level
25ø PEX LATERAL
REHAU EVERLOC COUPLING #260427
BOREHOLE
UNDISTURBED SOIL
25ø PEX U-TUBE, SEE DETAIL THIS DWG
GRADE 1°
GRADE 1°
GRADE 1°
ca 1.0m
0.3m
0.8-1.3m
DEPENDING ON FINAL GRADE
0.2m
0.4 – 0.6m
r=800mm MIN
0.2mm POLYETHYLENE SHEET (8 MIL)
1.0m
2.25 OR 3.18
5.0m
center of the field
EDGE OF FIELD


2005/10/18


House Supply
House Return
Fan Coil
Water in
55°C
32°C
Water out
Fan
Air out
Air in
Stale air to outdoors
Fresh air from outdoors
Heat Recovery Ventilator
Stale air from house (ducted from bathrooms and kitchen)
Supply
District Heating Mains
Return

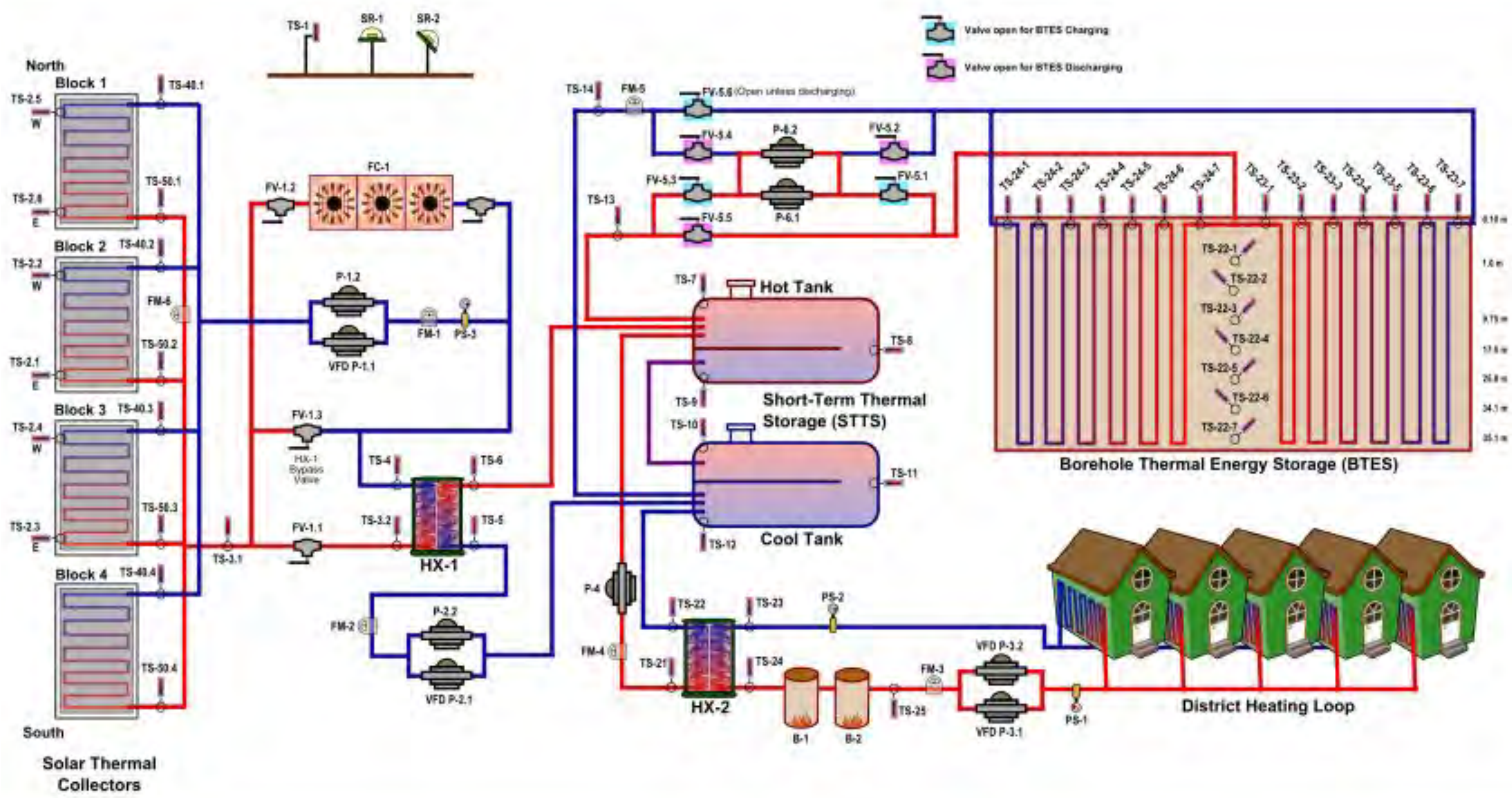

NU-AIR

Canada

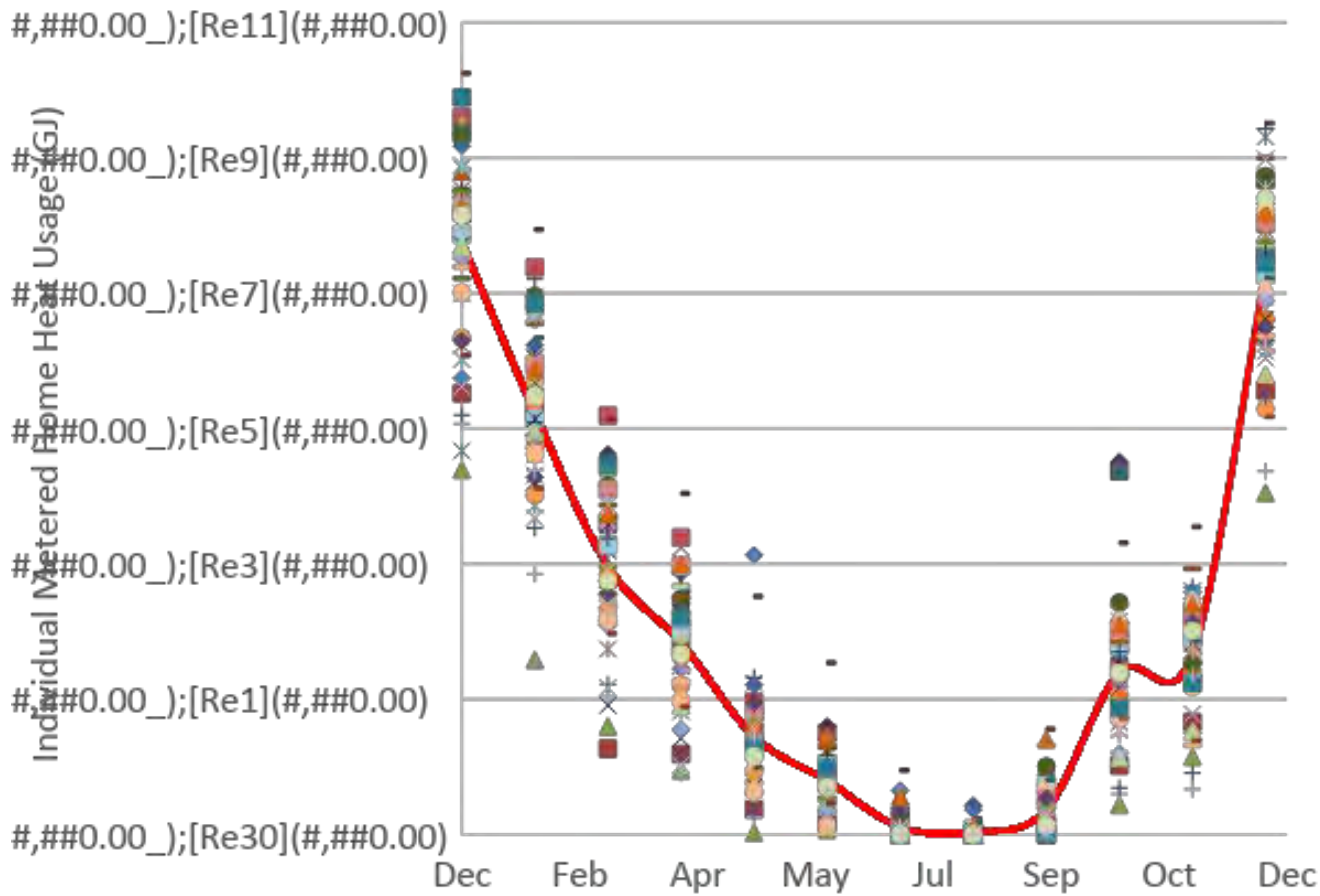
- R2000 performance level (≈ 30% better)
- 145 m^2 avg. above grade built area.

- ESP-r simulations for heating load calculations
- TRNSYS simulations for energy performance and design optimization

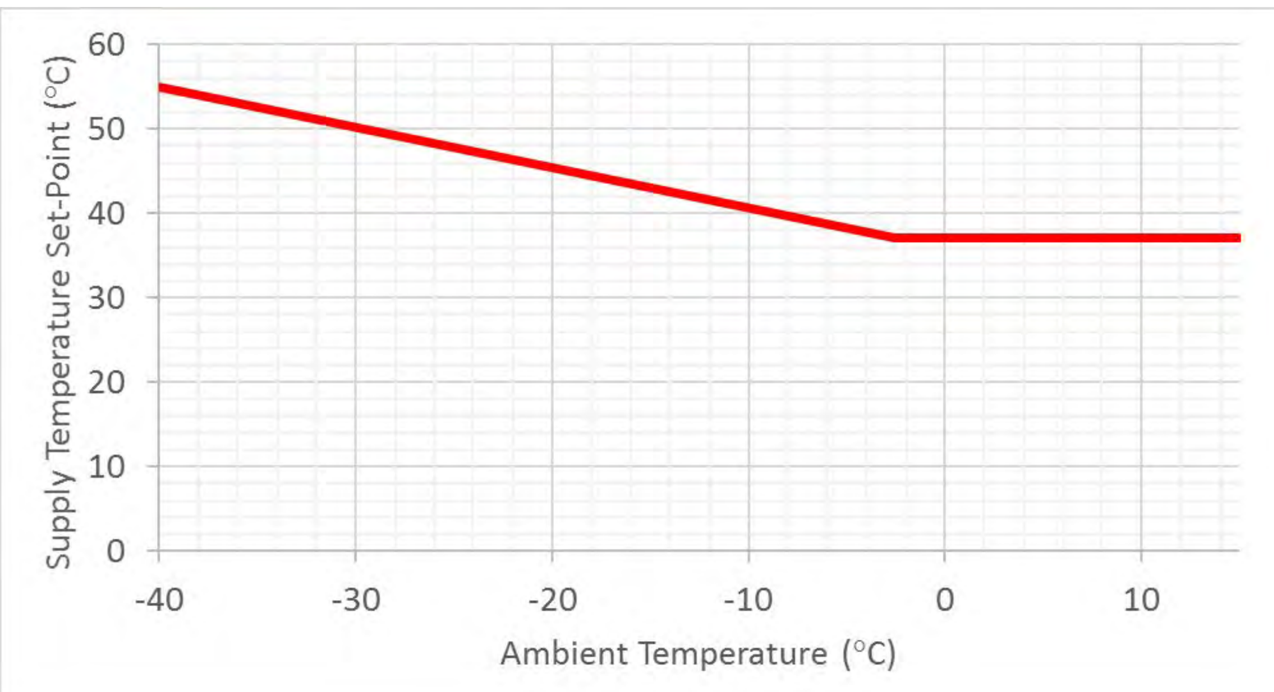
Monitoring Results

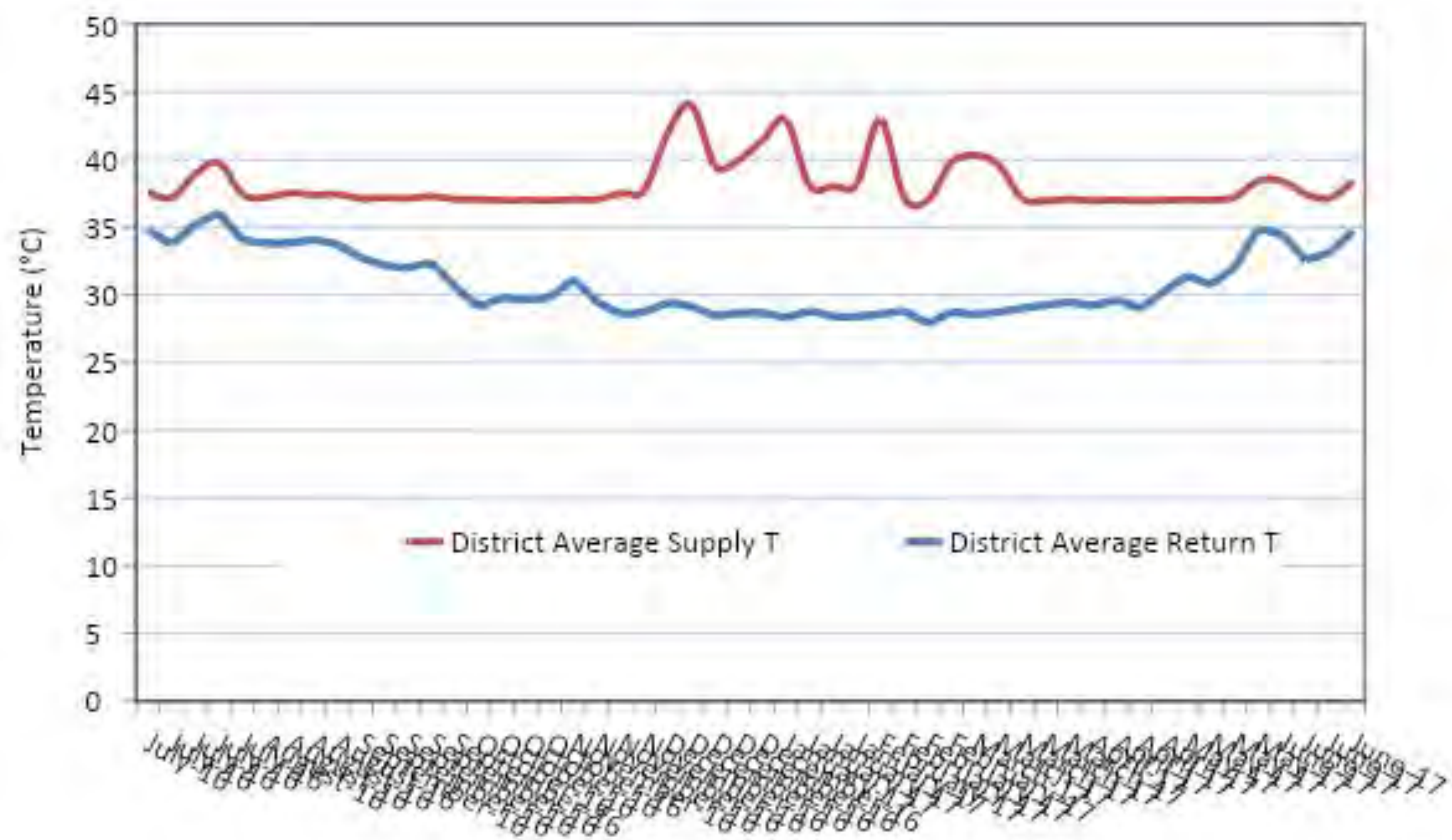


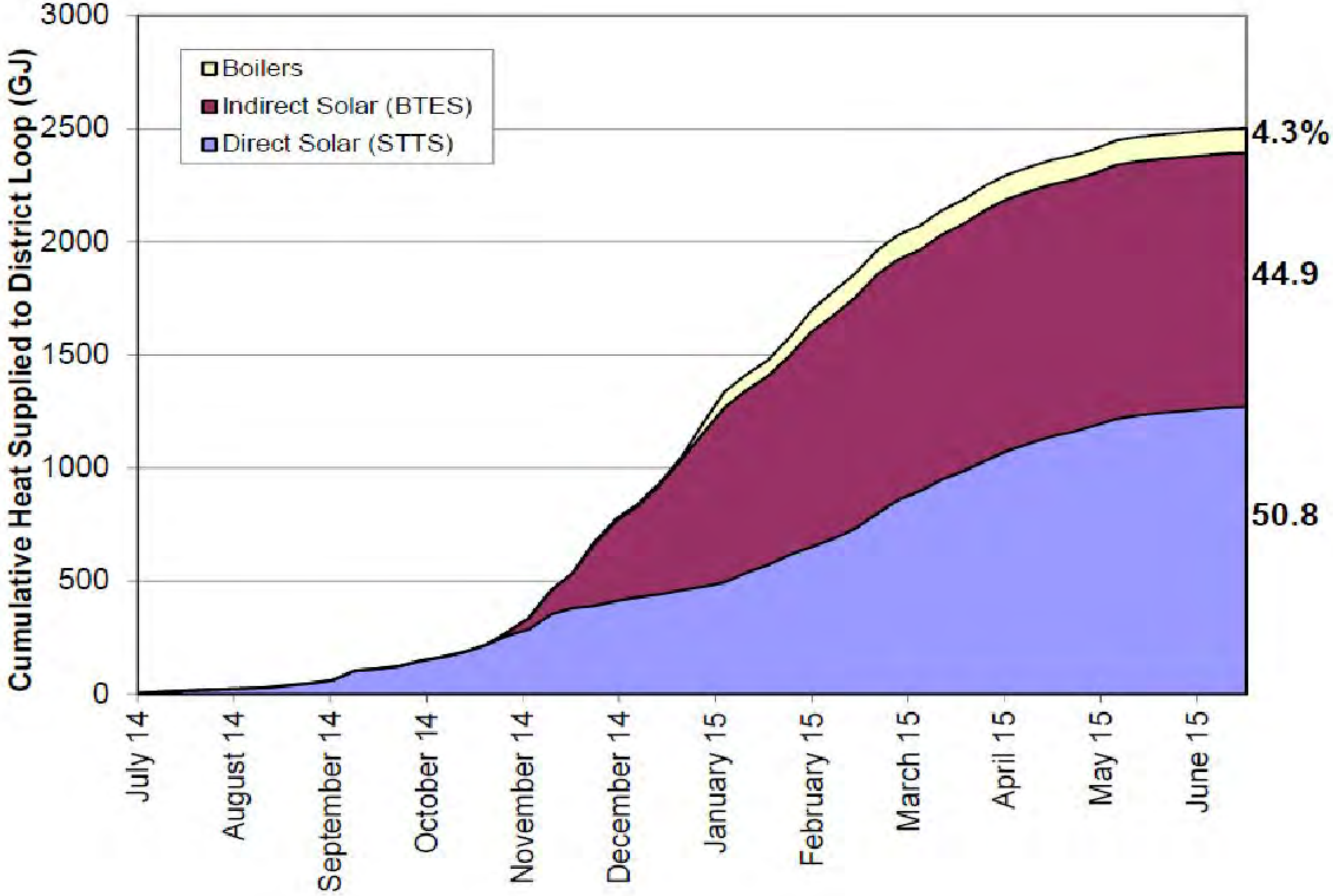
- Estimated 44.8 GJ/yr
- Measured* 43.2 GJ/yr



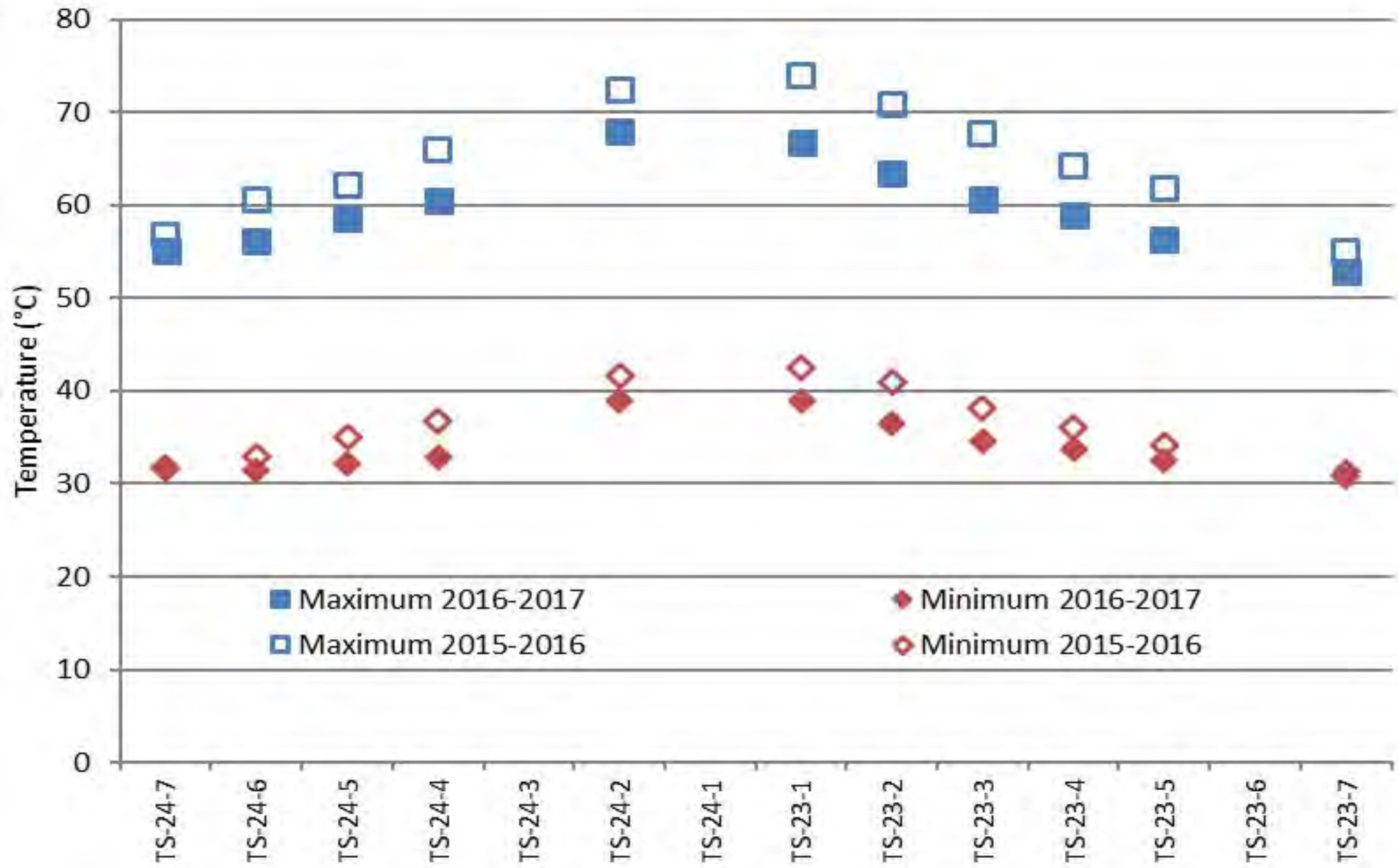
*2012-2017

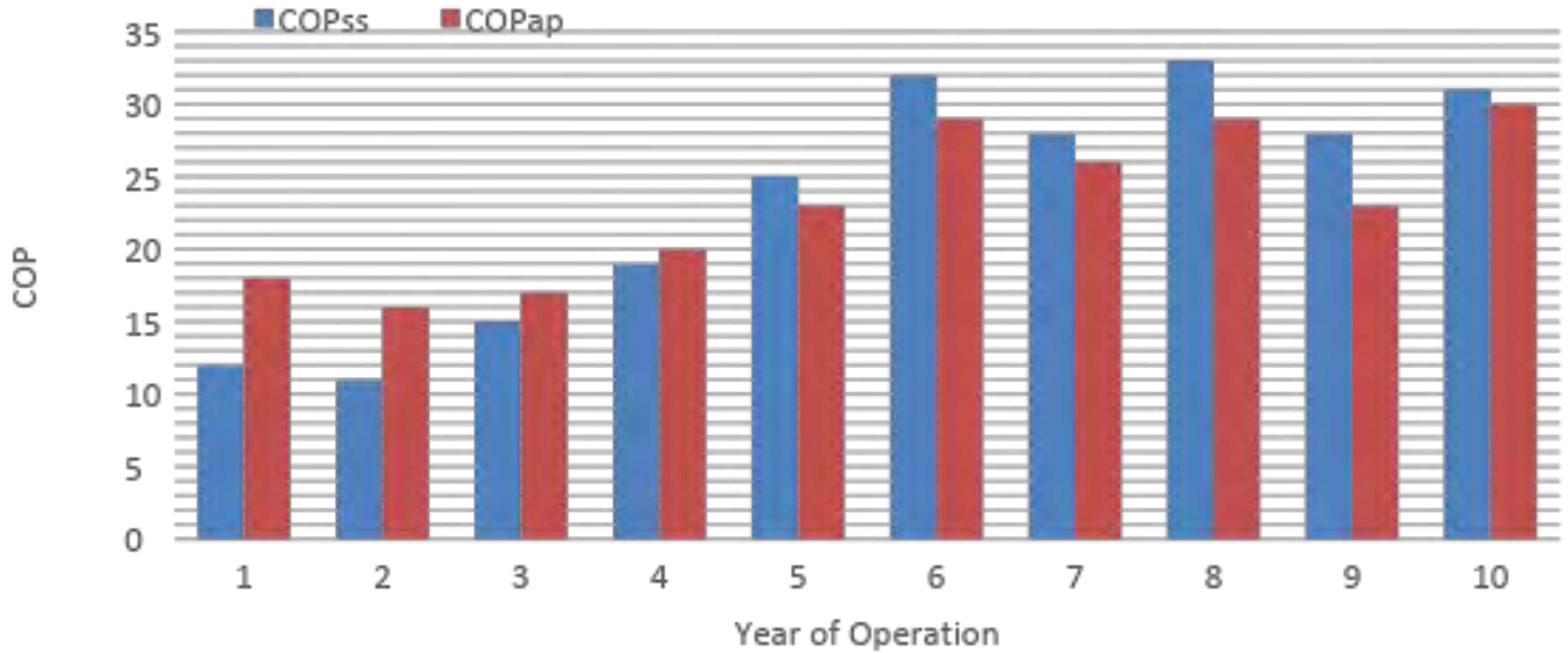

60
50
40
30
20
10
0
-40
-30
-20
-10
0
10
Supply Temperature Set-Point (°C)
Ambient Temperature (°C)


50
45
40
35
30
25
20
15
10
5
0
Temperature (°C)
District Average Supply T
District Average Return T

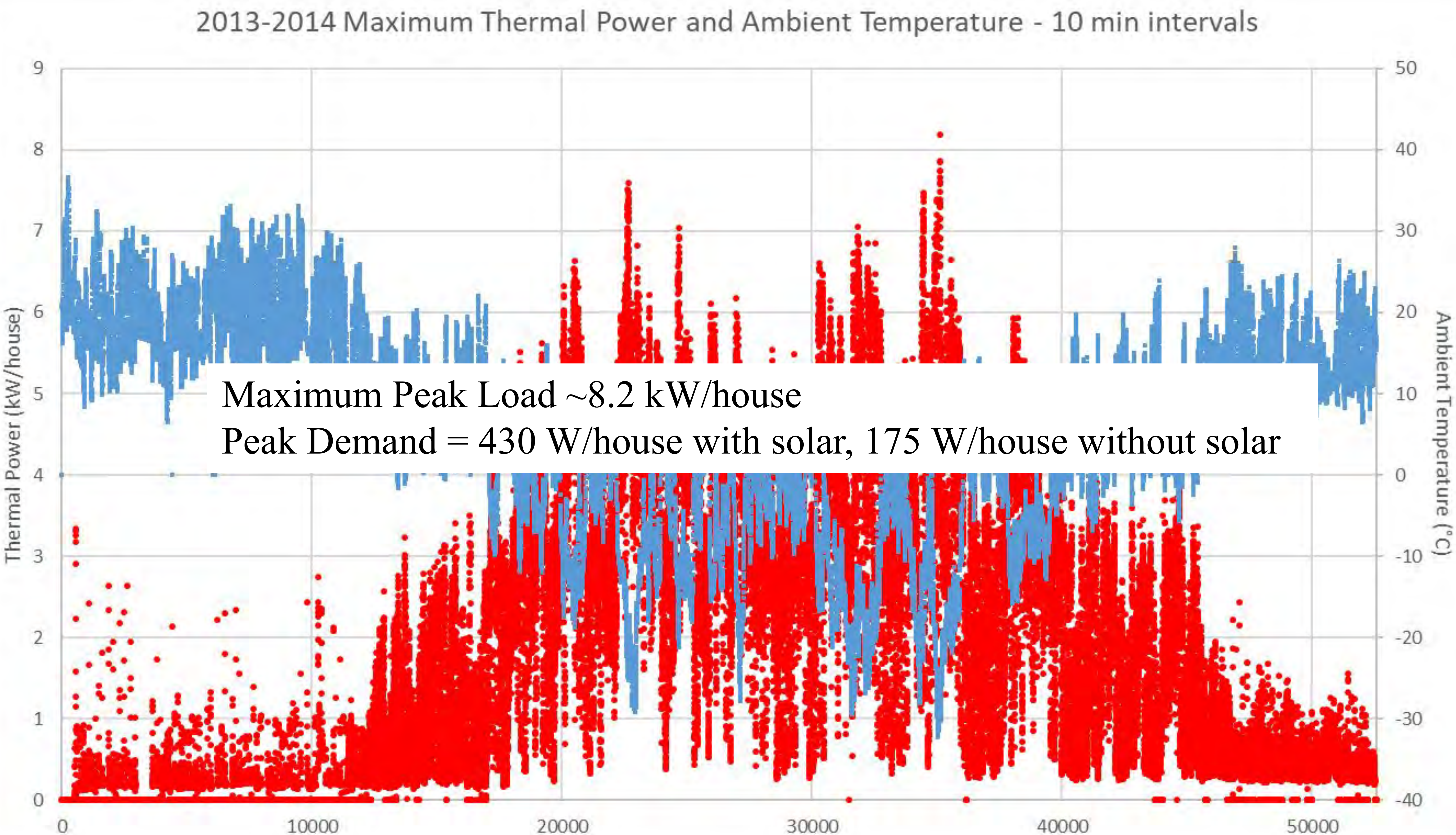


3000
2500
2000
1500
1000
500
0
Cumulative Heat Supplied to District Loop (GJ)
Boilers
Indirect Solar (BTES)
Direct Solar (STTS)
4.3%
44.9
50.8
July 14
August 14
September 14
October 14
November 14
December 14
January 15
February 15
March 15
April 15
May 15
June 15

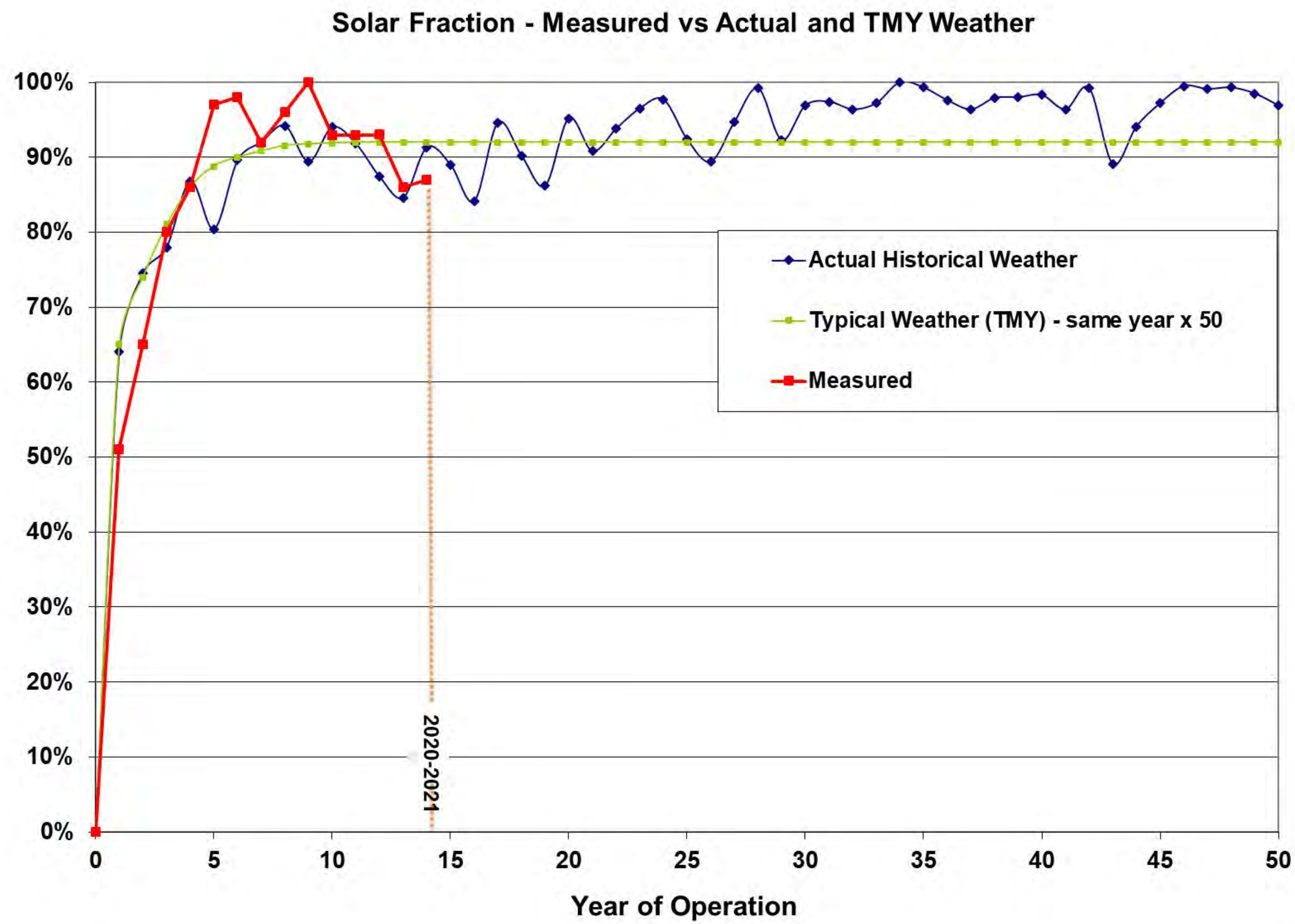

80
70
60
50
40
30
20
10
0
Temperature (°C)
Maximum 2016-2017
Maximum 2015-2016
Minimum 2016-2017
Minimum 2015-2016
TS-24-7
TS-24-6
TS-24-5
TS-24-4
TS-24-3
TS-24-2
TS-24-1
TS-23-1
TS-23-2
TS-23-3
TS-23-4
TS-23-5
TS-23-6
TS-23-7



- COP_{SS} – (Heat consumed x solar fraction)/(electricity for solar + storage pumps)
- COP_{ap} - (Heat consumed)/(electricity for all pumps)
- Pumps offset by PV

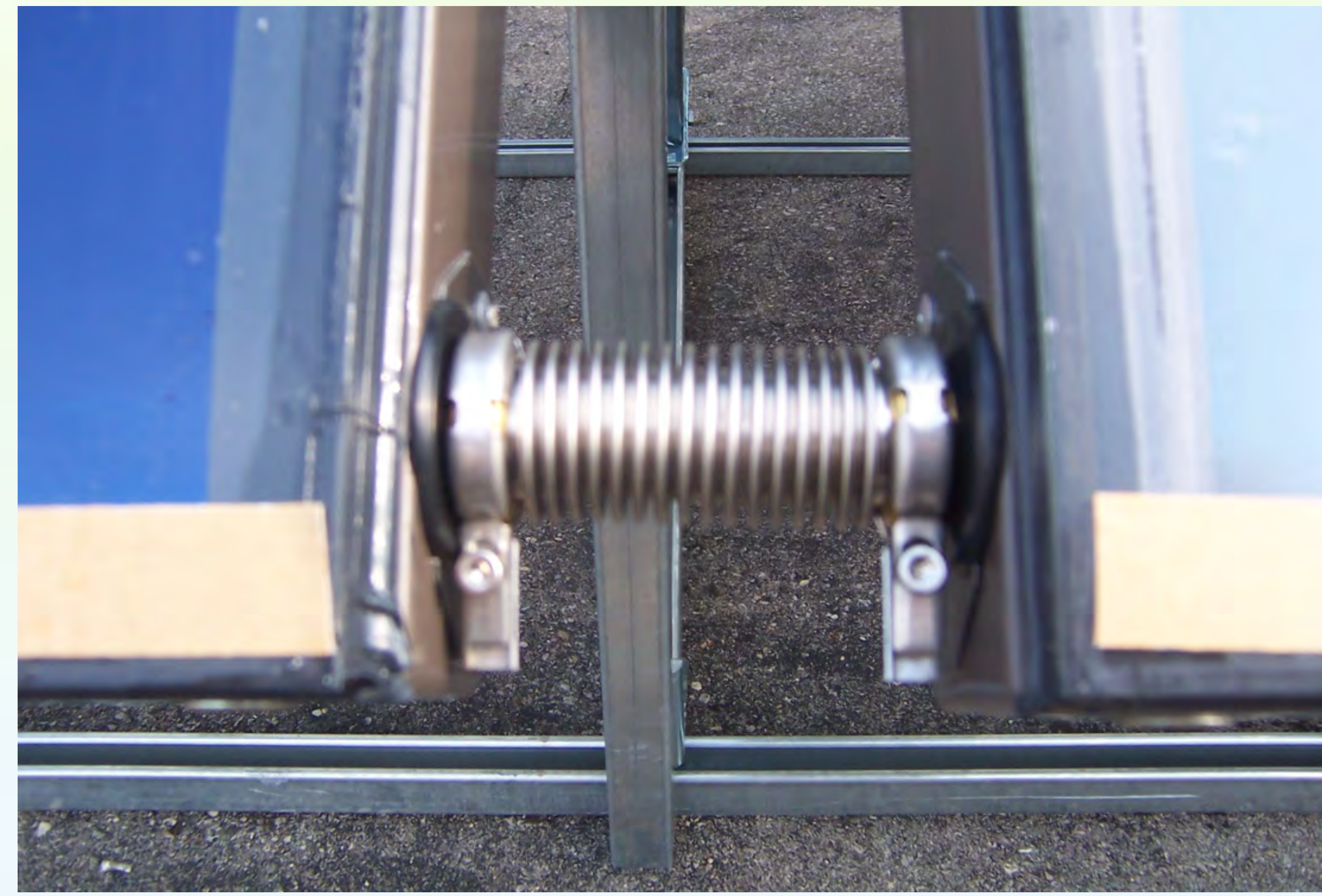

2013-2014 Maximum Thermal Power and Ambient Temperature - 10 min intervals
Thermal Power (kW/house)
Ambient Temperature (°C)
0
1
2
3
4
5
6
7
8
9
-40
-30
-20
-10
0
10
20
30
40
50
0
10000
20000
30000
40000
50000
Maximum Peak Load ~8.2 kW/house
Peak Demand = 430 W/house with solar, 175 W/house without solar

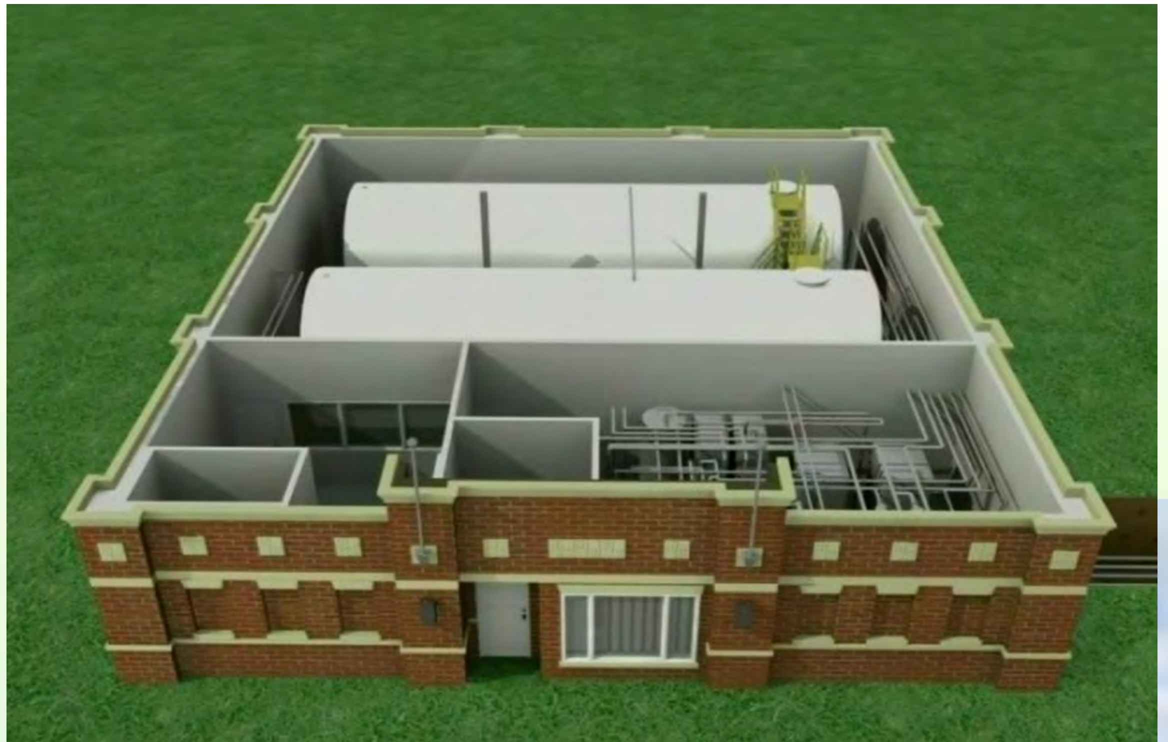
- Average SF for the last 5 years is 90%
- 100% in 2015/2016 Heating Season ☼☺

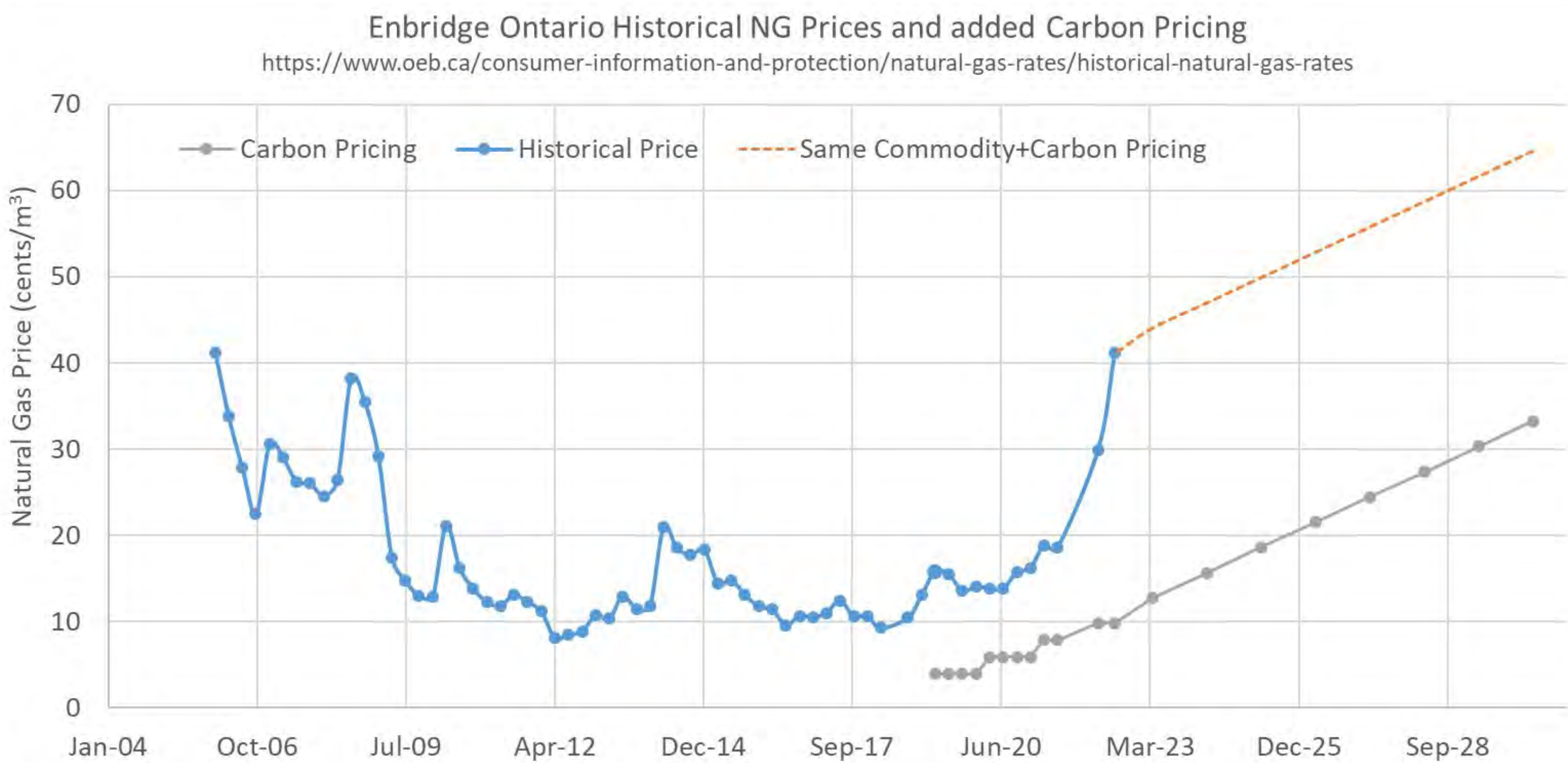


A few maintenance challenges

- Collectors are not manufactured anymore
- Bellows o-ring's failure
- Open tank water quality issue
- Aging controls system



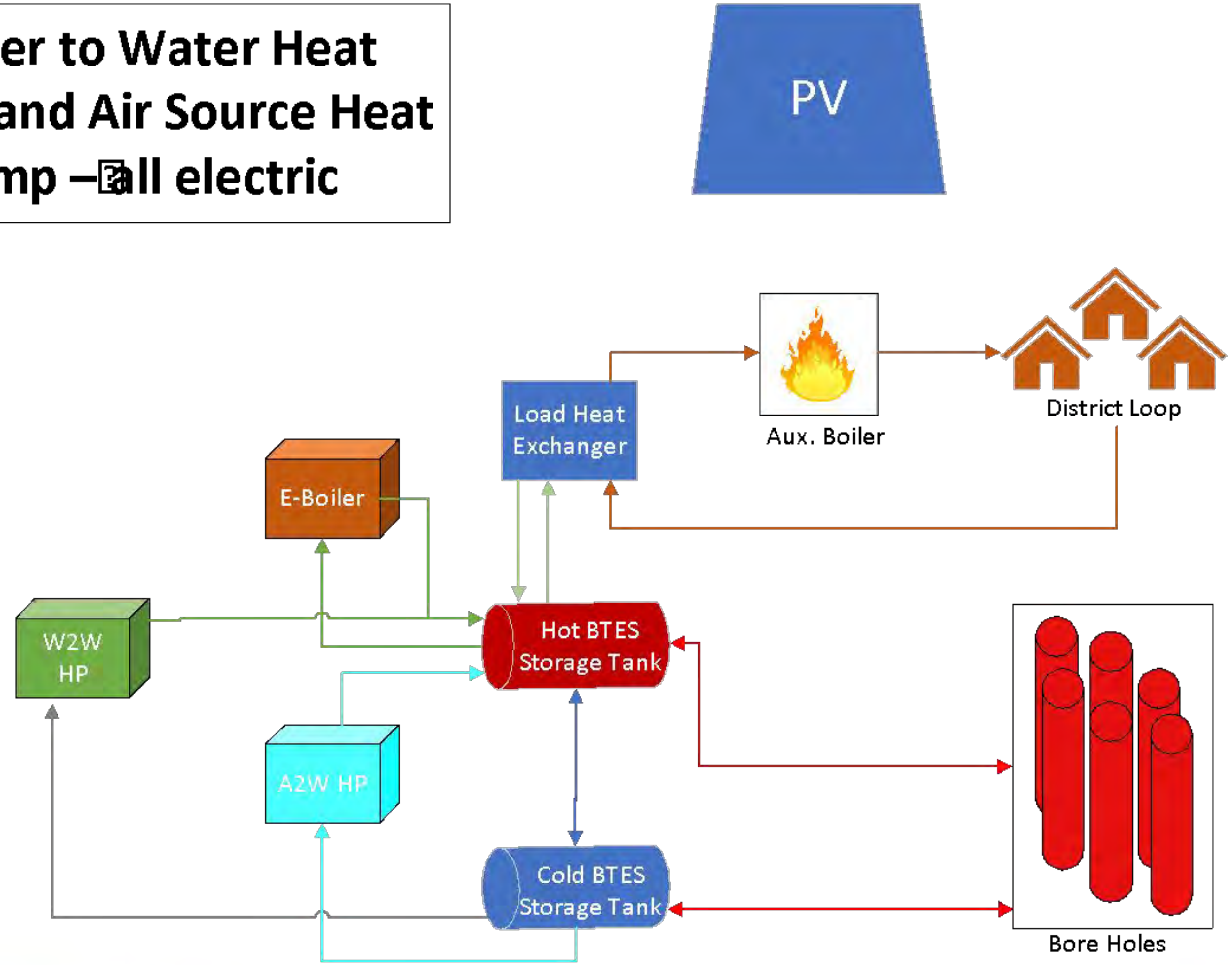



Enbridge Ontario Historical NG Prices and added Carbon Pricing
https://www.oeb.ca/consumer-information-and-protection/natural-gas-rates/historical-natural-gas-rates
Carbon Pricing
Historical Price
Same Commodity+Carbon Pricing
Natural Gas Price (cents/m³)
70
60
50
40
30
20
10
0
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Mar-23
Dec-25
Sep-28

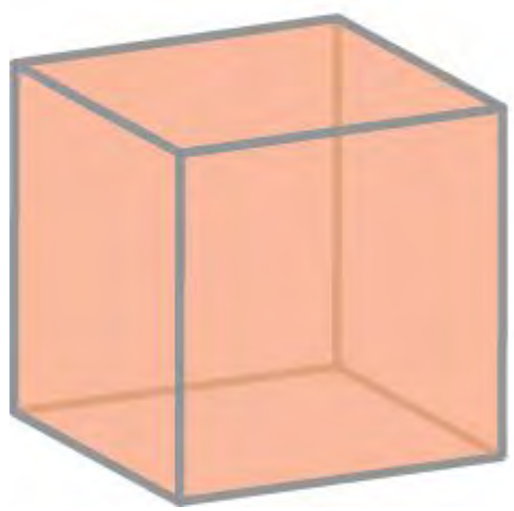
Conclusions for DLSC

- System has performed as expected and simulated
- Maintenance and operational cost challenges for small system – would co-op model help? Challenges due to low NG prices.
- Most maintenance costs from two design decisions: bellows with o'rings and vented water tank
- Pilots of this nature need funding for corrections after learning

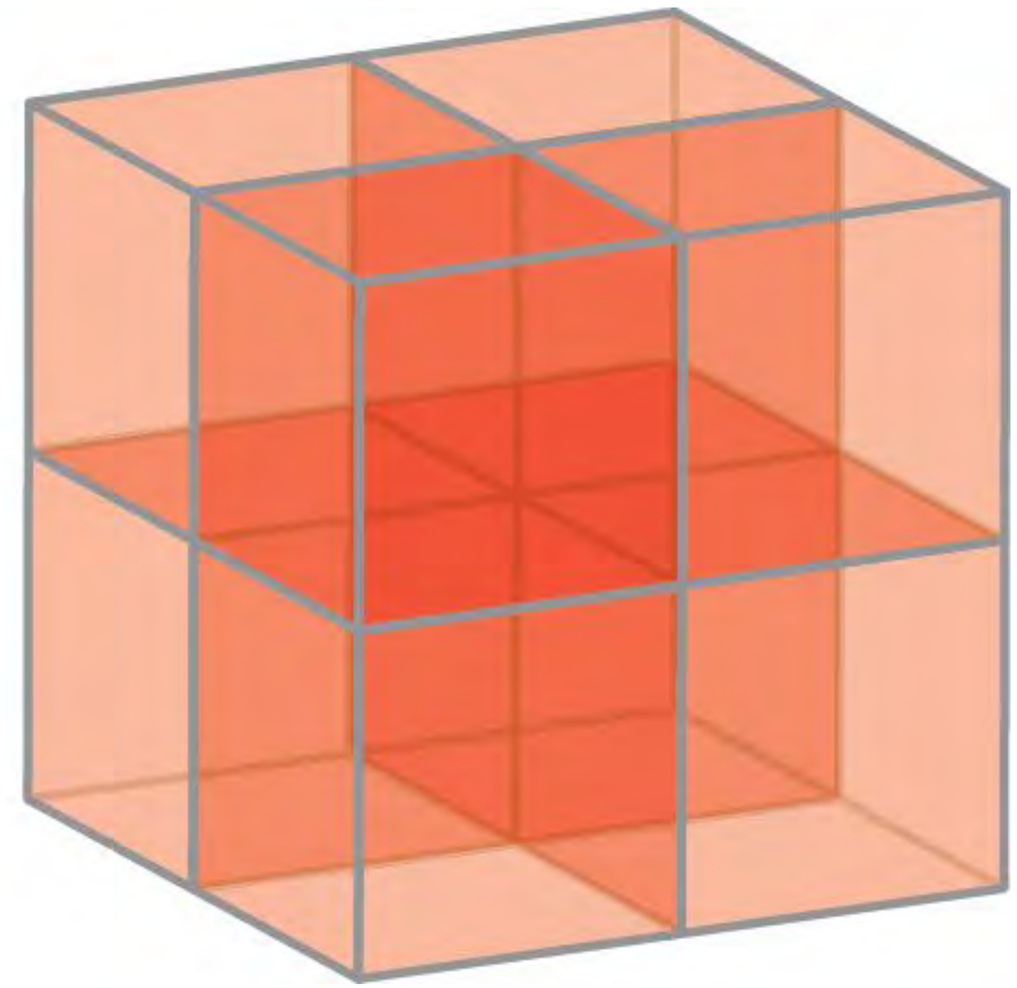
Water to Water Heat Pumps and Air Source Heat Pump – all electric



Efficiency vs Surface area / Volume ratio



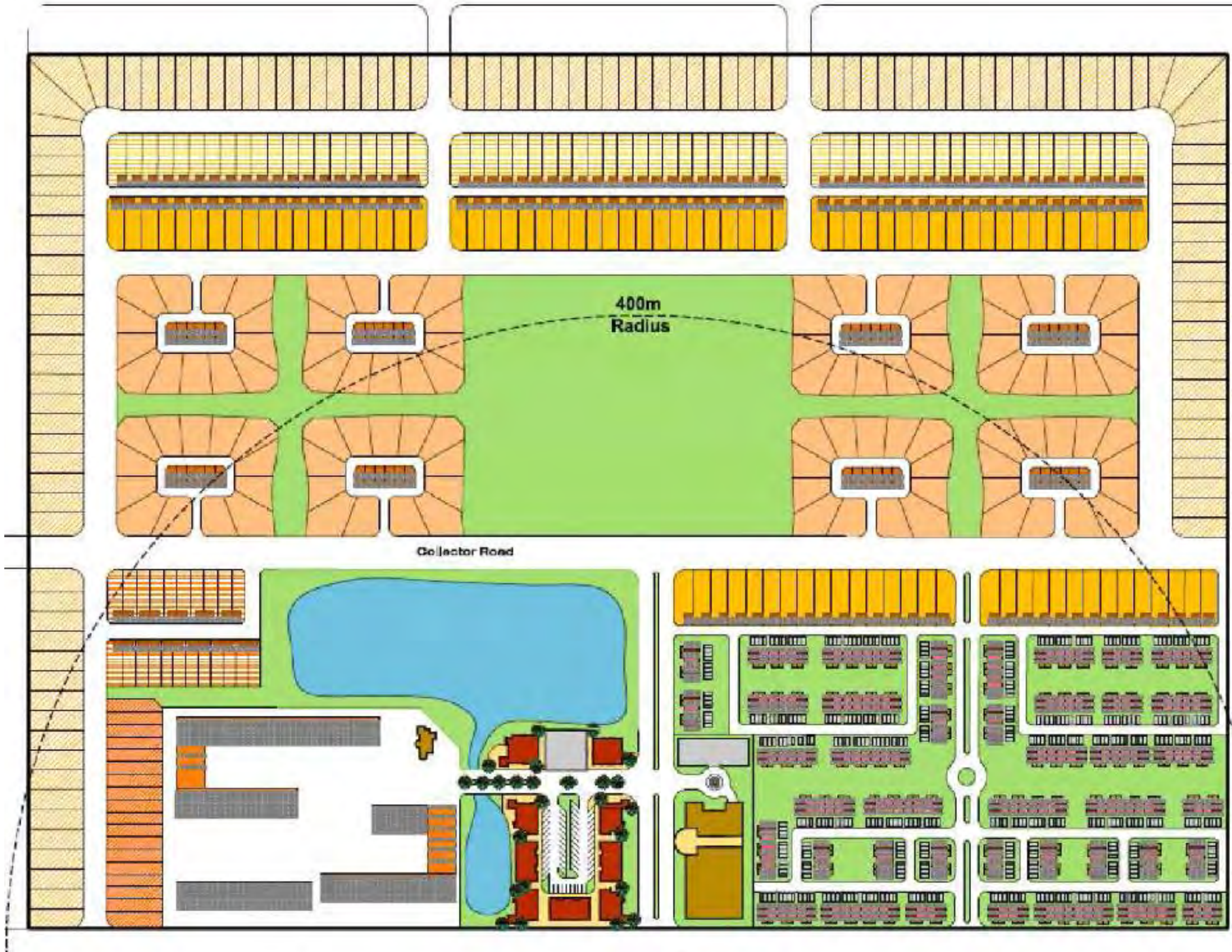
Volume: 34,000 m^3
Efficiency: 45%



Volume: 262,000 m^3
Efficiency: 77%

Can we have a large Net-Zero Community with reasonable density?

What would be the best technology scenario?



1000+Solar Community - Layout

Single Family Units

- Style 1: 2300 sqft Single Family Unit (104 Units)
- Style 2: 2000 sqft Single Fam., Front Garage (125 Units)
- Style 3: 1800 sqft Single Family Unit (89 Units)
- Style 4: 1600 sqft Single Family Unit (64 Units)

Multi Family Units

- Style 5: 1400 sqft Semi-Detached Unit (22 Units)
- Style 6: 1800 sqft Semi-Detached Unit (18 Units)
- Style 7: 1400 sqft End Unit Townhouse (84 Units)
- Style 8: 1200 sqft Interior Unit Townhouse (148 Units)
- Style 9: Apartment Building (400 Units @764sqft)

Commercial/Office Uses

- Commercial/Retail (approx. 30,000 sqft)
- Office (approx. 55,000 sqft)

Area = 41.78 hectares (103.25 acres)
Total Residential Units = 1054
Density = 25.23 uph (10.21 upa)

25 UPH - 10 UPA

Total estimated roof-top available area 20,097 m^2 (216,322 ft^2)

Electrical Plug + Lighting Loads

	Current Plug Load (kWh/day)
Detached	19
Town/Duplex	16
Apartments	14
TOTAL ANNUAL (MWh)	6,282
Required PV Area (m^2)	22,041

Can be reduced, but has impact on SH load

	Technology Scenario	DWH	Space Heating	Solar Tech	Seasonal Thermal Storage	Space Heating back-up
1	BAU	Gas storage	NG furnace	-	-	-
2	ST-BTES	Gas storage	DH	ST, PV	BTES	Gas Boiler
3	ST-BTES	Loop WWHP	DH	ST, PV	BTES	W(G)SHP
4	ST-BTES	Loop WWHP	DH	ST, PV	BTES	Elec Boiler
5	PV-ASHP	Storage ASHP/Instant Elec.	ASHP	PV	-	-
6	PV-GSHP	Storage ASHP/Instant Elec.	GSHP	PV+ Unglazed ST	-	-
7	PV+CO_2ASHP+BTES	Loop WWHP	DH	PV	BTES	CO_2-ASHP
8	HT-PVT-BTES	Loop WWHP	DH	HTPVT, PV	BTES	WSHP

	Technology Scenario	DWH	Space Heating	Solar Tech	Seasonal Thermal Storage	Space Heating back-up
1	BAU	Gas storage	NG furnace	-	-	-
2	ST-BTES	Gas storage	DH	ST, PV	BTES	Gas Boiler
3	ST-BTES	Loop WWHP	DH	ST, PV	BTES	W(G)SHP
4	ST-BTES	Loop WWHP	DH	ST, PV	BTES	Elec Boiler
5	PV-ASHP	Storage ASHP/Instant Elec.	ASHP	PV	-	-
6	PV-GSHP	Storage ASHP/Instant Elec.	GSHP	PV+ Unglazed ST	-	-
7	PV+CO_2ASHP+BTES	Loop WWHP	DH	PV	BTES	CO_2-ASHP
8	HT-PVT-BTES	Loop WWHP	DH	HTPVT, PV	BTES	WSHP

PVT collectors

Source: CanmetENERGY and and Naked Energy

	PV Area	Solar Thermal Area	TOTAL AREA FOR HEATING
	m^2	m^2	m^2
Base Case	35,134		35,134
ST+BTES+NGWH+PV	21,776	9,019	30,795
ST+BTES+HP+WWHPWH+PV	8,068	8,821	16,889
ST+BTES+EB+WWHPWH+PV	7,232	12,244	19,476
PV+ASHPWH+CCASHP	15,708	-	15,708
PV+ASHPWH+GSHP	11,060	6,378	17,438
PV+CO_2ASHP+BTES+WWHPWH	18,274	-	18,674

Conclusions

- Not enough roof area
- No significant difference between low-carbon options in terms of total required area
- Many questions remain

Next Steps

- Optimize energy efficiency options for buildings
- Optimize scenarios based on cost functions and optimal buildings design
- Evaluate technical potential for building integrated panels - BIPV/BIST/BIPVT
- Propose solutions for required area within the community

Next Steps

- Finalize PVT scenario
- Add cost functions (can two utilities scenario compete with a single one?)
- Evaluate electrical peak demand (what is the value of self-consumption?)
- Add resiliency as parameter

Thank You!

lucio.mesquita@nrcan-rncan.gc.ca
www.dlsc.ca

BIPV, Building-Grid Interaction and Dynamic Pricing of Electricity
Andreas Athienitis

The presentation begins with an introduction to major international trends in high performance buildings, including the adoption of net-zero energy, energy flexibility, and artificial intelligence to integrate and use building automation. It highlights the need for energy flexibility and identifies key research facilities and an overall approach to reaching these goals. The presentation looks at the Varennes Municipal Library (Quebec) as a case study. The presentation posits that using BIPV in buildings will become more cost-effective when integrated with energy storage, heat pumps, and electric vehicles.

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

BIPV, BUILDING-GRID INTERACTION AND DYNAMIC PRICING OF ELECTRICITY

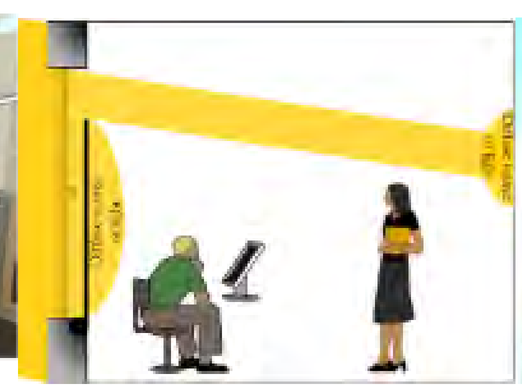
Andreas Athienitis, Professor and Director, Concordia Centre for Zero Energy Building Studies, Montreal

IEA SHC Task 63 Seminar on Solar Neighborhoods, Calgary, September 23, 2022

Major international trends in high performance buildings

- Adoption of net-zero energy (ASHRAE) as a long term goal; nearly zero or net-zero ready in some cases until 2030. Carbon-neutral is another common goal.
- Measures to reduce/shift peak electricity demand from buildings, thus reducing the need to build new power plants; optimize interaction with smart grids; resilience to climate change; charging EV; **energy flexibility** in buildings;
- Steps to efficiently integrate new energy technologies such as building-integrated photovoltaics, thermal and electrical storage;
- Increased use of IoT technologies; massive amounts of data – use of artificial intelligence (AI) techniques to integrate and efficiently use building automation and information systems.

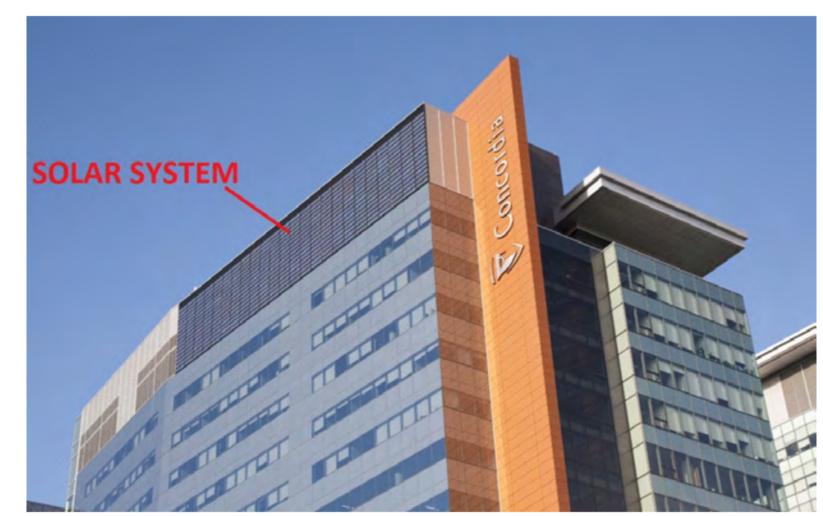
NREL RSF



Bottom-up shades

STPV

EcoTerra BIPV/T



Concordia JMSB

Near net-zero house

Ecoterra house (Chen et al., 2010)

- 2-story residential building
- Roof BIPV/T:
  - o *DHW heating*
  - o *Space heating*
  - o *Clothes dryer*

o *2007 - 2011*

JMSB building - Concordia

JMSB (Athienitis et al., 2010)

- High-rise institutional building
- UTC – PV/T hybrid
- Façade BIPV/T
  - o *Fresh air pre-heating heating*

o *2009*

Varennes Library

BIPV/T roof on Varennes library

- 2-story institutional building
- Roof BIPV/T
  - o *Fresh air pre-heating heating*

o *2011 - 2016 ongoing for grid interaction*

Solar Decathlon entry

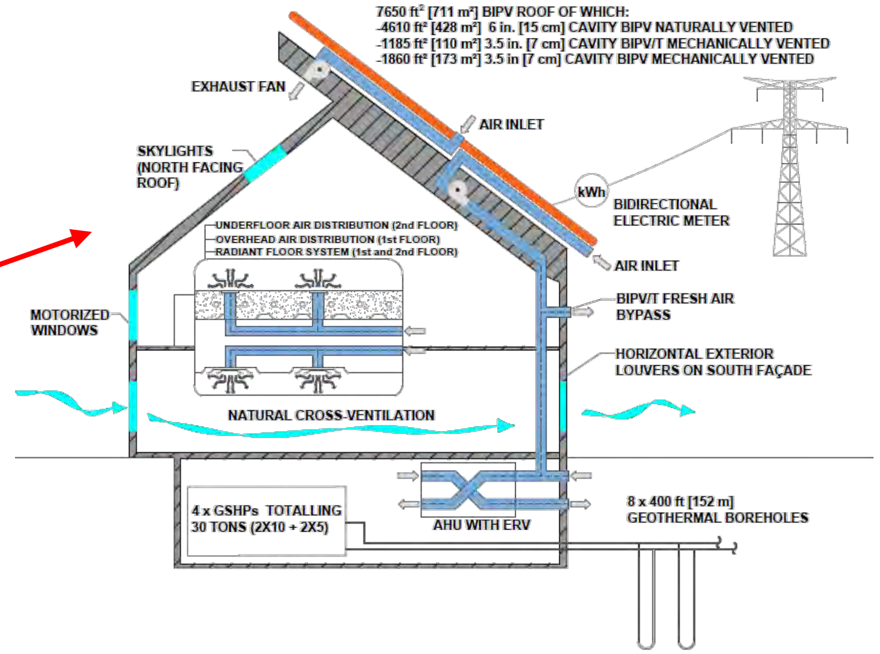
DPD (Rounis et al., 2018)

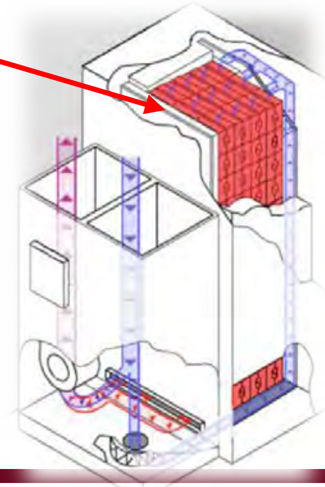
- 2-story residential building
- *Row house typology*
- Roof BIPV/T
  - o *Air/water Heat Pump*
  - o *Storage tank*
  - o ***Solar Decathlon China 2018***

In the presentation will use the term BIPV/T to also include BAPV/T

Background – need for energy flexibility

- **Buildings account for nearly 60% of electricity consumption in Québec** - even more important during peak demand periods of the grid due to high consumption of electricity for space heating during extreme cold weather. During 2022 – extreme cold winter peak demand **reached 40.51 GW**.
- Buildings contain thermal mass – the cheapest form of energy storage that can be used to provide flexibility to the grid by preheating outside the peak periods.
- Active thermal storage in the form of radiant floor (TABS) can also provide more controllable heat storage to reduce peak demand (eg Varennes Library, Schools). Hot water tanks (e.g. LTE PVT system).
- Active high temperature thermal storage (e.g. ThermElect) can also be used as part of an HVAC system to provide peak load reduction and shifting (demand response, MPC).
- Battery/EV charging/discharging strategies for buildings.
- It is important to be able to model, quantify and predict the **flexibility** that can be provided to the smart grid.





High temperature thermal storage

School with geothermal heat pump, floor and air heating

Key research facilities and overall approach

- Utilize building physics and data from buildings such as those monitored by Hydro Québec and the *Experimentation Houses for Building Energetics (EHBE)* develop a methodology for generation of **reduced order data driven grey-box RC models (ROMs);**
- Validate key models in SSEC facility, EHBE and **case studies;**
- Reduced order models (ROMs) form the basis of **model predictive control (MPC)** to realize the predicted **energy flexibility;**
- **Methodology for automatically generating** and calibrating data driven models – applied to selected houses monitored by LTE
- **Zone and building archetypes for flexibility and MPC – Position paper (IBPSA Building Simulation Journal)**
- **Heuristic MPC planned/started for selected case studies/zones**

EHBE facility (LTE)

SSEC lab

FBL

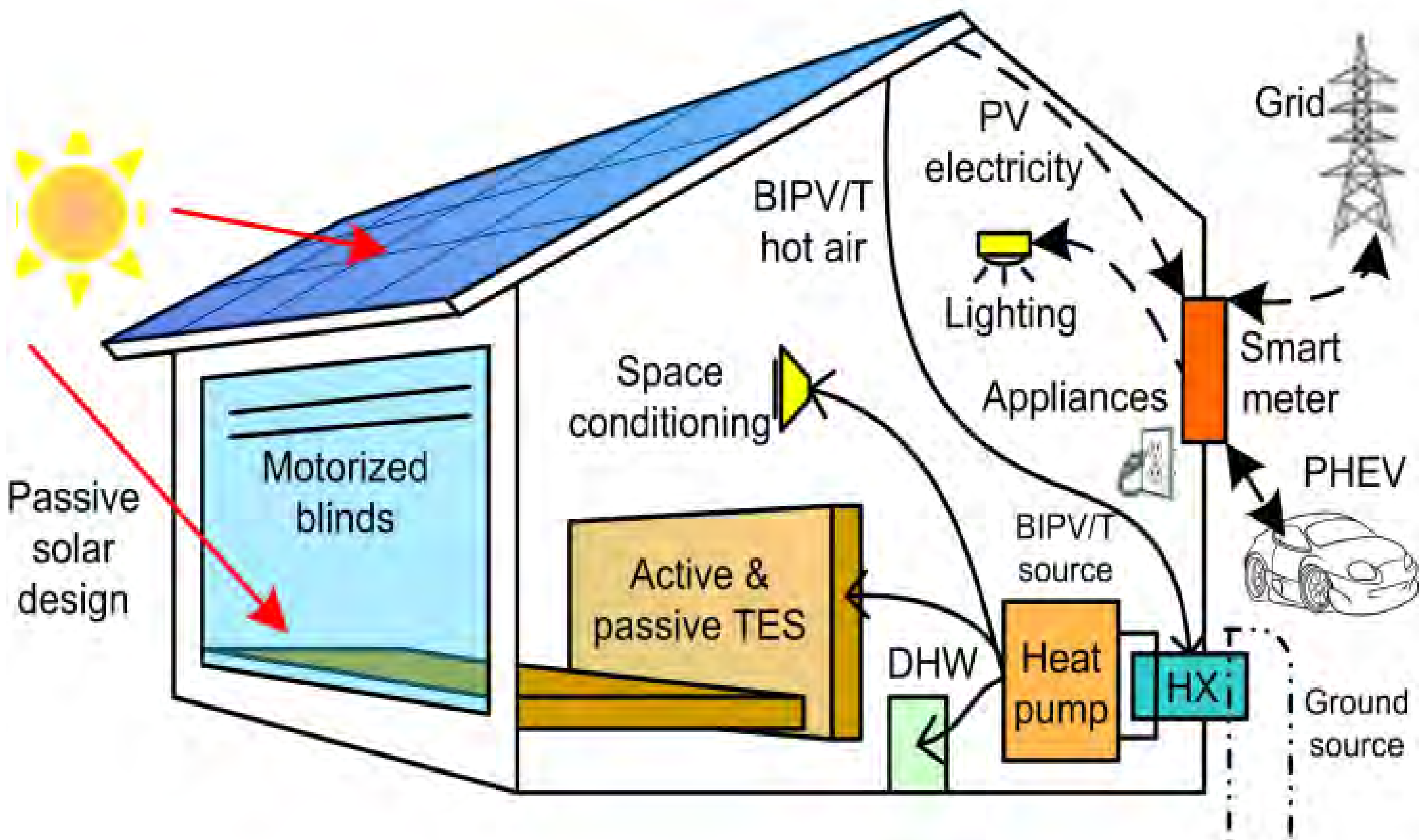
LTE – smart building PVT + storage + load

Varennes Library – NZEB with heat pump, active thermal storage and BIPV/T

Smart Solar Building concept – towards resilience/net zero

Optimal combination of solar and energy efficiency technologies and techniques provides **different pathways to high performance and an annual net-zero energy balance**

Solar energy: electricity + daylight + heat



Integrated approach to **energy efficiency and passive design**

Integrated design & operation

Solar optimization: requires **optimal design of building form**

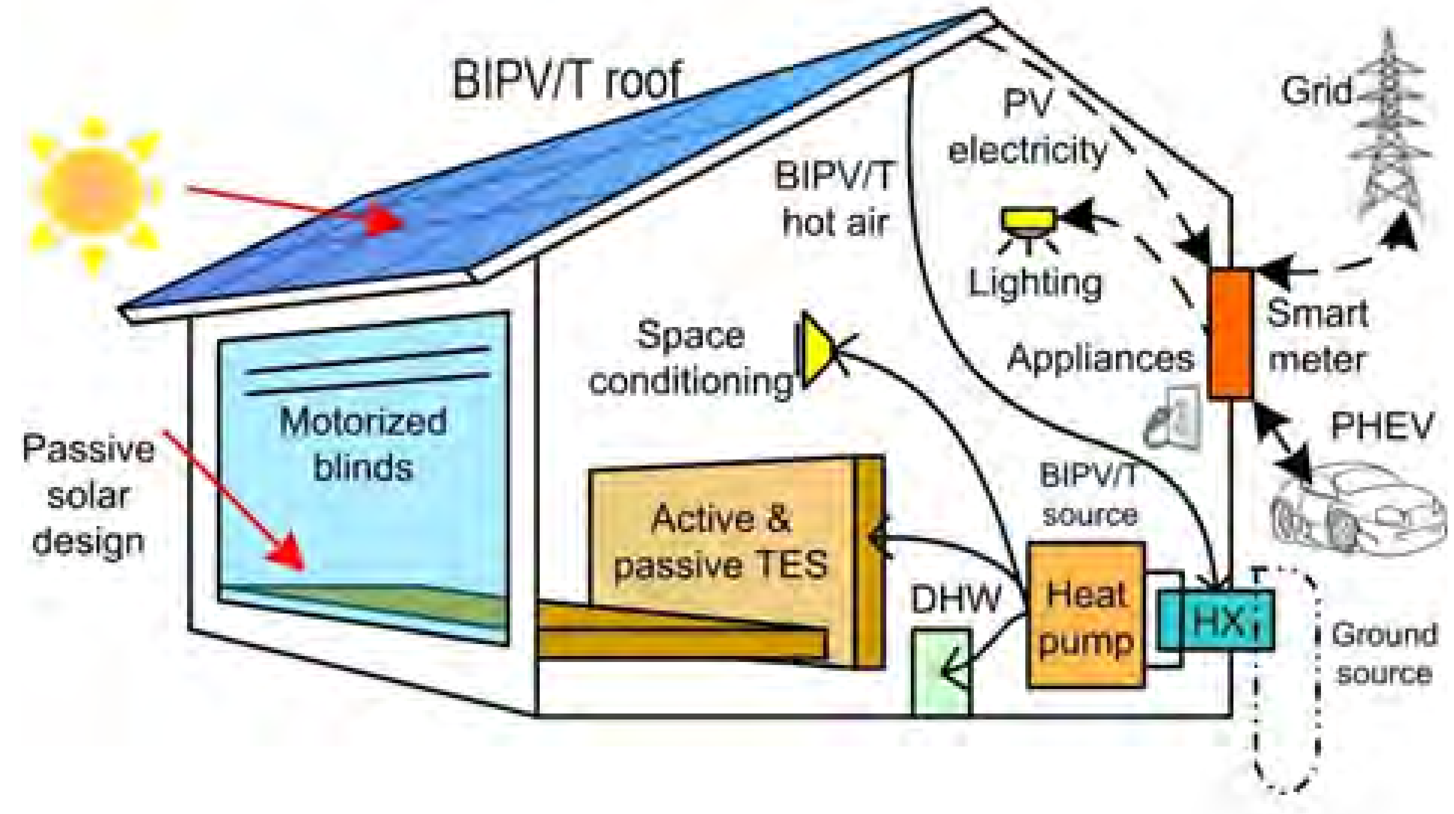
Key design variables: geometry – solar potential, thermal insulation, windows, BIPV, energy storage

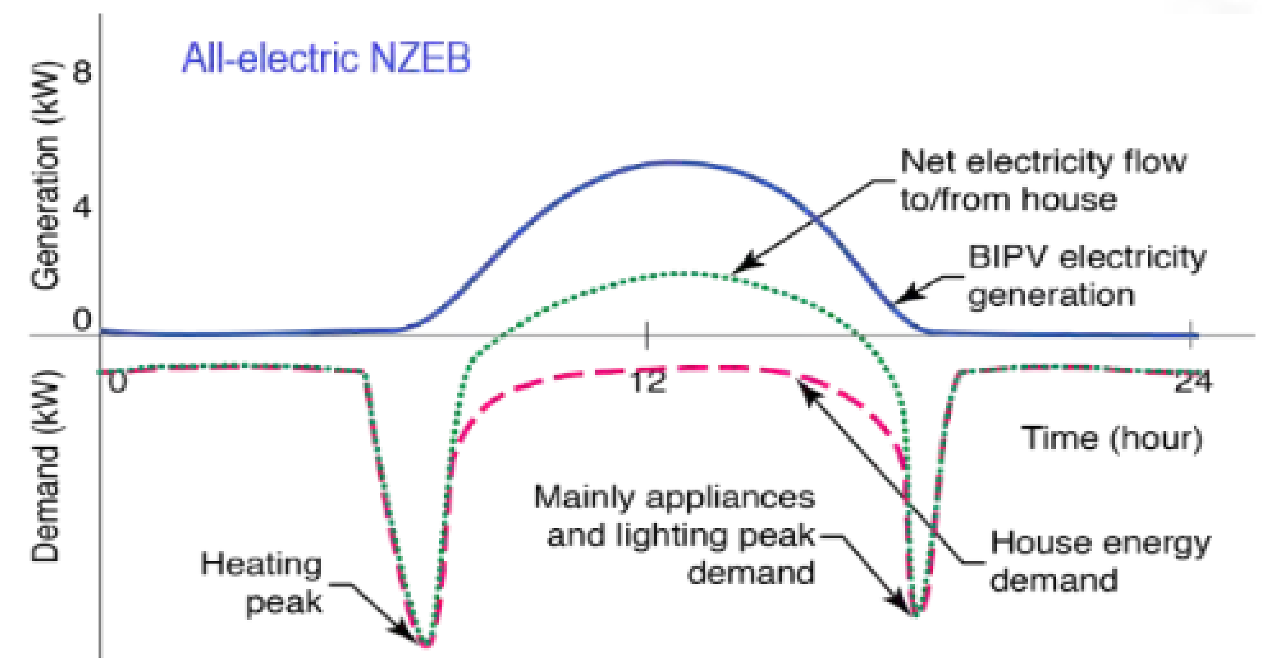
Integrated smart solar building concept and grid integration – need for energy flexibility

8

Varennes Library, Canada's first net-zero energy Institutional building designed with our guidance (2016).

Currently studying/optimizing its grid interaction under NSERC/Hydro Quebec Industrial Research Chair





Building Energy Flexibility Index (BEFI)

A methodology for the definition and calculation of a dynamic as a state variable was developed.

The dynamic energy flexibility is defined as the capability for a building to:

(a) reduce its electricity demand during a critical period for the grid; and

(b) reduce or increase its electricity consumption anytime when needed for the grid.

BEFI in zone level:

$$\overline{BEFI}(\mathrm{t},\mathrm{Dt}) = \frac{\int_t^{t+Dt} P_{\mathrm{Ref}}dt - \int_t^{t+Dt} P_{\mathrm{Flex}}dt}{Dt}$$

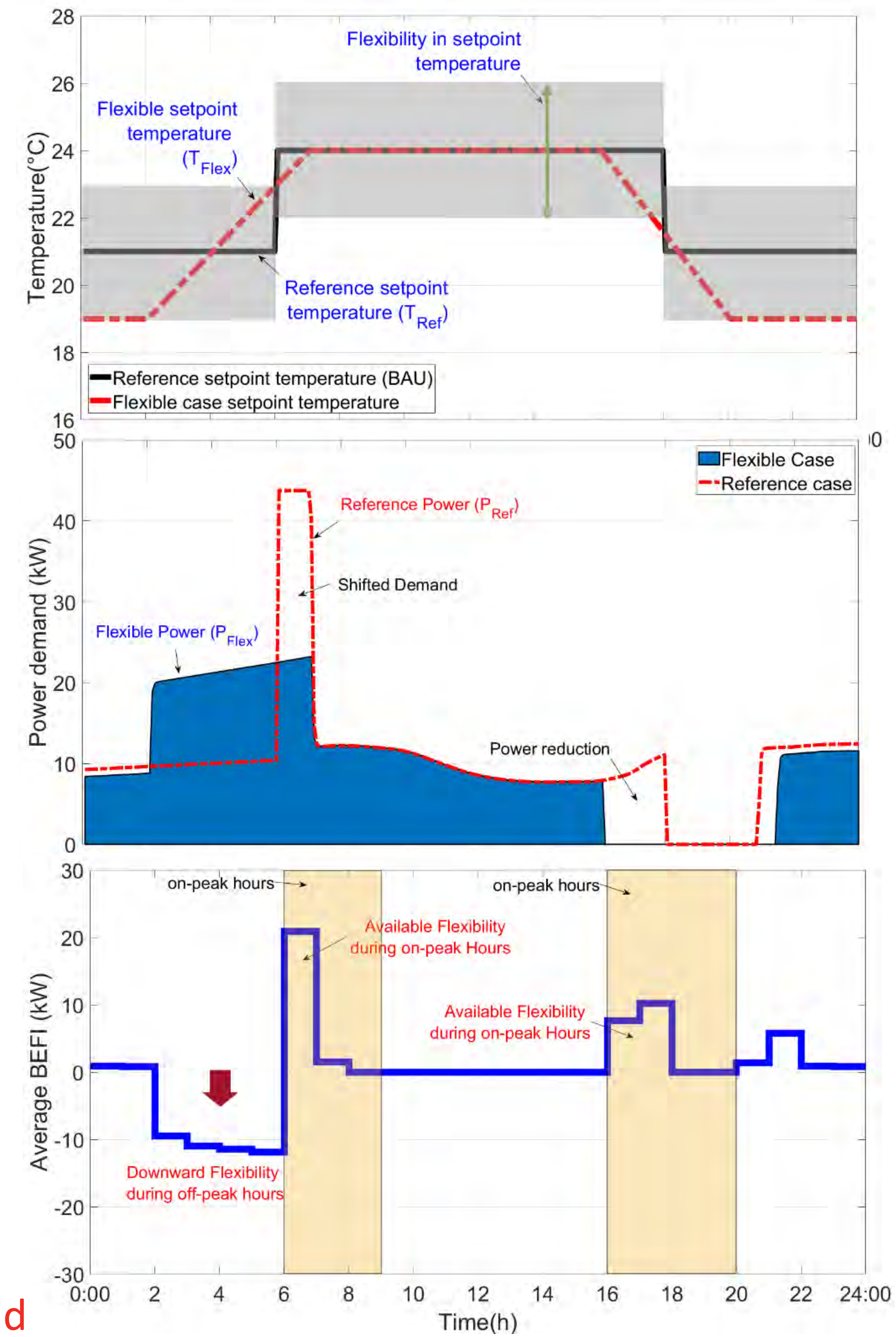
BEFI as percentage:

$$BEFI\% = \frac{\bar{P}_{\mathrm{Ref}} - \bar{P}_{\mathrm{Flex}}}{\bar{P}_{\mathrm{Ref}}} \times 100$$

BEFI in Building level:

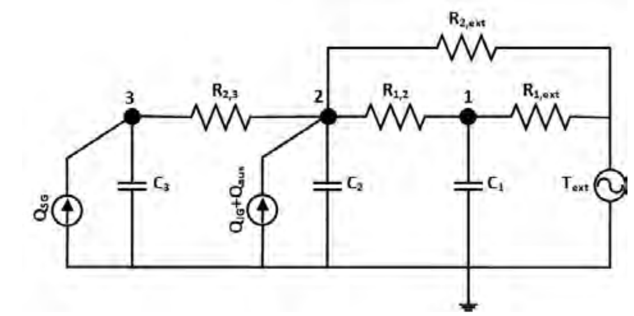
$$\overline{BEFI}_{\mathrm{Building}} = \sum_{1}^{n} BEFI_{\mathrm{Zone}}$$

Reduce electricity consumption during peak (high price) periods or sell to grid

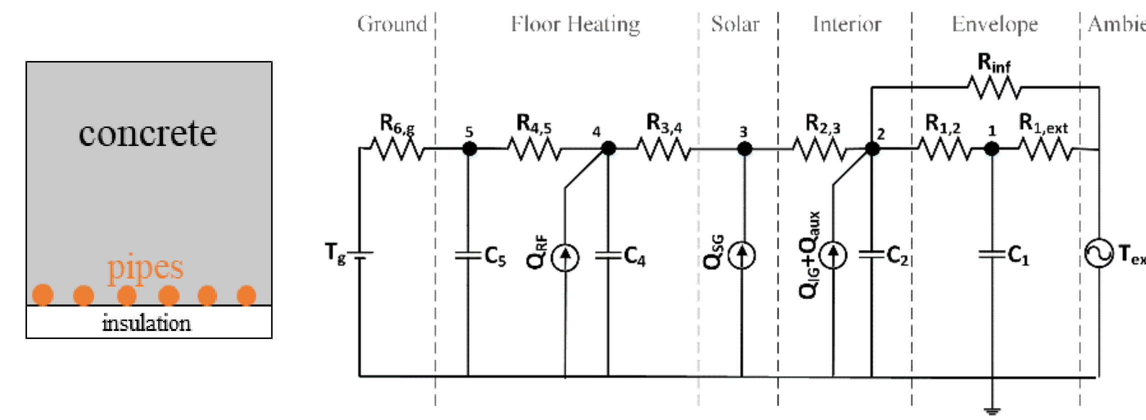


Archetype zones and archetype buildings – RC models and BEFI

Classroom heated with convective (forced air) systems – 3rd order RC model and zone BEFI   (school case study)



Thermal zone that includes radiant floor heating – 3rd – 4th order RC model and zone BEFI (school, Varennes Library)

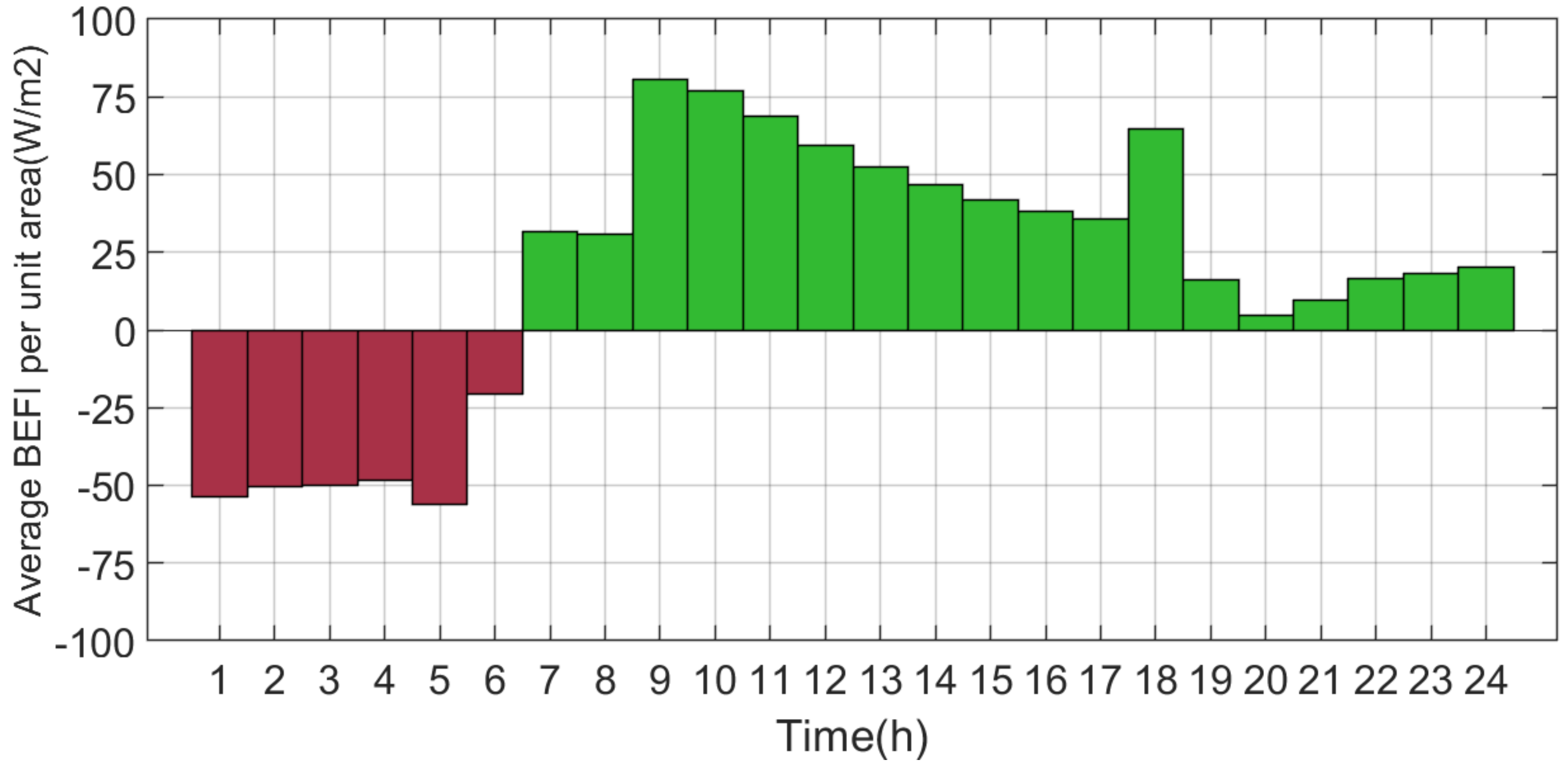


BEFI for thermal storage: e.g. associated with liquid PV/T (e.g. LTE building retrofit)

3rd order RC model archetype for 2-storey houses such as EHBE (baseboard convective heating)

System BEFI from building zones or group of buildings calculated from subsystem BEFIs; applied to school case study

Horizon du Lac School - Building level Flexibility – BEFI system preliminary results



The uncertainty of BEFI is determined by the **uncertainties** in both **model formulation** and **weather forecast**.

Uncertainty in modeling: ±15% for parameter identification

Uncertainty in weather forecast: ± 3% for one to three hours prediction

- The school has **potential flexibility of between 50 to 80 kW,** which represents between **40% to 65% building level energy flexibility.**
- Considering that there are more than 2,600 schools in Québec, there is potential flexibility of about **208 MW peak load reduction in the morning, and 130 MW in the afternoon when needed by the grid**.

Navid Morovat

Varennes Library – Canada's first institutional solar NZEB

Officially opened May 2016

- 110 kW BIPV system (part BIPV/T)
- Geothermal system (30 ton)
- Radiant floor slab heating/cooling
- EV car charging
- Building received major awards (e.g. **Canadian Consulting Engineering Award of excellence**)

Market is ready for such projects provided standardized BIPV products are developed
Now modelling and optimizing operation and grid interaction under a NSERC Hydro Quebec Chair

We guided the energy design of the building

Typical institutional building energy consumption:
250-300 kWh/m²/yr

Example of net-zero energy building:
Energy consumption: 70 kWh/m²/yr
Energy production: 54 kWh/m²/yr
Displaced grid electricity: 81 kWh/m²/yr

Varennes Municipal Library (2016) – Solar NZEB - DESIGN

South elevation – before final

Official opening:
May 16, 2016

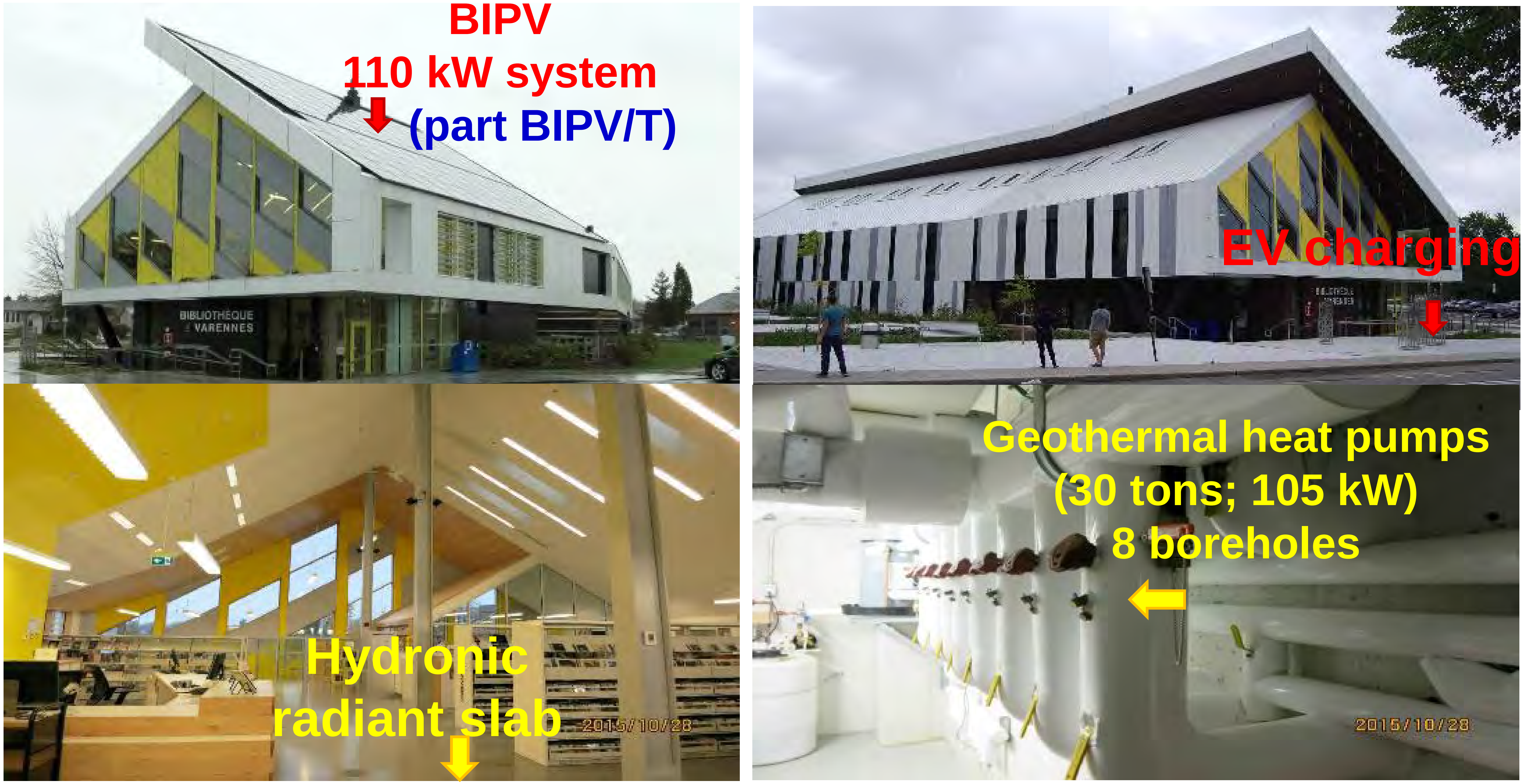
2017 sq.m. NZEB

First public institutional designed solar NZEB in Canada
110 kW BIPV (part BIPV/T), Geothermal
Radiant heating/cooling, passive solar

Our team provided advice: **choice and integration of technologies and early stage building form**
Design required several iterations - e.g. **final choice of BIPV system required minor changes in roof** design for full coverage. **Roof slope close to 40 degrees to reduce snow accumulation.**

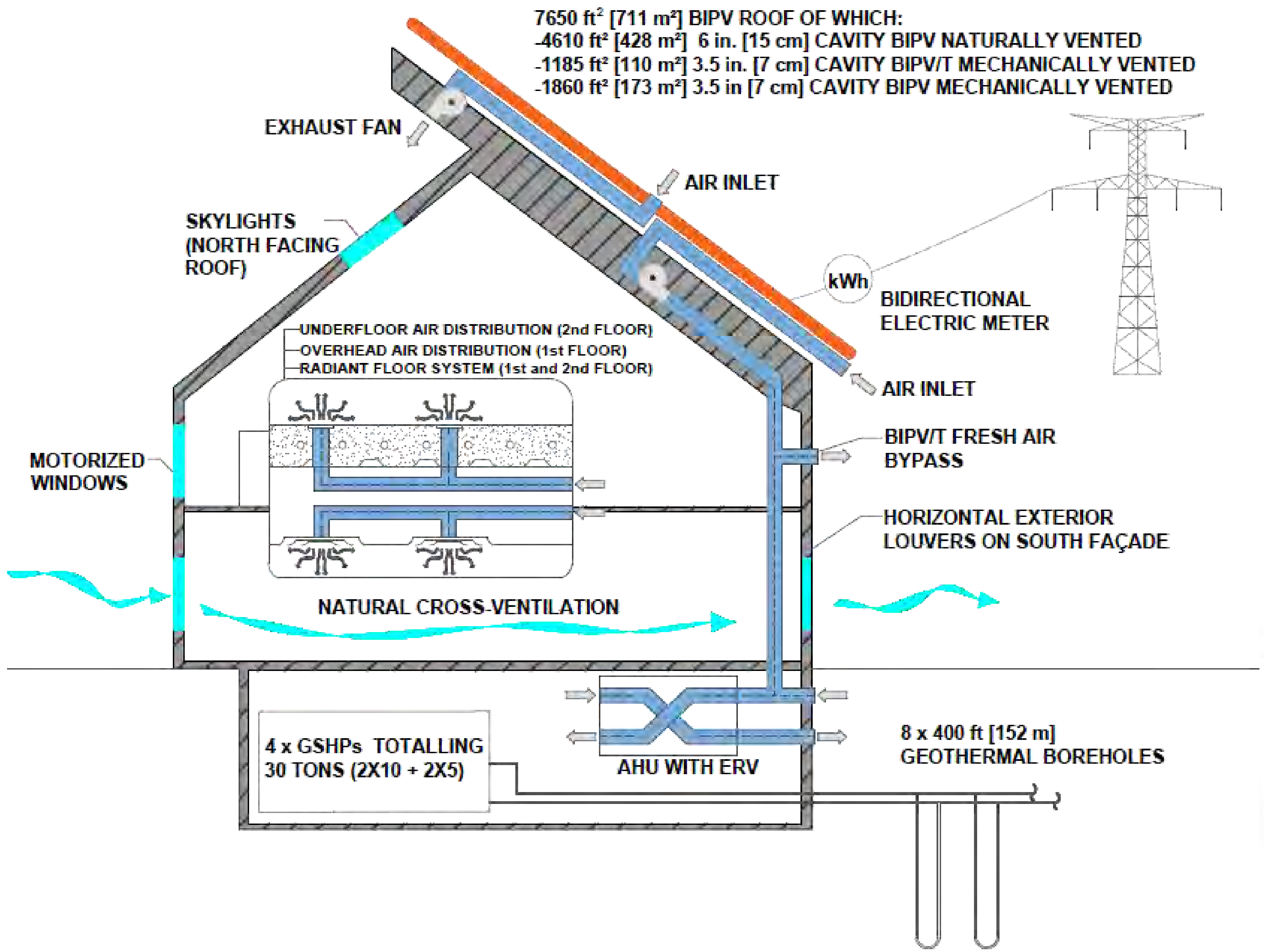
PRESENTLY MONITORING PERFORMANCE & OPTIMIZING OPERATION

Varennes Library – key features

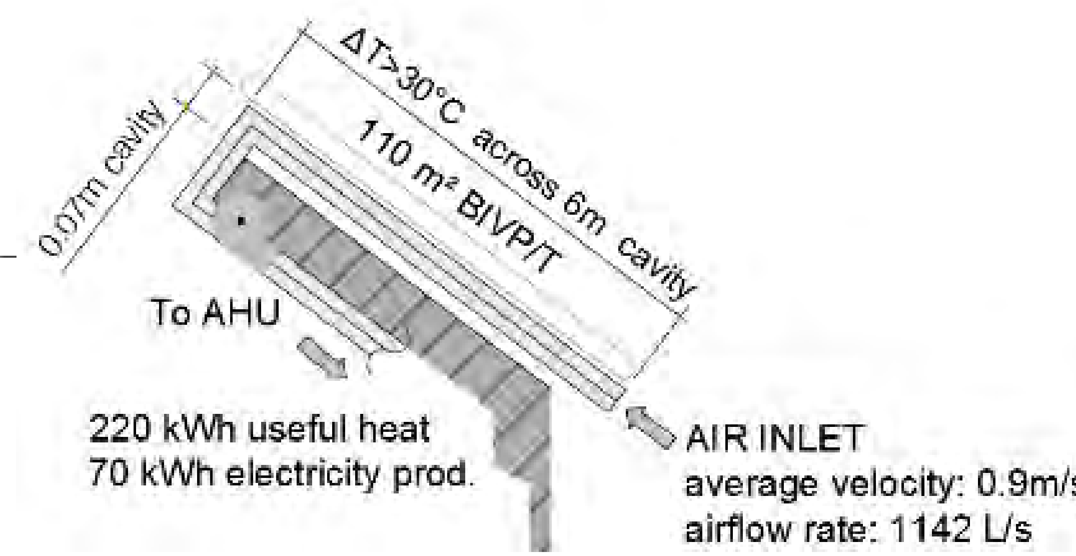


Reaches net zero (primary energy factor for hydro about 1.4), consumption 60-70 kWh/m2/year

LIBRARY SYSTEMS: HEAT PUMP, THERMAL STORAGE, BIPV/T, EV



- Custom BIPV/T, one inlet
- Fan activated for outlet air temperature >25°C
- Rated electrical efficiency: 15.9% STC
- Combined efficiency up to ~60% (thermal + electrical)



Energy flexibility modelling based on measured data

Overview of energy flows in a NZEB like Varennes Library

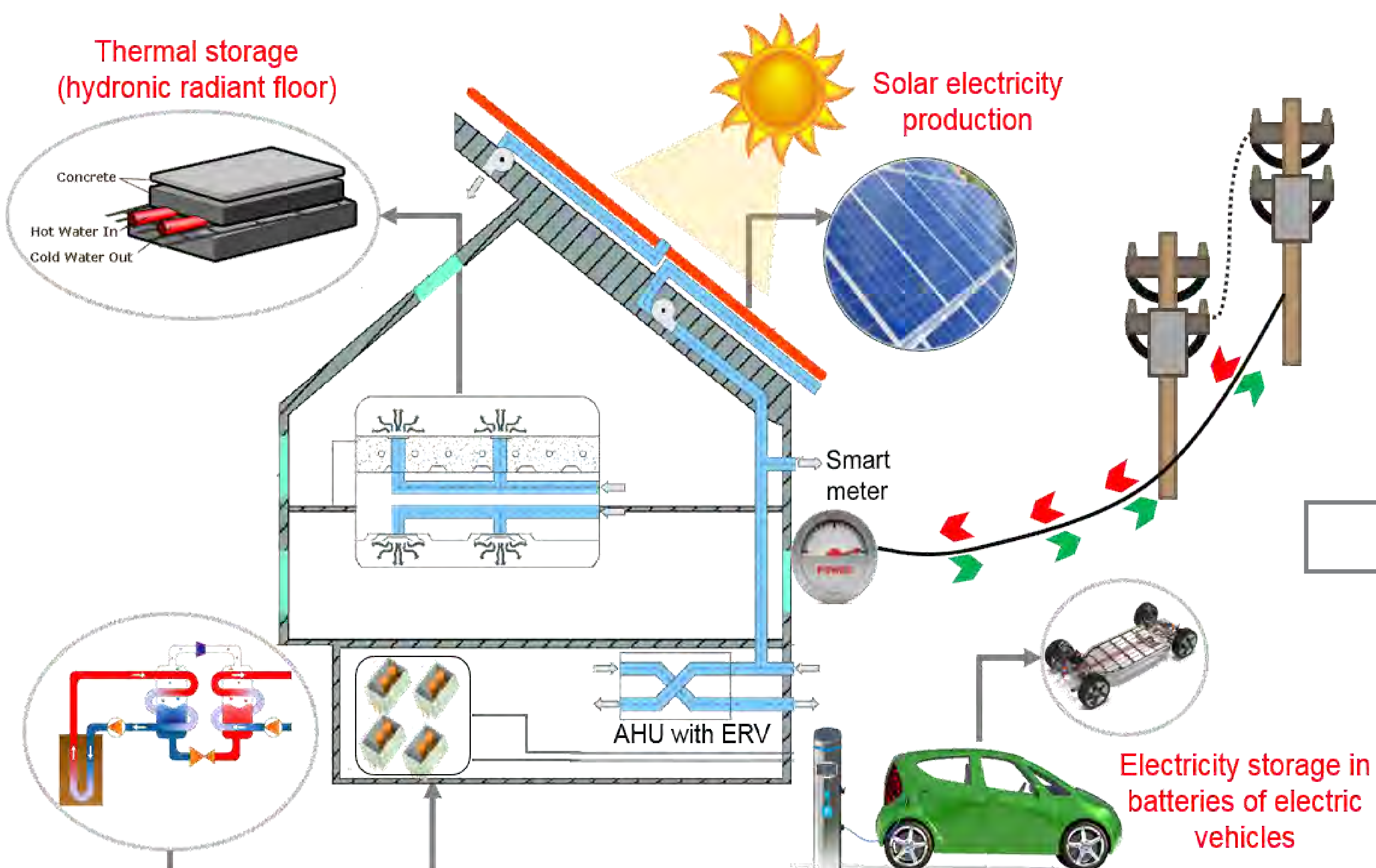
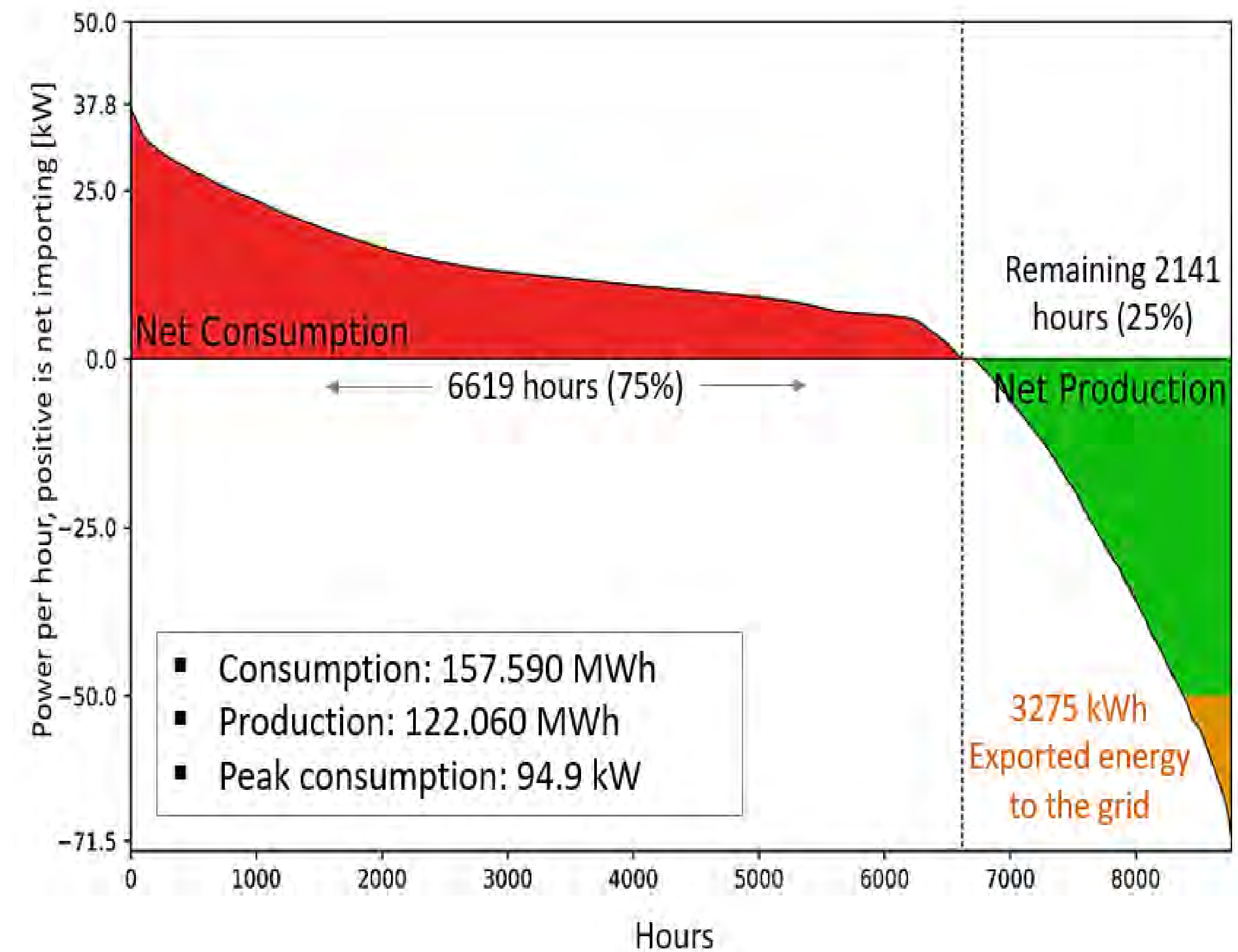


Illustration of different energy technologies that can be used to enhance flexibility in the operation of the Varennes library



Load duration curve: [top] net consumption, [middle] net production and [Bottom] the energy exported free to grid

Note: grid will buy up to a max. of 50 kW from building

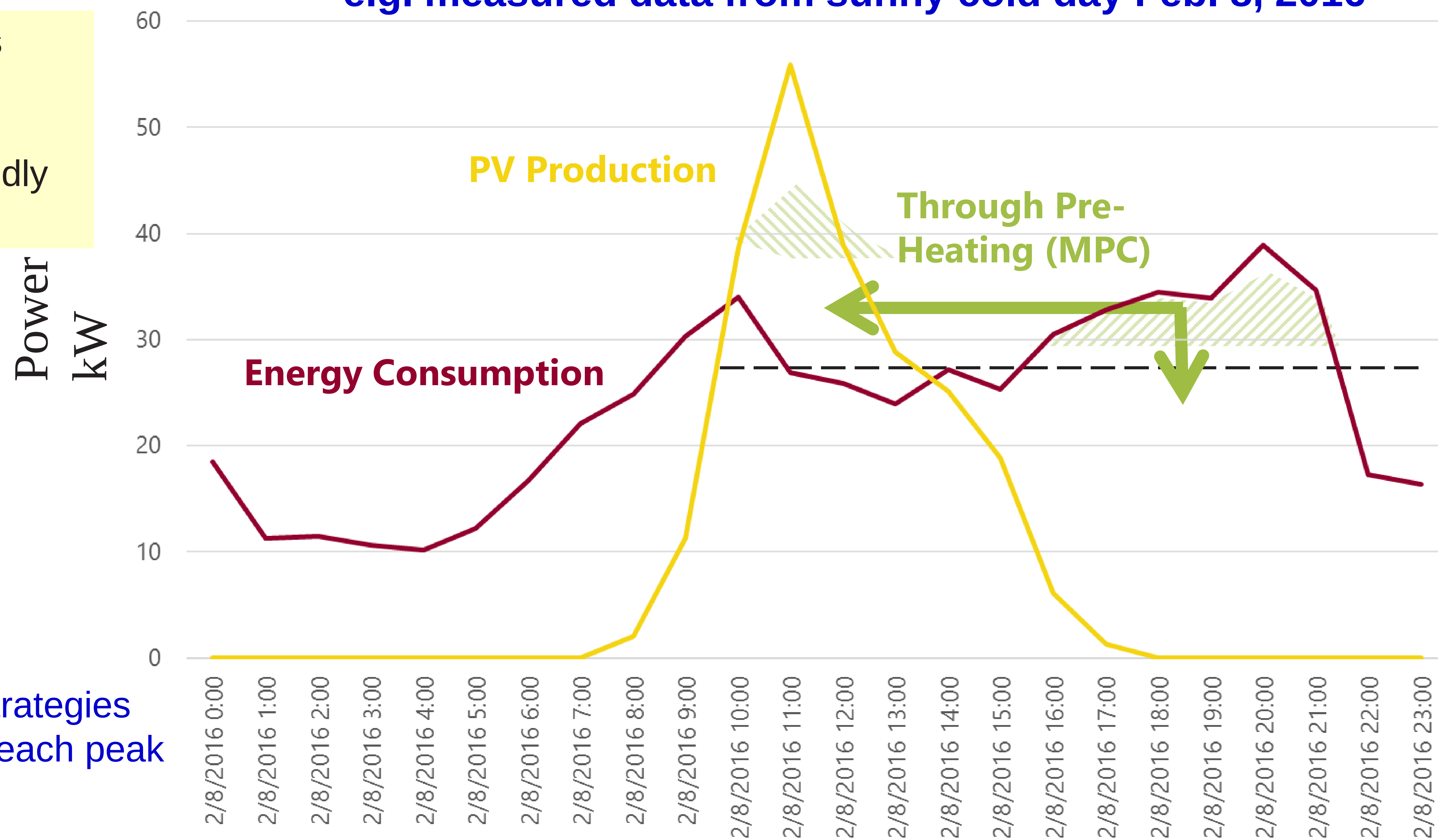
Production and Consumption Mismatch:

use predictive control to reduce peak demand during cold days

e.g. measured data from sunny cold day Feb. 8, 2016

Varennes Library:

Grid-friendly NZEB?

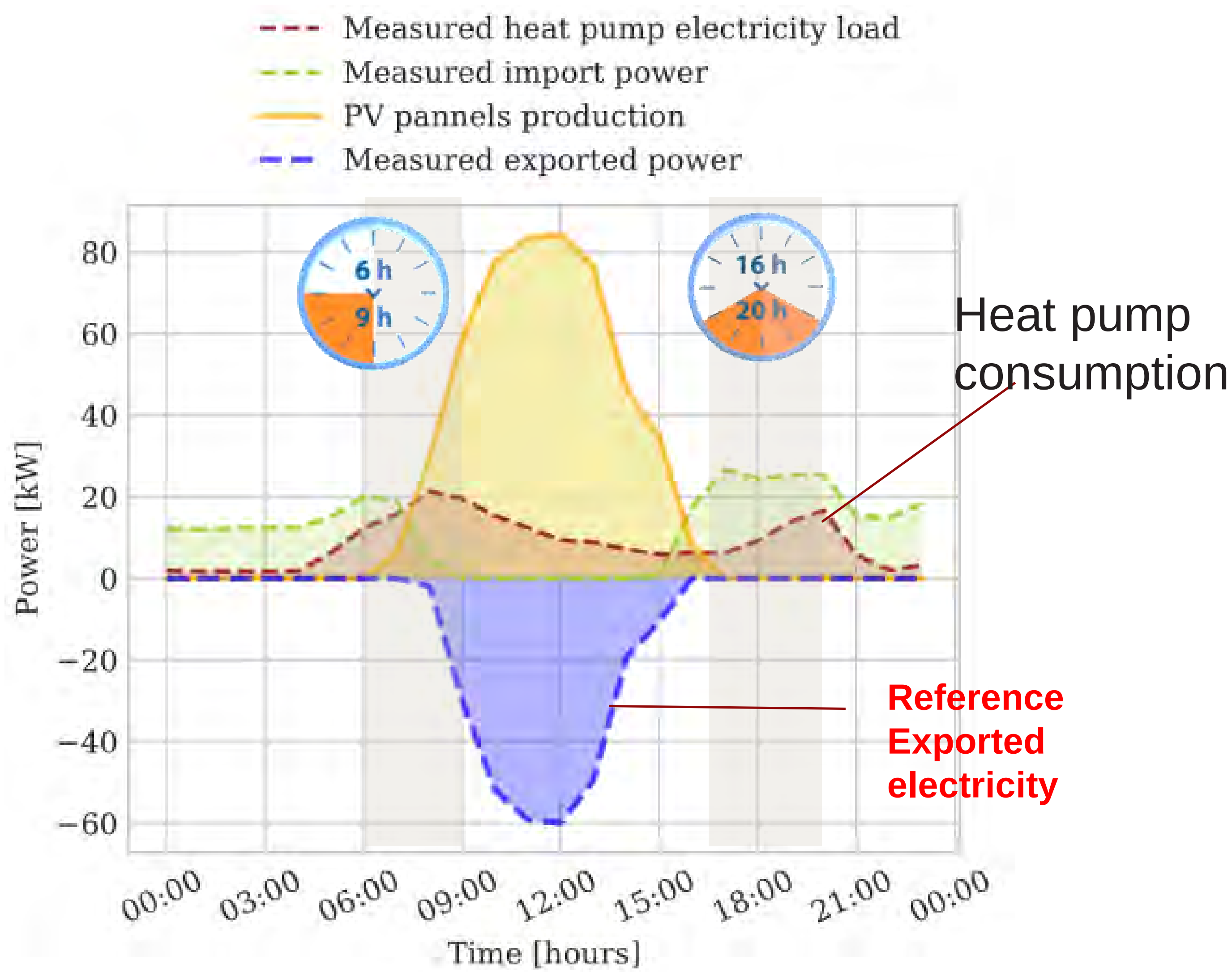


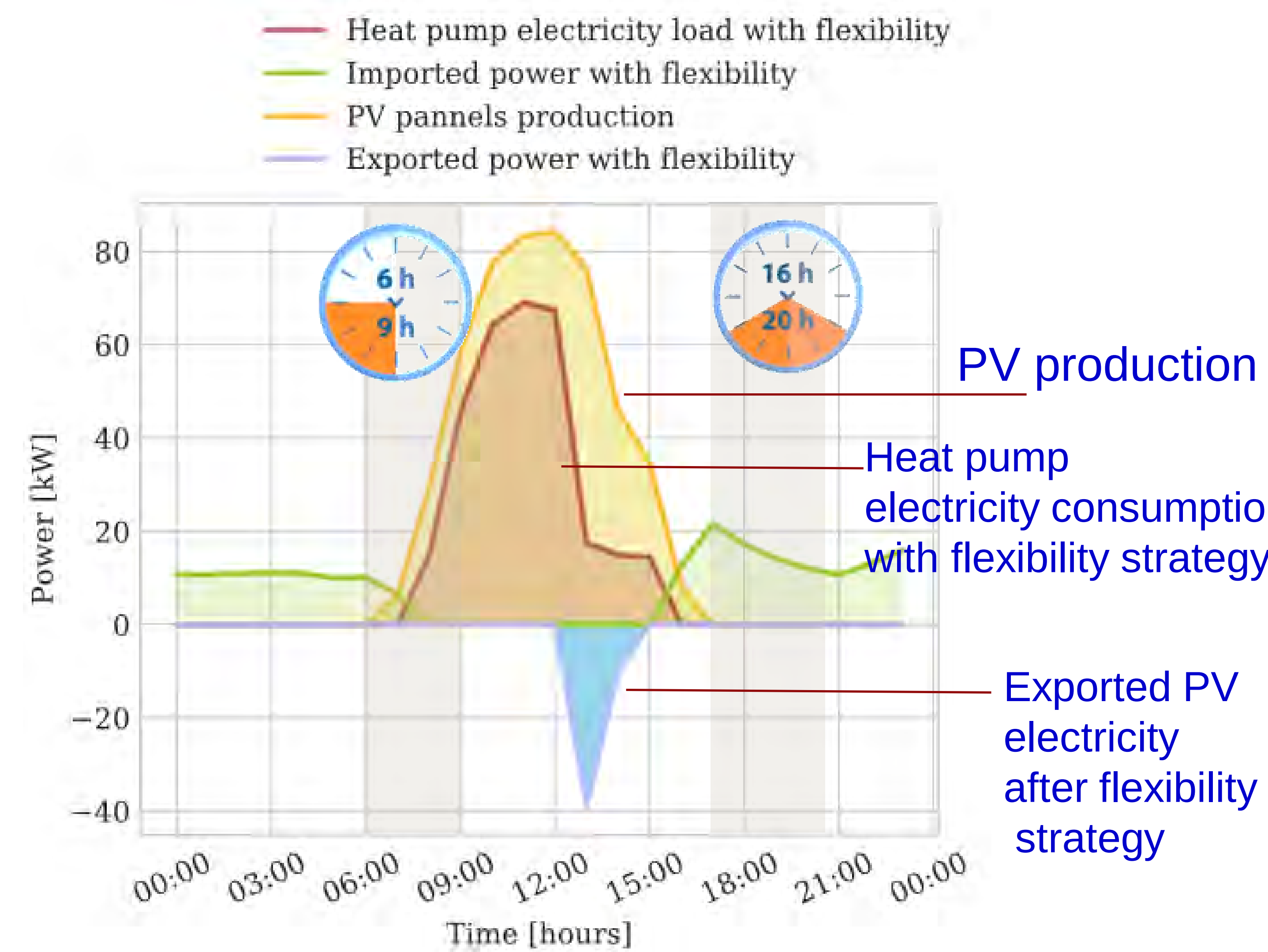
Smart NZEB can become **tool of the grid through MPC**

Quantify & Harness energy flexibility

Different strategies
To reduce each peak

VARENNES LIBRARY ENERGY FLEXIBILITY MODELLING WITH MEASURED DATA





Measured data as a reference scenario
sunny cold day on February 2, 2018

Energy flexibility quantification and use:
sunny cold day on February 2, 2018

To reduce consumption during peak periods of the grid and **increase self consumption** of PV electricity (outside peak periods)

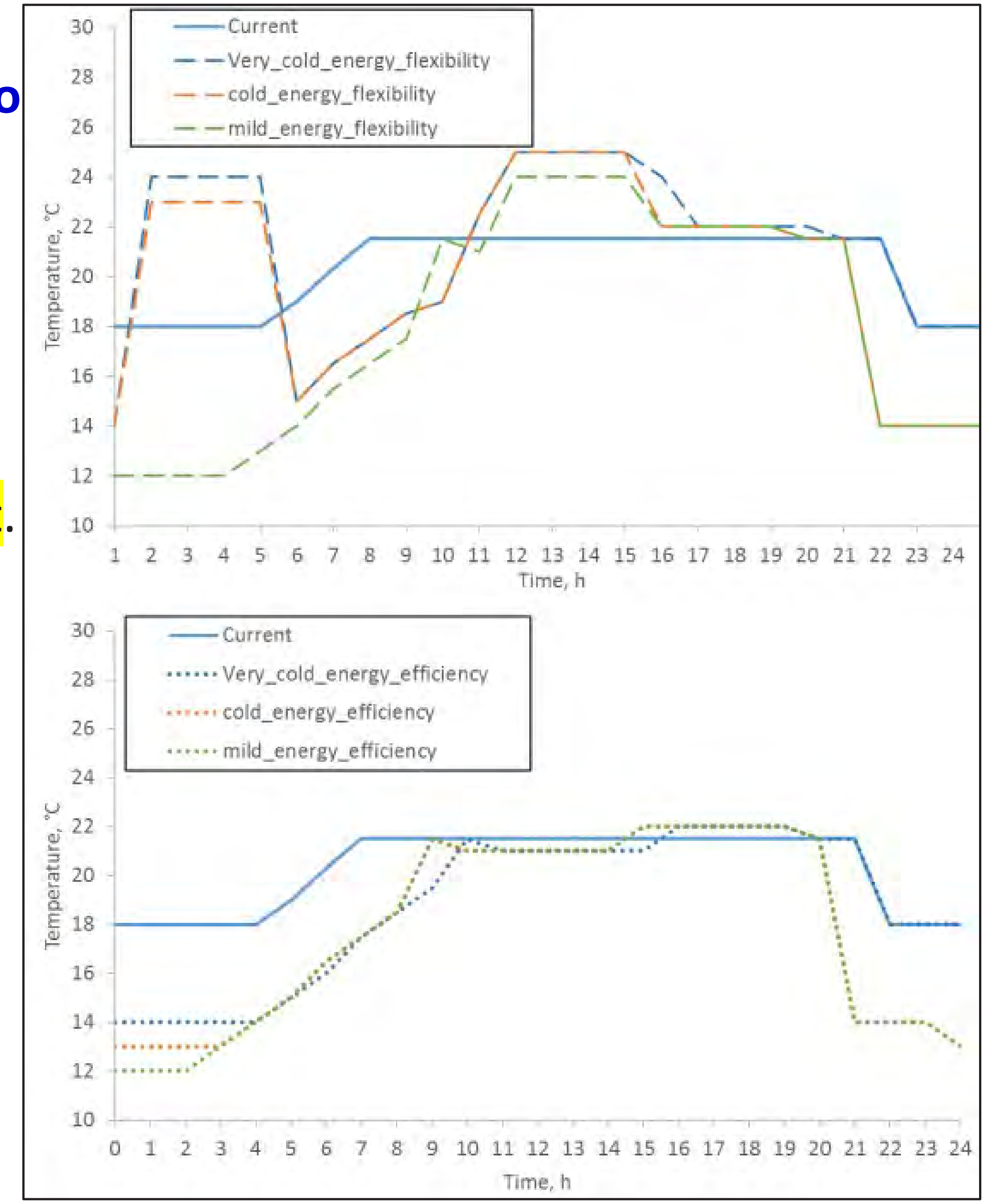
How much can we **reduce peak demand and consumption during peak periods for the grid?**

Heuristic MPC – Varennes Library and Implementation

- Based on 6-10th order RC model (3rd to 5th order for each floor).
- Expected weather conditions are clustered into **9 possible scenario** and each scenario, **two sets of predictive setpoint profiles** are developed with targets to maximize: **i) Energy-efficiency** and **ii) Energy flexibility**.
- Objective of the **energy-flexibility case:** shift load at two peak demand periods for the grid at Quebec based on weather forecast.
- Considered weather scenarios are:

Ambient Temperature	Cloudiness		
	Sunny	**Semi-cloudy**	**Cloudy**
Very Cold Minimum: -20°C Maximum: -10°C Average: -15°C	Scenario 1	Scenario 4	Scenario 7
Cold Minimum: 10°C Maximum: 0°C Average: -5°C	Scenario 2	Scenario 5	Scenario 8
Mild Minimum: 0°C Maximum: 10°C Average: 5°C	Scenario 3	Scenario 6	Scenario 9

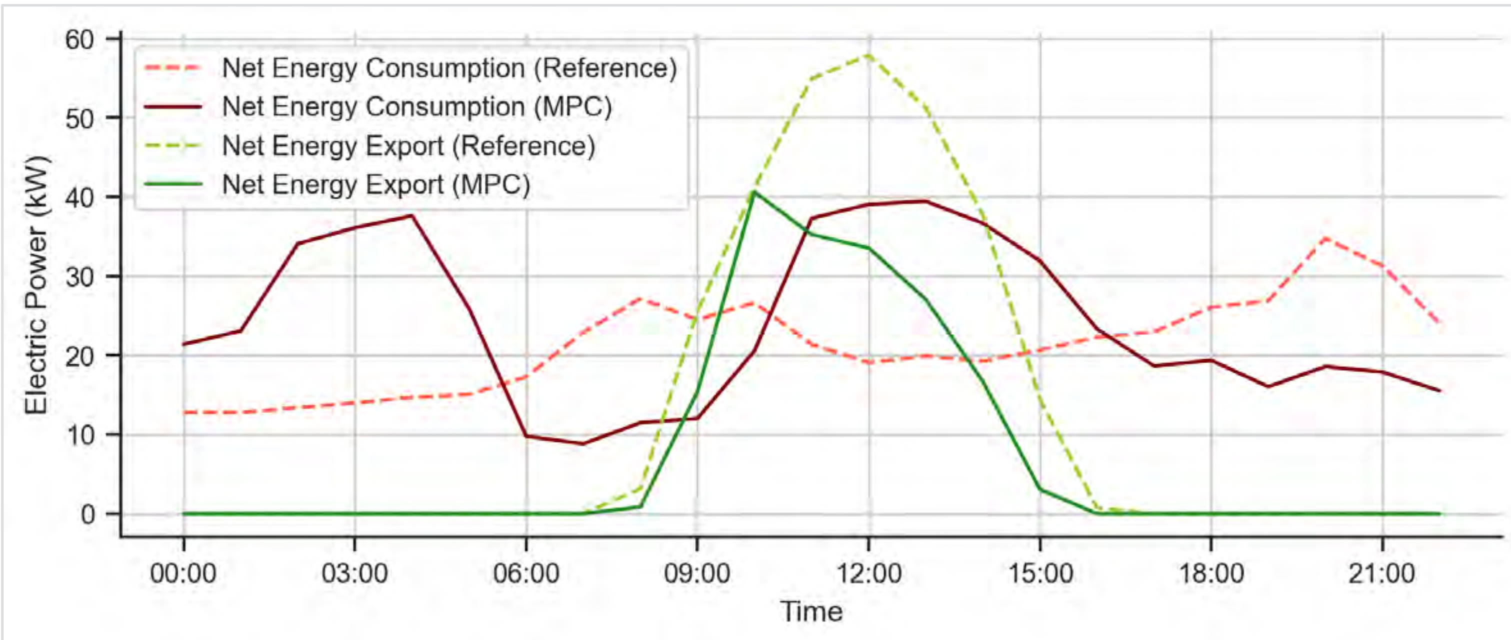
Near-optimal heating setpoint profile on sunny day

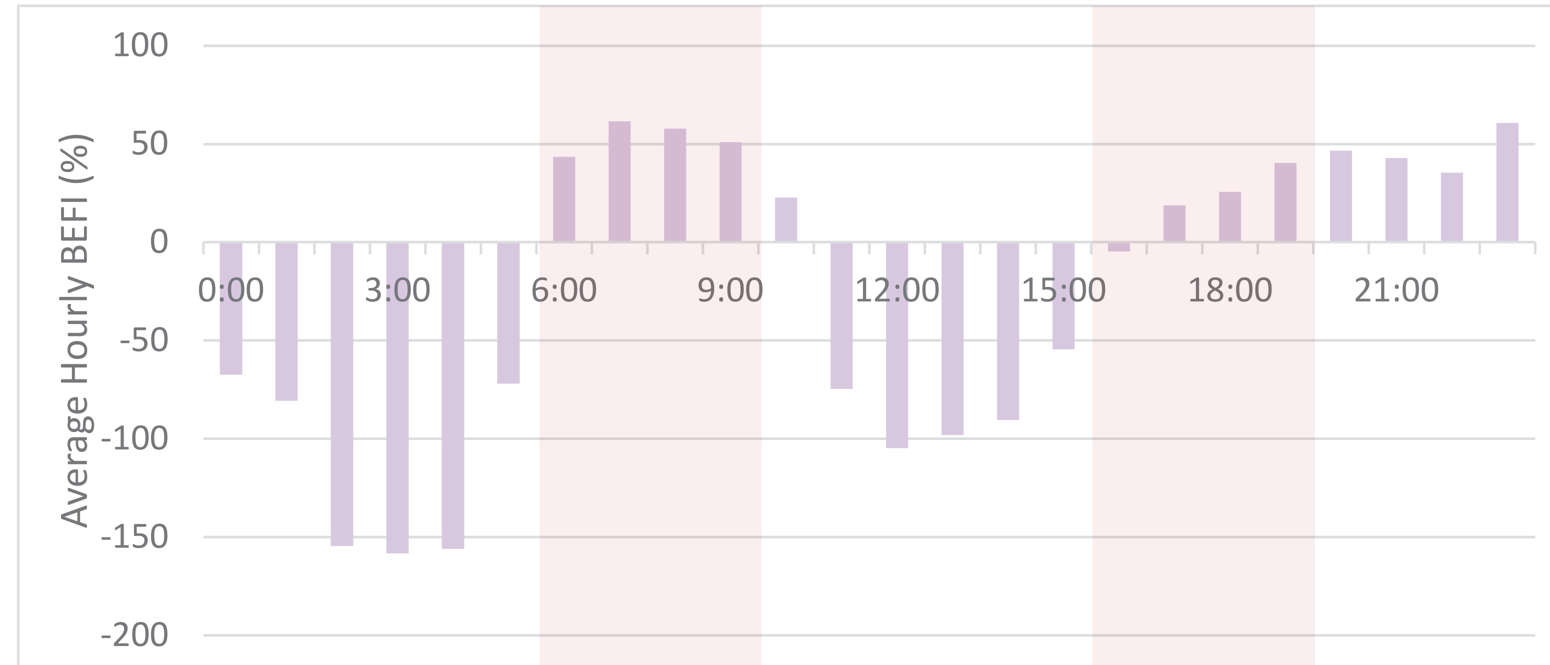


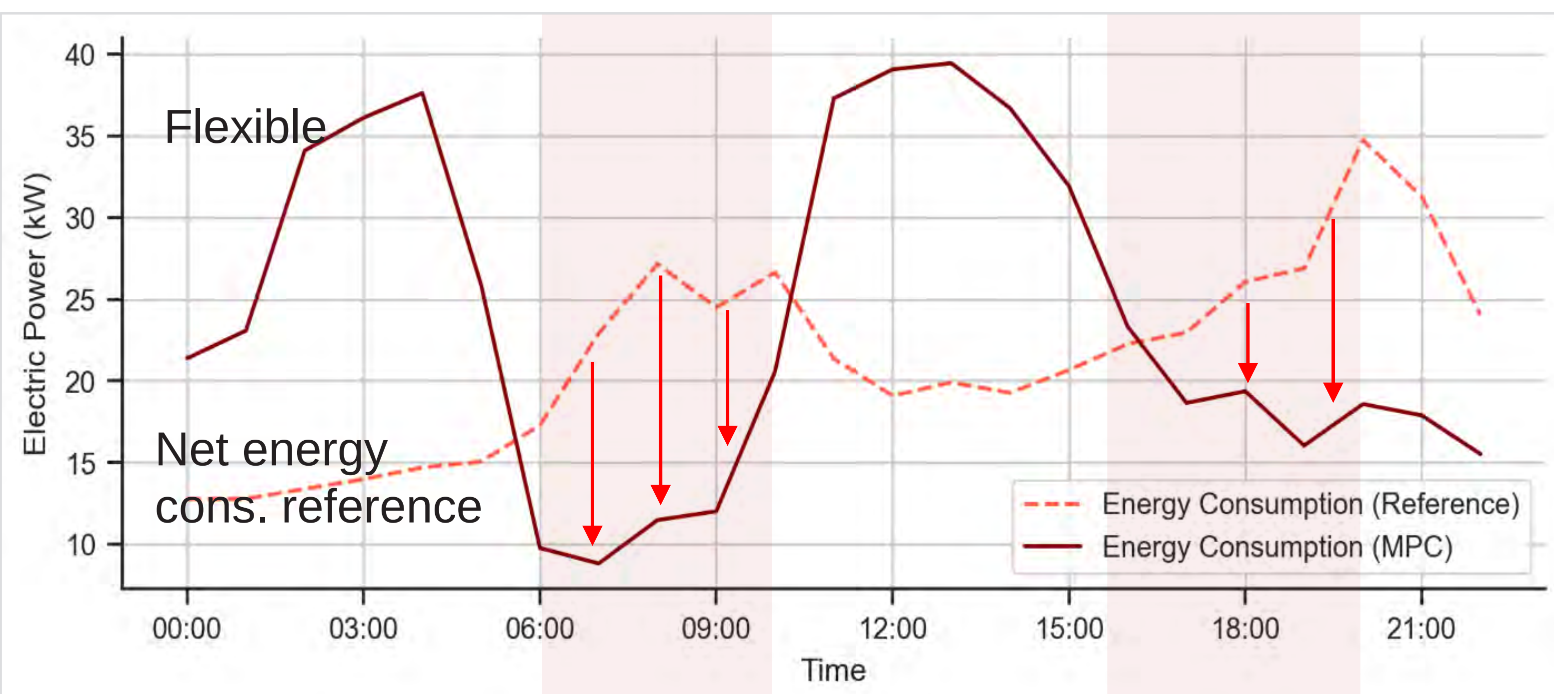
Canadian case study IEA Annex 81

- **Preliminary version of MPC was implemented during this winter, initially when Library is closed. Will apply also to school building.**

Heuristic Test at Varennes Library (23/12/21 to 03/01/22)







- Morning Peak Reduction: **- 50 kWh**
- Evening Peak Reduction: **-20 kWh**

Self-consumption of PV electricity was increased by about 40%

Conclusion

- Use of BIPV in buildings will become more cost-effective when integrated with energy storage (thermal mass, water tanks, batteries), heat pumps and electric vehicles.
- We can predictively store electricity (or convert to heat) when electricity prices are low and sell it to the grid when prices (and grid needs) are high.
- Already, a certain size of PV and battery storage (minimum sizes) are mandated in some locations for buildings above a certain size.
- The energy flexibility that can be provided by solar buildings to smart grids can be predicted and this information communicated to the grid.
- **Model predictive control (MPC)** is applied to activate the energy flexibility.

Liquid PVT system
With water storage tank

LTE lab building, Hydro-Quebec

JMSB BIPV/T, Concordia

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https://www.concordia.ca/faculty/andreas-athienitis.html
https://www.concordia.ca/research/zero-energy-building.html
http:/www.solarbuildings.ca

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IEA Solar Heating and Cooling Programme (group 4230381)

Technology Collaboration Programme
by iea

Solar: A Key Ingredient of Holistic Approach to Sustainable Community Design - London, Ontario Case Studies

Milfred Hammerbacher

The presentation opens with an introduction to S2E, a sustainable community/building/microgrid developer. This is followed by a definition of the term sustainable community and continues with a discussion of the two case studies, West 5 and EVE Park in London, Ontario. The presentation concludes with an emphasis on the importance of considering future generations, and the power that building sustainable communities has in fighting climate change.

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SOLAR: A KEY INGREDIENT OF HOLISTIC APPROACH TO SUSTAINABLE COMMUNITY DESIGN

LONDON, ONTARIO CASE STUDIES

Milfred Hammerbacher, CEO- S2E Technologies Inc.
Seminar on Solar Neighborhoods, Calgary, Canada, September 23rd, 2022

S2E Background

A pure play Solar Company → Sustainable Community / Building / Microgrid Developer

- R&D solar cell technology
- Built and operated Solar panel manufacturing facility
- Developed several 100MW's of solar farms

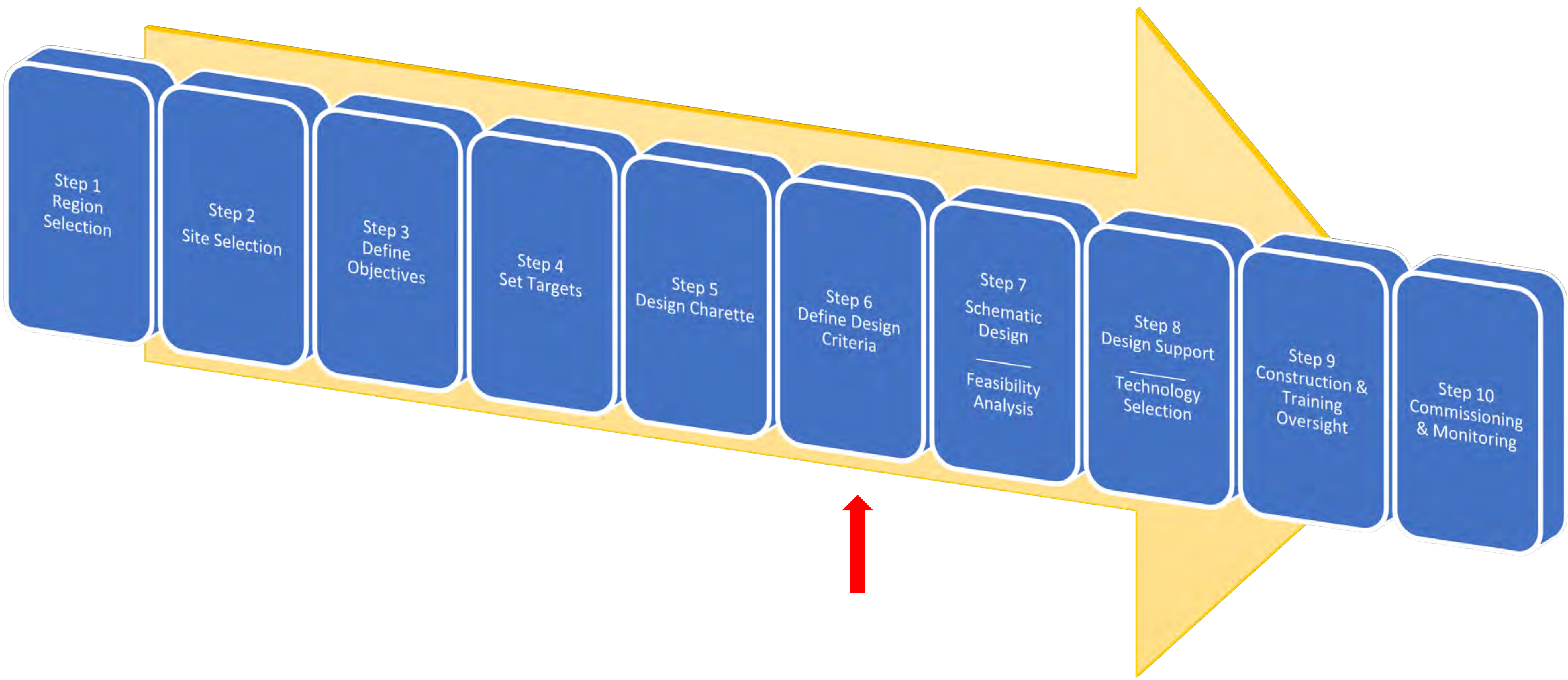
→

- Technology and creative partner behind West 5 NZE Community
- Co-Developer of Naya – sustainable resort
- Developer of EVE Park – NZE condo neighborhood
- Partner in Longos Grocery Store Microgrid

Sustainability

Meeting our needs today without compromising the ability of the 7th generation of our descendants to meet their own needs.
(c. Great Law of Iroquois Confederacy)

Sustainable Community Process



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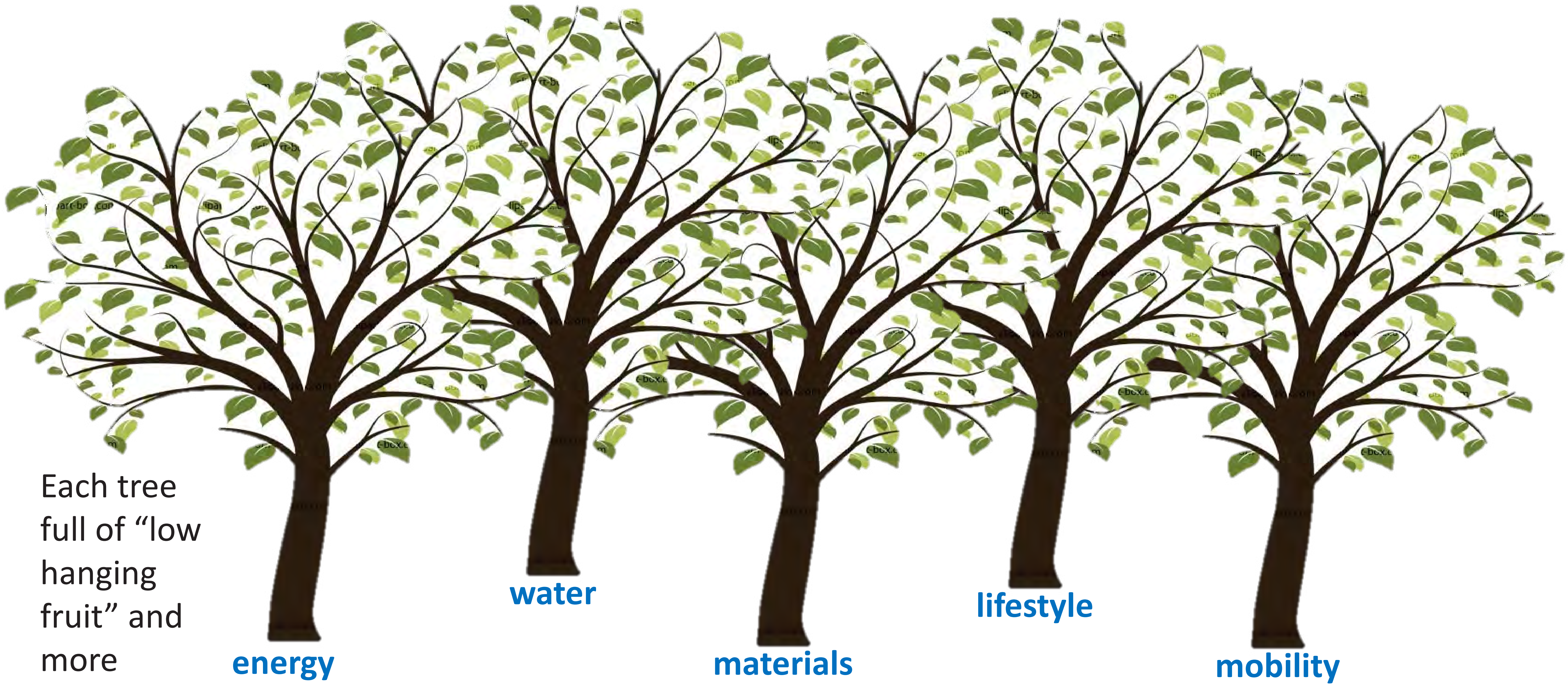
What is a Sustainable Community?

Sunset on West 5, London Ontario

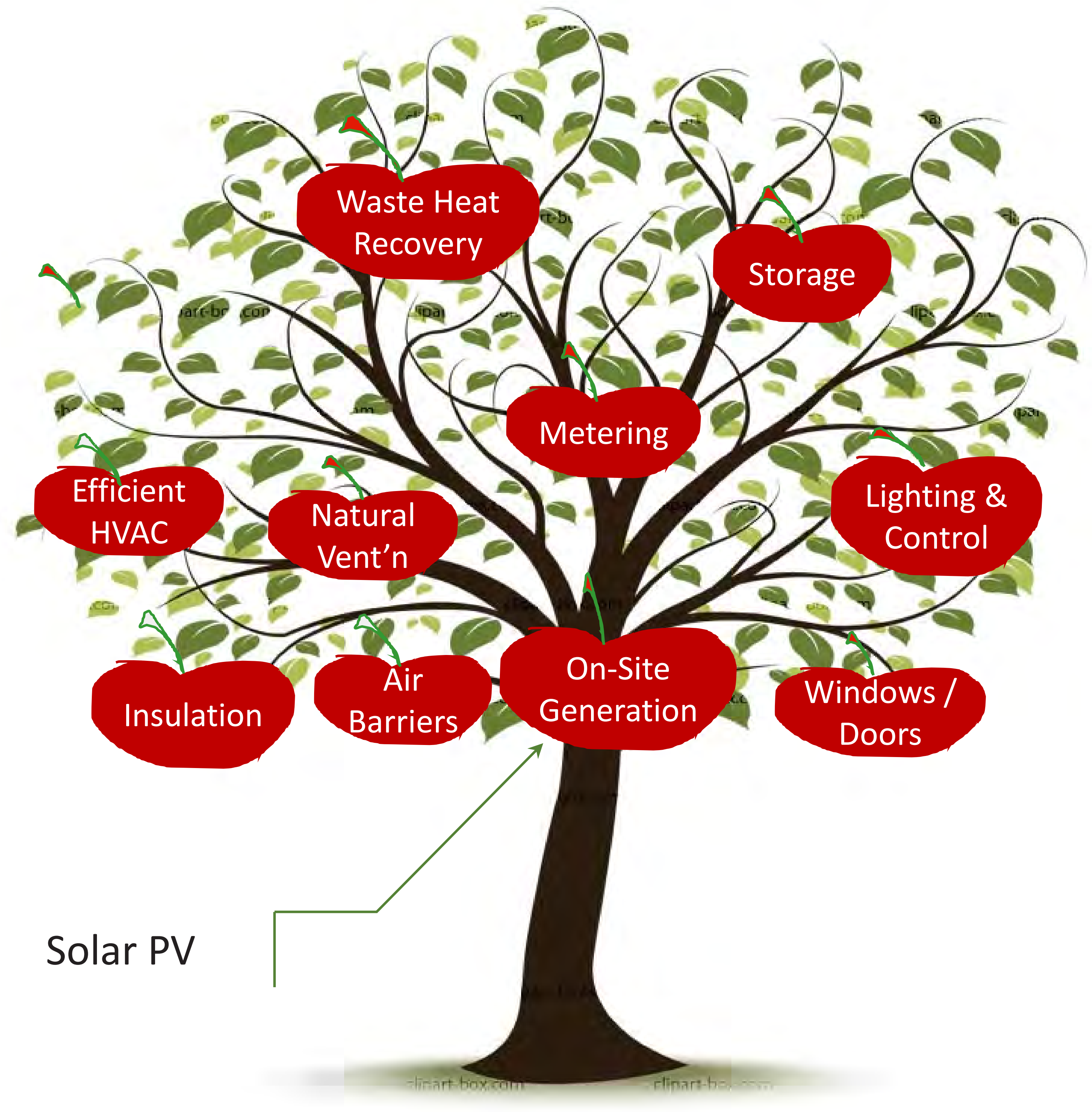
- Integrated (work / live / play)
- Self-sufficient energy (net-zero + storage)
- Self-sufficient water (net-zero + storage)
- Durable materials / resilient design
- Recycling / zero-waste / closed-loop
- Local / organic food
- Active transportation / cycling / EV's
- Training / awareness programs
- Smart technologies
- Reduced CO_2 footprint

Our Solutions: Like an orchard of fruitful trees…



Each tree full of “low hanging fruit” and more challenging topics….

Energy Tree


Waste Heat Recovery
Storage
Metering
Efficient HVAC
Natural Vent'n
Lighting & Control
Insulation
Air Barriers
On-Site Generation
Windows / Doors
Solar PV

Case Study West 5, London, Ontario

- First fully inclusive Net Zero Energy Community in North America
  - 28.3 hectares
  - 2,000 living units
  - Over 32,000 to 46,000 m^2 of commercial and office space
- Master plan concept designed by s2e for Sifton Properties, acting as the sustainable partner in the development.
- Interconnected walkways, trails and open green spaces. A safe, walkable, pedestrian-centric designed for active lifestyle.
- Electricity Micro Grid
- Under continuous construction:
  - First commercial building in operations since 2015.
  - Second commercial building in operations since 2016.
  - Over 200 townhomes fully occupied
  - First 12 story mixed-use 150 unit residential and commercial building completed last summer
  - Retirement apartments Phase II under construction.
  - ~3 MW of PV installed

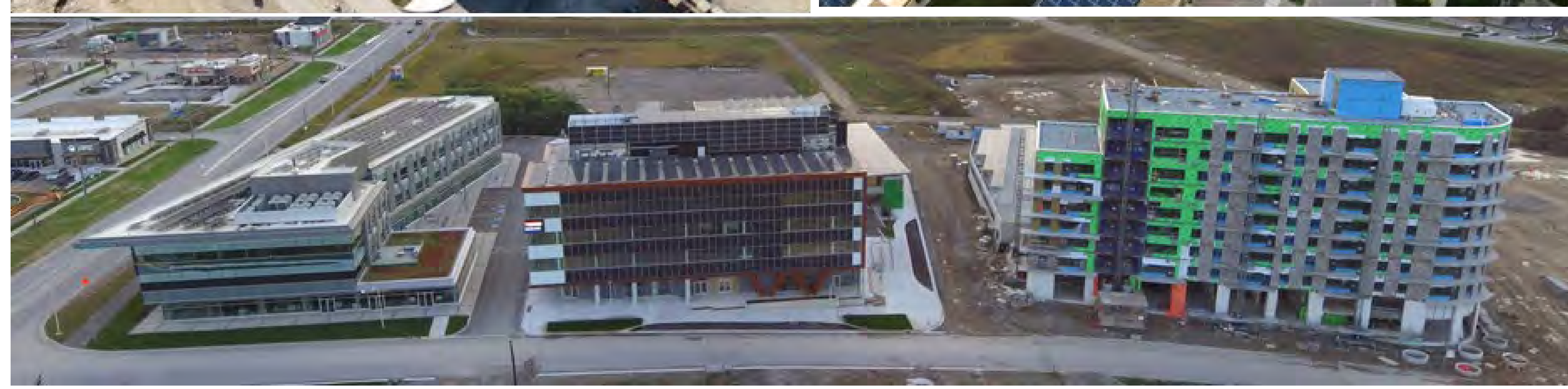
West 5


Building-15 / 16
Building-4
EVE Park
Carport
Building-3
Building-2
Battery Location
Carport
Building-1

West 5

Lessons Learned





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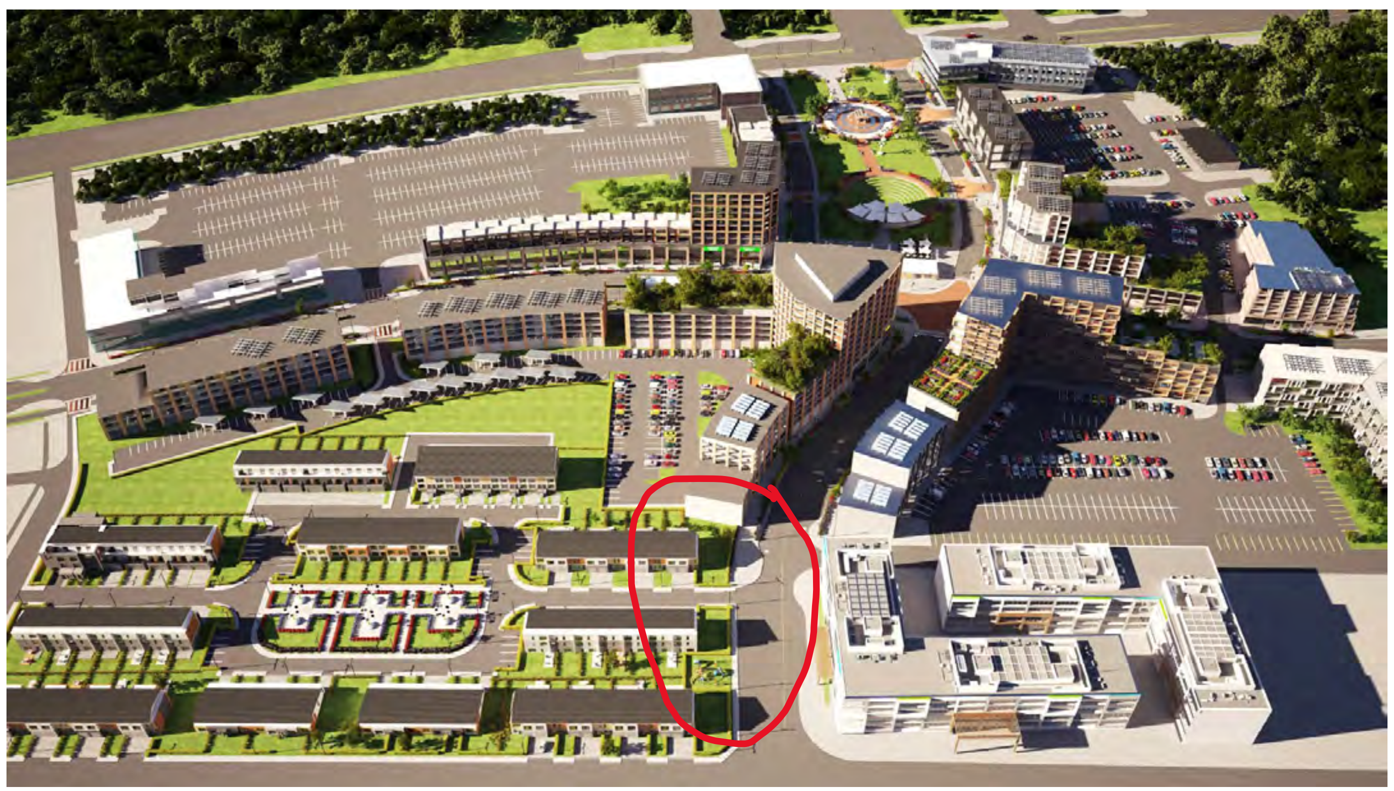
West 5 - Rules and Regulations

Municipal Regulation – All buildings must face major streets



West 5 - Rules and Regulations

Provincial Regulation – Classification of PV carports as Ground Mount Systems

West 5 - Architectural Compromise or Adaptation

Facades – Beauty / Efficiency / Cost / Constructability

Case Study EVE PARK London

- 84 for-sale condominium homes
- Net Zero energy,
  100% solar electric homes
- Efficient Water Systems
- Superior Indoor Air Quality
- Connection to West 5 Smart Grid for battery backup during power outage
- Automated Parking Tower Integration
- All-electric carshare fleet

Evolved Living

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EVE PARK

Solar Arrays - 580kw DC

EVE PARK

Lessons Learned

Always plan your projects for an impending pandemic disaster

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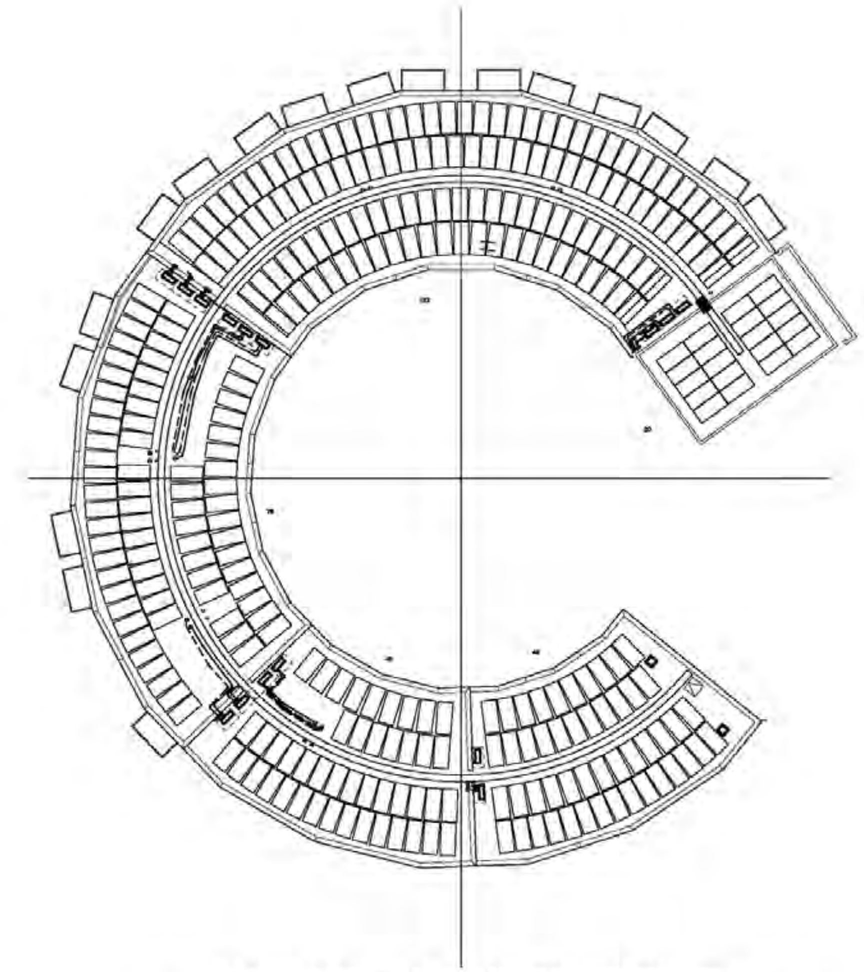
EVE Park - Architectural Compromise or Adaptation

Solar Challenges

- Where is South Facing Roof?
- No parking lots?
- Facades very tough with shading and non-uniform direction facing



EVE PARK - NET METER ROOF TOP
317 PANELS @ 460 WATTS EACH: 146 KW
146 KW X 4 = 584 KW DC - 500 KW AC

EVE Park - Rules and Regulations

Leftovers from Provincial Government

- Short circuit current at the feeder substation is still a major limiter of amount of PV that can be installed in Ontario.
  - 500KW ceiling. Requires an expensive transfer trip on the feeder to go over that.

Summary

- Know and engage your stakeholders early (and there are many!)

  Don't forget the most important one; future generations

- Keep your goal always at the front

  Build sustainable communities to fight climate change

- PV should play an important role in almost all sustainable community design, but it should never be the singular focus of a design.
- Starting with low hanging fruit is always a good strategy.

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Is the real obstacle innovative technology needs, or us (humans)? Humans love the Status QUO!

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IEA Solar Heating and Cooling Programme
(group 4230381)