KPIs for Smart Liveable Cities: From Data to Design

Annemie Wyckmans, Acting Dean, Head of NTNU Smart Sustainable Cities

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Contributors:
Dirk Ahlers, Tone Woie Alstadheim, Fredrik Anthonisen, Patrick Driscoll, Luca Finocchiaro, Hans Henrik Grønsleth, Eszter Juhasz-Nagy, Gabriele Lobaccaro, Edvard Schreiner Sjøblom, Yu Wang, Håvard Wibe

An Integrated Approach for Urban Layout, Urban Infrastructures and Management

Shanghai

An Integrated Approach for Urban Layout, Urban Infrastructures and Management

Cities and their citizens want high quality of life and low greenhouse gas emissions

The (smart) city should make it easy, fast and affordable to live a high-quality sustainable life

Global policy effort:

UN Sustainable Development Goals

China's 13th 5-year plan

EU Energy Union

Urban Europe Strategic Research and Innovation Agenda

National policies and programmes

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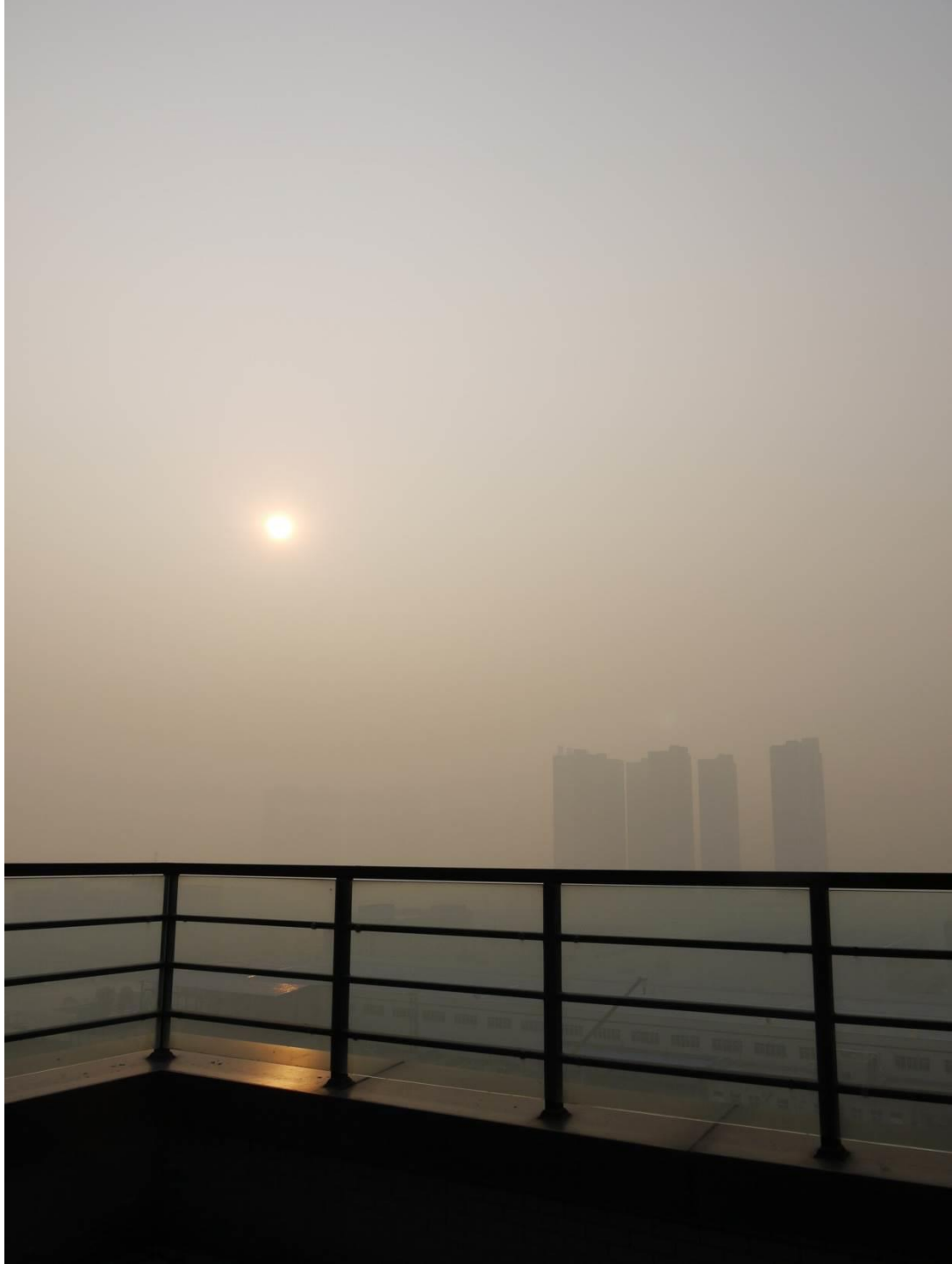
Energy-efficient

Climate-Resilient

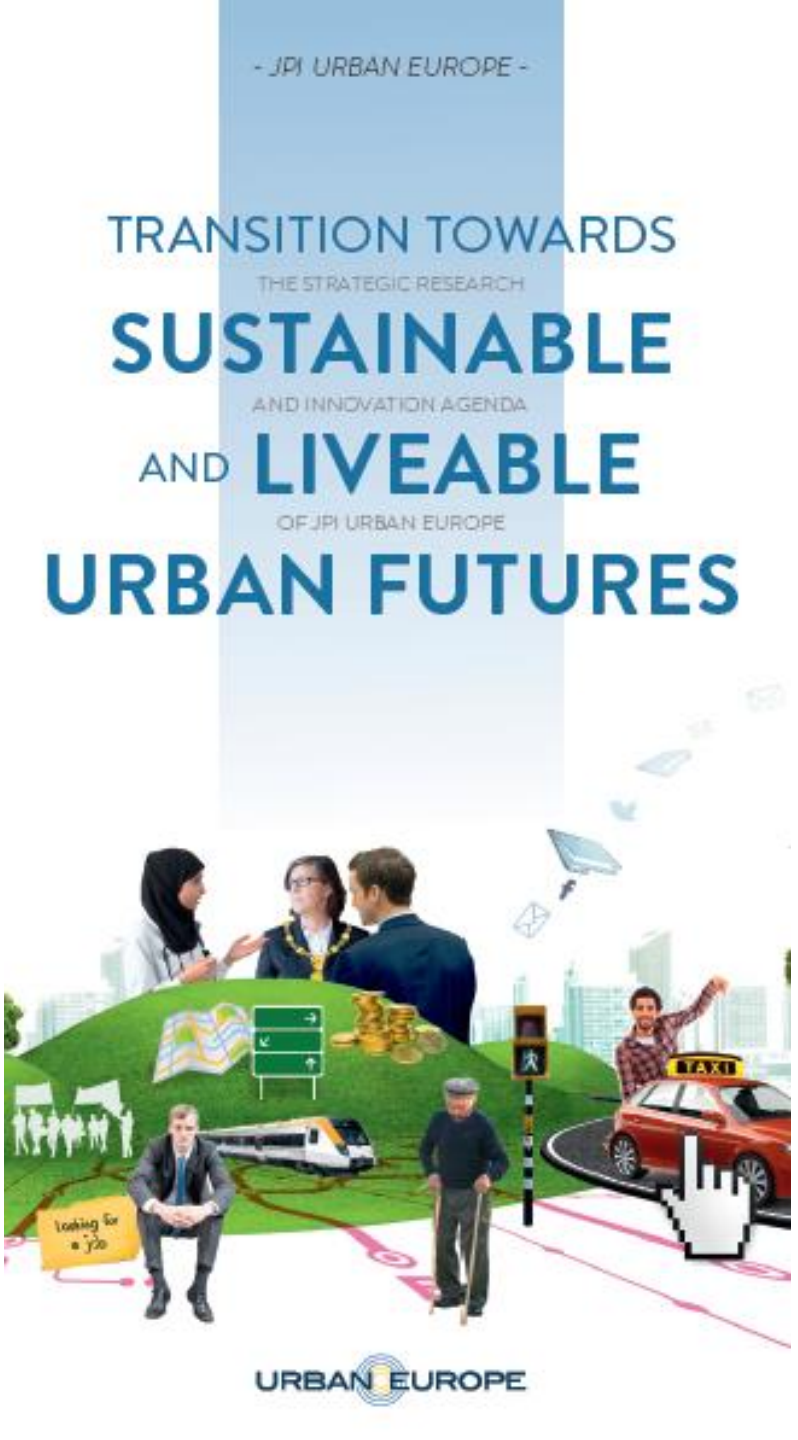
Smart, Circular Economy

Health-Promoting



Policy + Data + Design + People + Partnerships ++

- Well-documented data can support development of environmental strategies of city, regional and national authorities
- Decision support for green transition and growth, moving away from business as usual
- Integrated models for planning & management
- Better cooperation across the value chain
- More effective investments
- New jobs, e.g. in data certification, data management, smart infrastructures



Project Example: The Research Centre on Zero Emission Buildings / Zero Emission Neighbourhoods in Smart Cities (Application)

ZEB The Research Centre on Zero Emission Buildings (2009-2016)

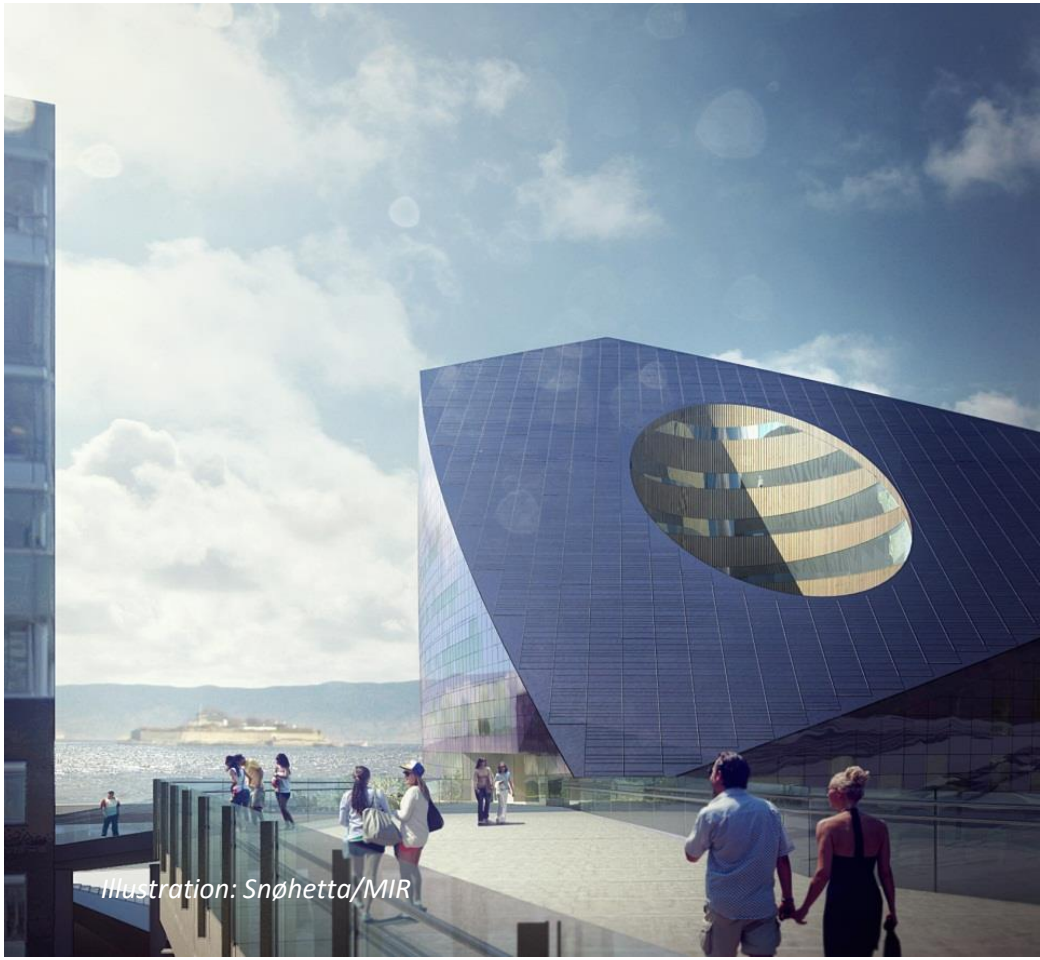
Develops competitive products and solutions for existing and new buildings

That will lead to market penetration of buildings with zero greenhouse gas emissions

Related to their production, operation, and demolition.

The centre encompasses new and existing buildings, residential, commercial, and public buildings

www.zeb.no



ZEB The Research Centre on Zero Emission Buildings

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

ZEB The Research Centre on Zero Emission Buildings (2009-2016)

22 industry / public sector partners

Users (the reference group)

Contractors

Manufacturers of materials and products for the building industry

Consultants, architects

Trade organizations

Property managers

Public administration

University and research institutions

The Research Council

International partners

VTT (Finland)

Chalmers (Sweden)

Fraunhofer (Germany)

TNO (The Netherlands)

LBNL (USA)

MIT (USA)

University of Strathclyde (Scotland)

Tsinghua University (China)

Politecnico di Torino

Shanghai JiaoTong University

EMPA

ZEB The Research Centre on Zero Emission Buildings

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

ZEB The Research Centre on Zero Emission Buildings (2009-2016)

WP1 Advanced material technologies

WP2 Climate-adapted low-energy envelope technologies

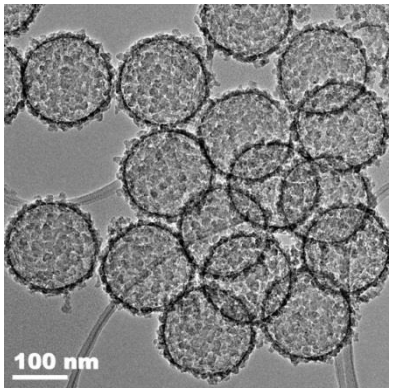
WP3 Energy supply systems and services

WP4 Use, operation, and implementation

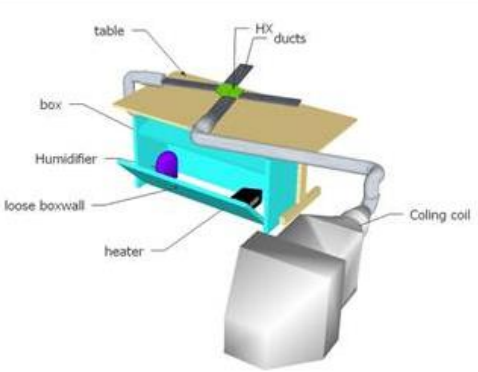
WP5 Concepts, strategies and pilot projects

VIP Leca Isoblokk

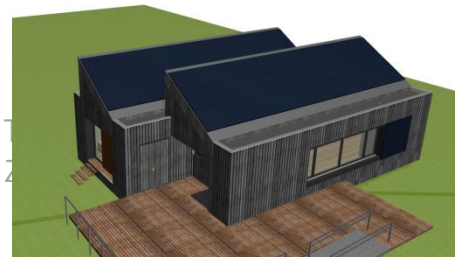
Nano insulation material



Membrane heat exchanger



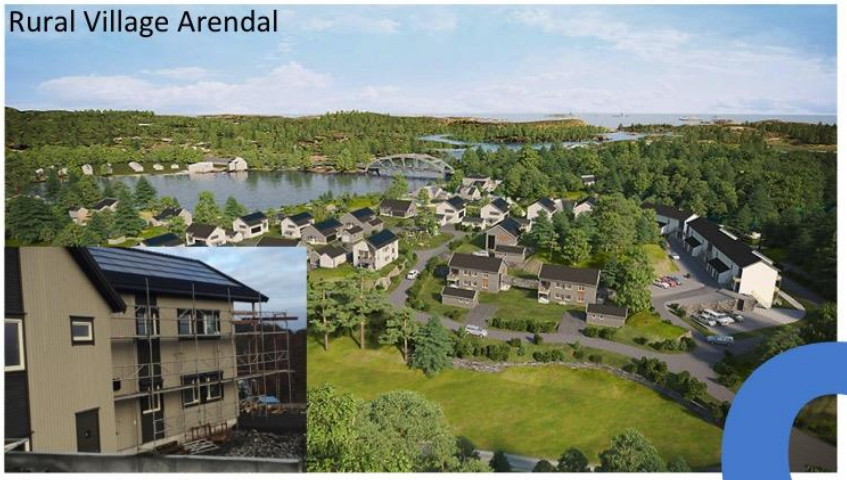
ZEB Living Lab



ZEB Definition

ZEB Pilot buildings

8 ZEB Pilot Buildings + 1 Living Lab



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ZEN The Research Centre on Zero Emission Neighbourhoods in Smart Cities (application)

33 partners from industry, research and public authorities
living labs in at least 7 cities

ZEN The Research Centre on Zero Emission Neighbourhoods in Smart Cities (application)

Oslo: Furuset

Bergen: Zero Village Bergen

Elverum: Ydalir

Trondheim: Knowledge Axis

Bodø: Airport area

Steinkjer: Residental area

Evenstad: Campus

Population of 30 000 people

Built floor area of more than 1 million m^2

ZEB Flexible Lab office building, NTNU Campus

ZEB Living Lab residential building, NTNU Campus

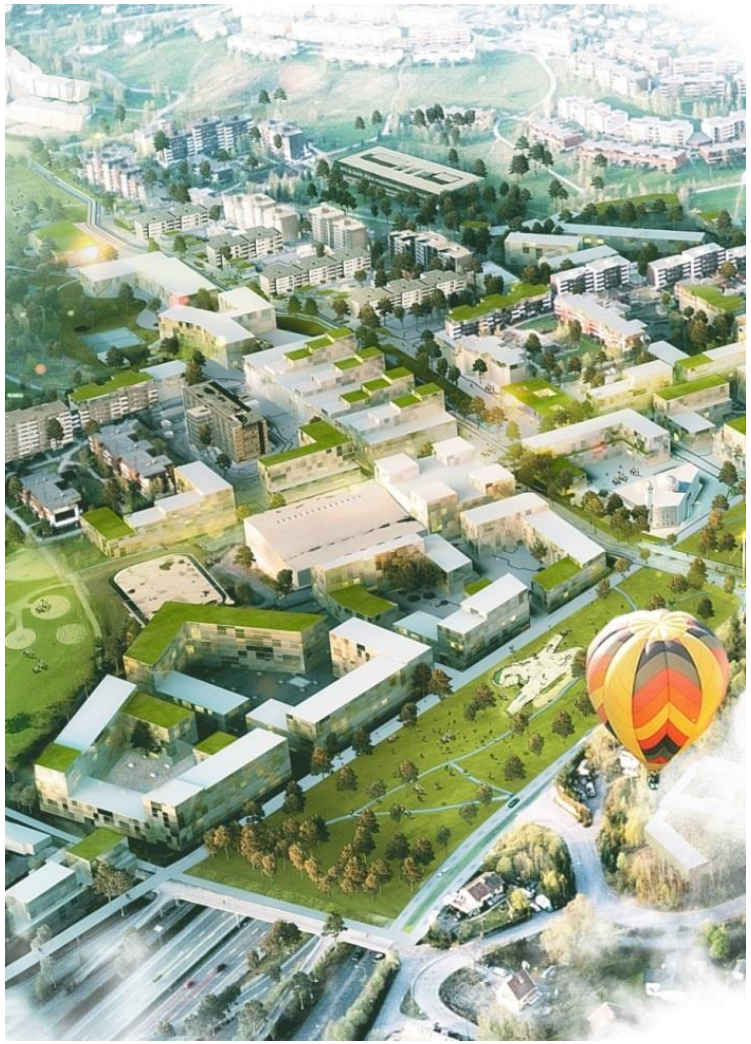
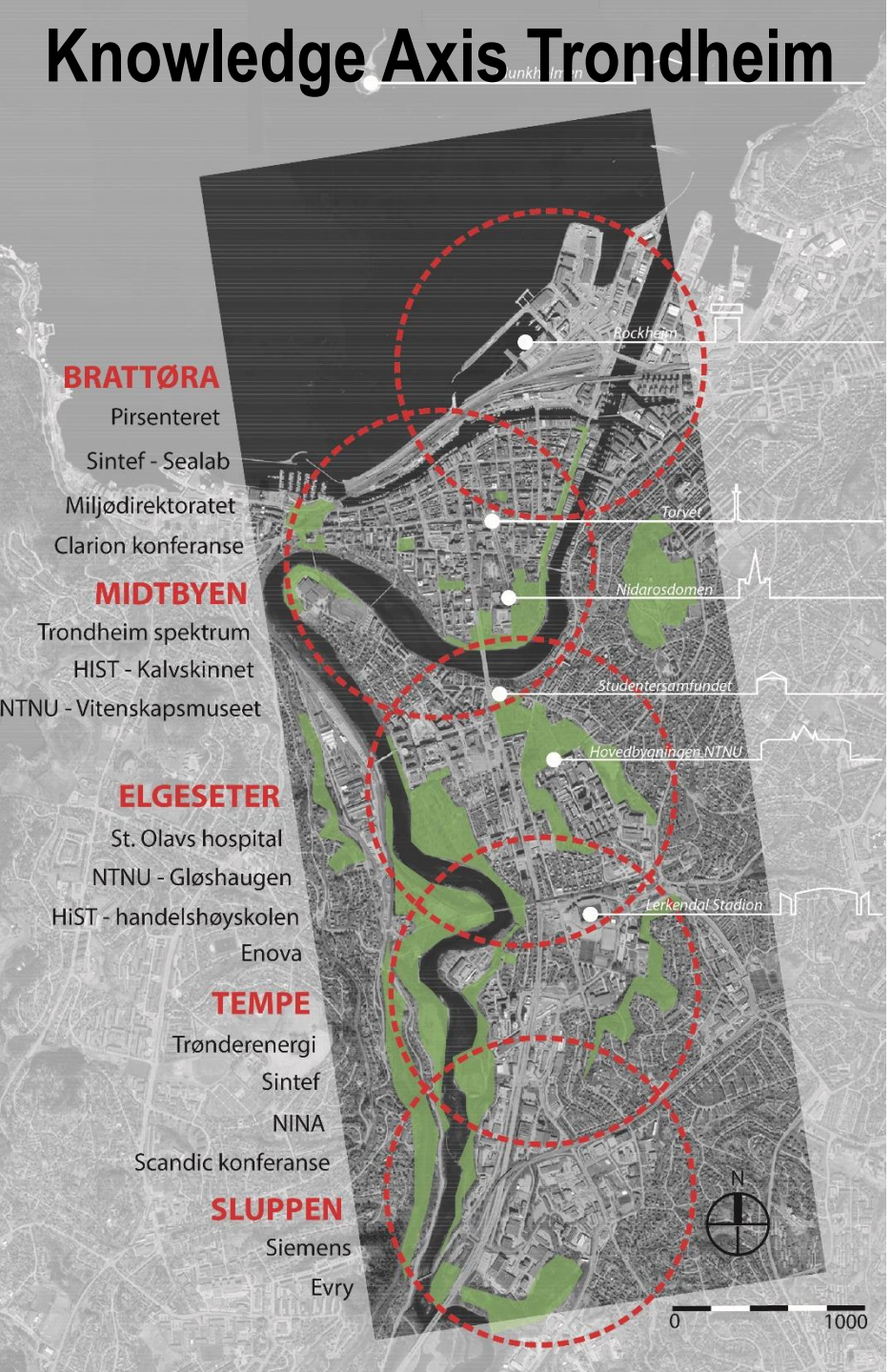


Illustration: FutureBuilt

Project Example: Knowledge Axis / Carbon Track and Trace



Trondheim Living Lab, Demonstration projects on energy, transport and ICT

New and better data by using sensors, satelite, GIS, cell phones etc

Better use of data in urban planning and design

Mobility Management: More environment-friendly transport policy

High quality of urban environment

Blue-green infrastructures: Nature-based solutions

Re-use and transformation of historic buildings and districts

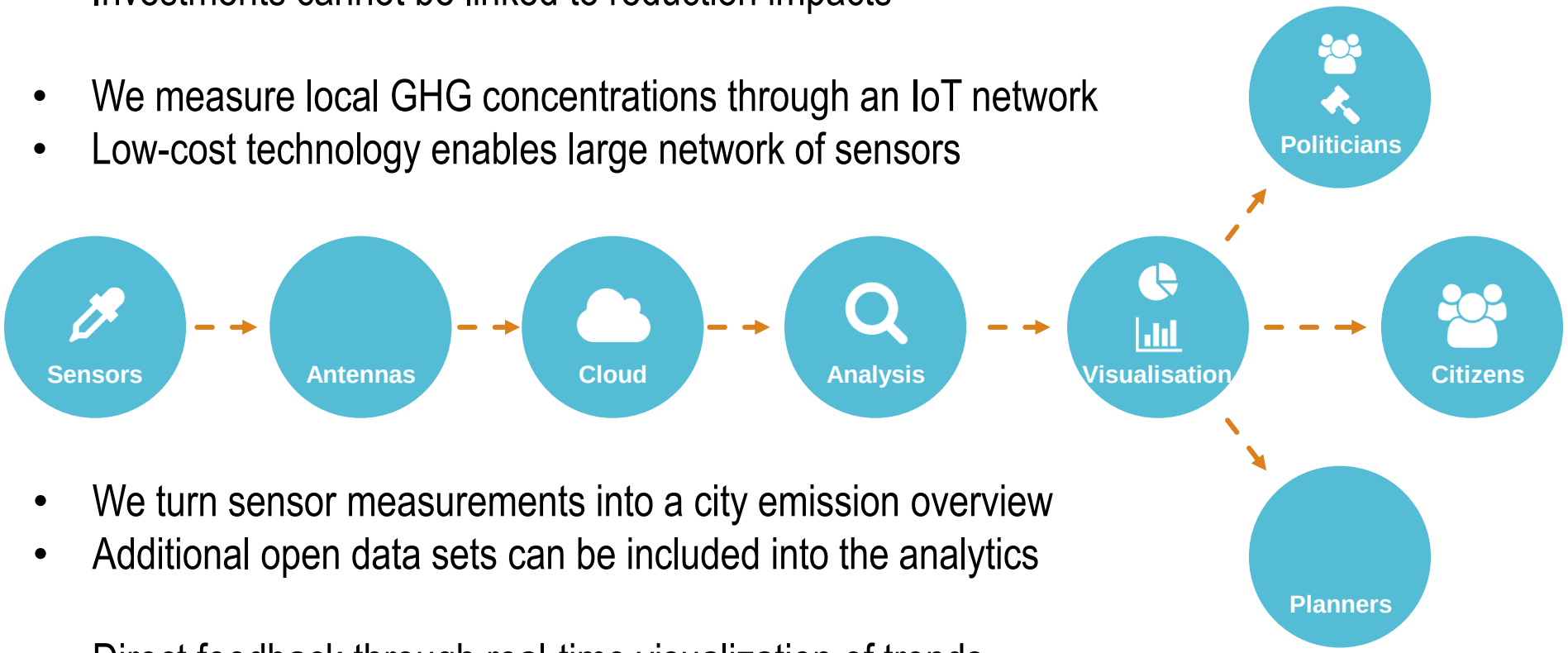
Triple Helix cooperation between city and regional authorities, industries, research and citizens

Influence citizen behaviour by better visualisation and dissemination of the information, smarter communication platforms, apps, art etc.

Carbon Track and Trace

- Cities have little data on their GHG emissions base lines
- Uncertainties in GHG emissions data are huge
- Investments cannot be linked to reduction impacts

- We measure local GHG concentrations through an IoT network
- Low-cost technology enables large network of sensors

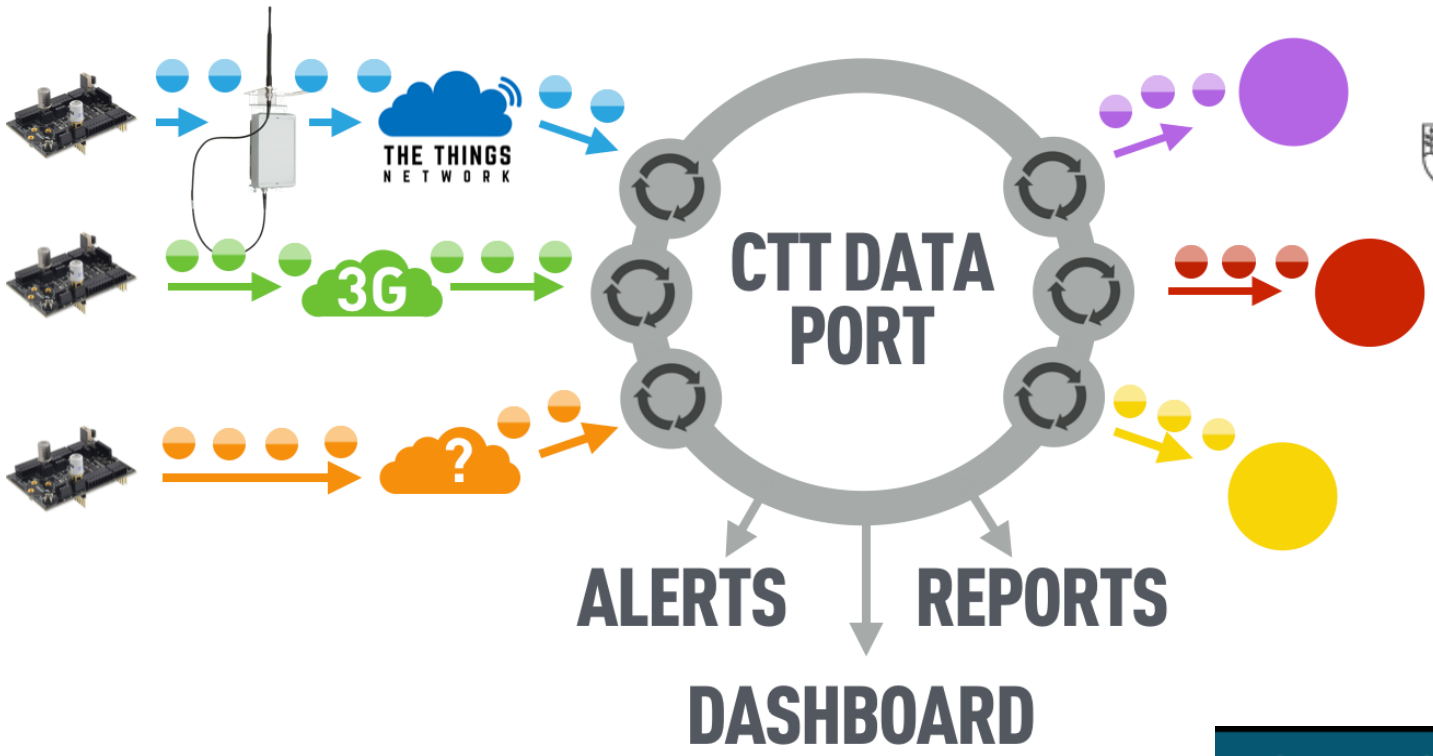


- We turn sensor measurements into a city emission overview
- Additional open data sets can be included into the analytics

- Direct feedback through real-time visualization of trends
- Effective policy optimization through fast feedback loops

***CTT 2.0** Stop guessing – start measuring*

Carbon Track and Trace (CTT) – From the Nordics to Asia



http://www.carbontrackandtrace.com

eit Knowledge & Innovation Community
Climate-KIC

vejle KOMMUNE

TRONDHEIM KOMMUNE

ICLEI Local Governments for Sustainability

NUMASCALE BIGGER DATA ANALYTICS

WIRELESS TRONDHEIM

NTNU
Det skapende universitet

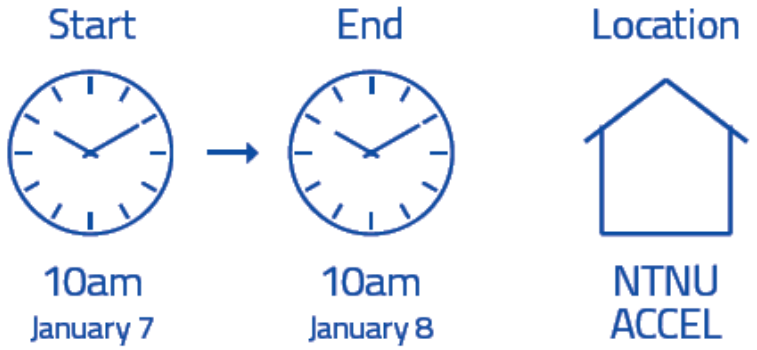

#Climathon

Climate Smart Through the Use of Data

Trondheim becomes climate smart: Carbon Track and Trace

Join us for 24-hour hack focused on these 3 challenges:

- How can you use existing open data sets to calibrate and check official reported emissions from Statistics Norway?
- How can the data from ground-level emissions sensors be integrated into the existing planning and decision support systems?
- Existing sensor systems are expensive, so can we build cheaper, open source sensor systems?



Register at: billetto.no/en/events/climathon-trondheim

eit Climate-KIC

TRONDHEIM KOMMUNE

NTNU
Det skapende universitet

7-8 January 2016: 50 participants, 24 hours, pitching good ideas to the city authorities, development of new business ideas

Next Event / Hackathon: 5-6 September 2016

Project Example: RAMSES Climate Change Adaptation, Mitigation and Sustainable Development of Cities

Cookbook for Integrated Assessment of Cities

Understanding Cities: The imperative for integration

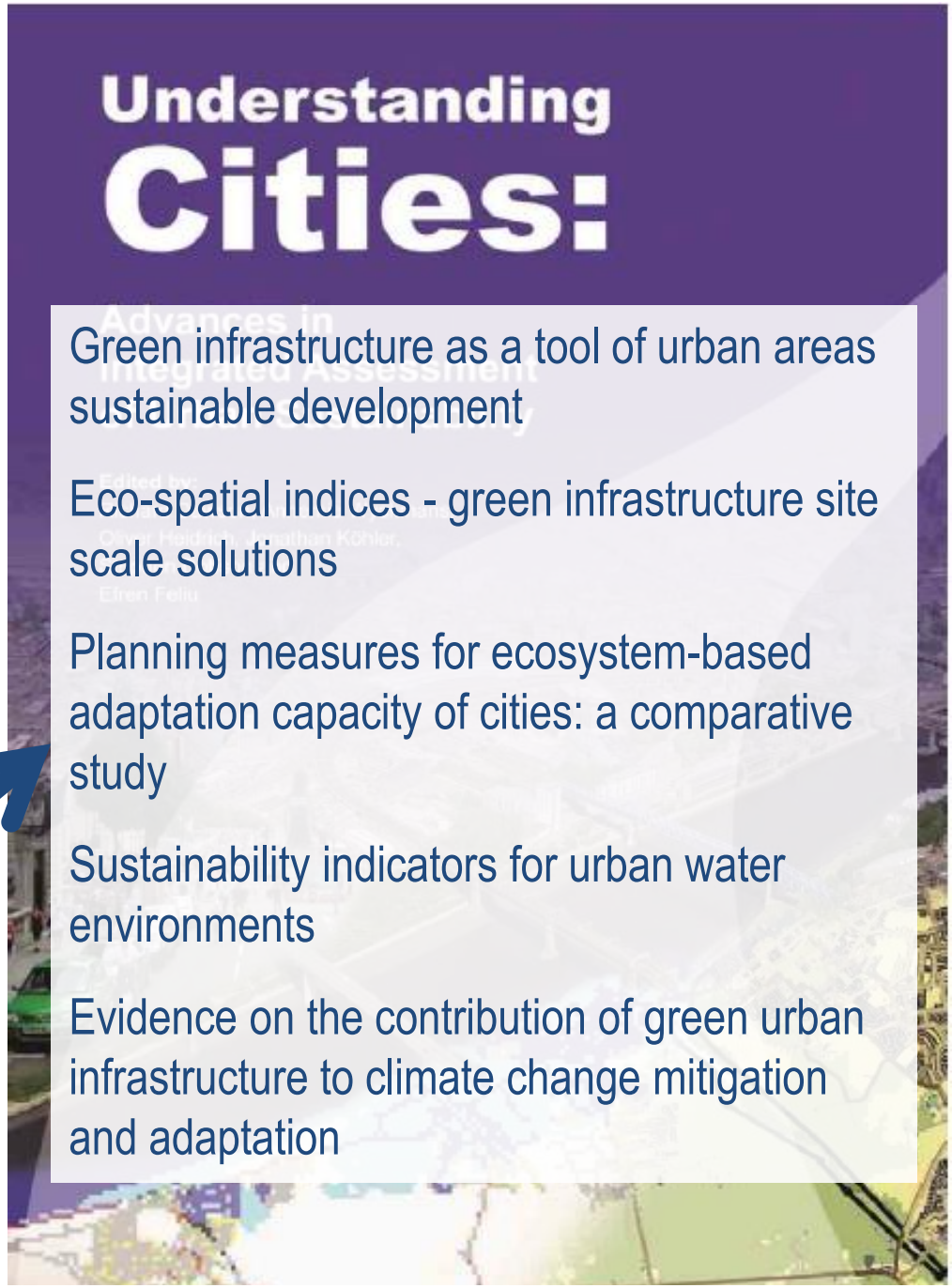
A review and analysis of quantitative integrated environmental assessment methods for urban areas

Adaptation and mitigation – how addressing climate issues stimulates integrated thinking

Green and blue infrastructures as enablers of resilient cities

A policy and governance context for integrated urban sustainability strategies

Understanding Cities: The way forward for integrated assessment



http://iaforcities.com; http://www.ncl.ac.uk/ceser/researchprogramme/costactiontu0902/Final_All_CoverLo.pdf

RAMSES Climate Change Adaptation, Mitigation and Sustainable Development of Cities www.ramses-cities.eu

Financed by EU FP7, Cooperation with 8 cities around the globe:
Hyderabad, Bogota, Rio de Janeiro, New York, London, Antwerp, Bilbao, Skopje

- Cooperation with the World Health Organisation
- Climate change has serious consequences for health: more extreme weather, precipitation, humidity, temperature, accessibility of water, clean air etc.
- Increased risk for illness and mortality
- Need for health-promoting environments, both indoors and outdoors
- Economic consequences? Insurance, productivity…

Measure	#	
Title	**Green roof - flooding**	
Description	roofs partially or completely covered with vegetation	
Type of infrastructure	green/blue	
Scale of implementation	building/site	
Main threat addressed	flooding (sea, tidal, fluvial and pluvial)	
Expected outcome	temporal buffer for water runoff: "intercept, retain, and evapotranspire between 34% and 69% of precipitation, with an average retention of 56%" (Gregoire et al. 2011, p 963)	
Performance indicator	% precipitation retained [(precipitation−runoff)/precipitation)]×100 peak & average (Gregoire et al. 2011, p 963)	
Affected urban surface parameters	☐ Plane area index (λp) ☐ Frontal area index (λf) ☐ Building height (h)	☒ Emissivity (ε) ☒ Albedo (α) ☒ Vegetative fraction (λp) ☒ Vegetative type (vtyp)
Resilience dimensions	☒ Adaptability, flexibility ☒ Connectivity, feedbacks, safe failure ☒ Dependence on local ecosystems ☐ Diversity ☐ Learning, memory	☒ Performance ☐ Rapidity, responsiveness ☐ Redundancy, modularity ☐ Resourcefulness ☐ Robustness ☐
Scientific references	Berardi, U, GhaffarianHoseini, A-H & GhaffarianHoseini, A 2014, 'State-of-the-art analysis of the environmental benefits of green roofs', Applied Energy, vol. 115, pp. 411–428. Carter, T & Keeler, A 2008, 'Life-cycle cost–benefit analysis of extensive vegetated roof systems', Journal of Environmental Management, vol. 87, no. 3, pp. 350–363. Etc	

Measure	Title
ACF	Flood adapted construction
AHF	Flood adapted HVAC
ALF	Flood adapted location
AUF	Flood adapted use
BIE	Building insulation - energy
BIH	Building insulation - heatwaves
BRF	Blue roof
BSE	Building shading - energy
BSH	Building shading - heatwaves
CIR	Critical infrastructure location
CPH	Cool pavements
CRH	Cool roof
DER	Decentralised renewable energy systems
EEH	Energy efficient appliances
ETH	Electric transport
GFH	Green façade
GMR	Electrical grid monitoring & control systems
GRF	Green roof - flooding
GRH	Green roof - heatwaves
MER	Multiple energy modes
MNF	Multipurpose flood management zones - green
MTR	Multiple transport modes
MYF	Multipurpose flood management zones - grey
NTH	Non-motorized transport
PPF	Permeable pavements
RHD	Rainwater harvesting - drought
RHF	Rainwater harvesting - flood
UBF	Urban lakes and water bodies - flooding
UBH	Urban lakes and water bodies – heatwaves
UGF	Urban vegetation, trees and parks - flooding
UGH	Urban vegetation, trees and parks - heatwaves

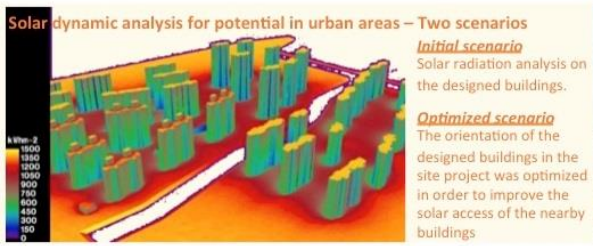
We need to identify win-win solutions, added value, co-benefits

Climate

Winter Passive Strategies
- Passive solar heating
- Thermal mass

Summer Passive Strategies
- Shading
- Natural ventilation

	Jun	Jul	Aug	Dec	Jan	Feb
Average Temp(℃)	23	27.5	27.7	6.5	4.3	6.1
Maximum Temp(℃)	31	35.5	38	-4.3	-8.7	-7.5
Average RH(%)	83.5	81	78	74.5	74	75

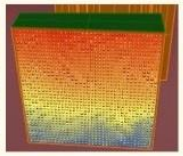


Solar dynamic analysis for potential in urban areas – Two scenarios

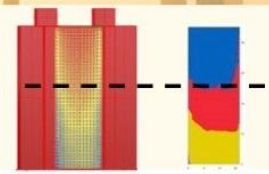
Initial scenario
Solar radiation analysis on the designed buildings.

Optimized scenario
The orientation of the designed buildings in the site project was optimized in order to improve the solar access of the nearby buildings

Solar Radiation

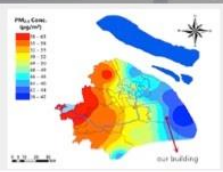


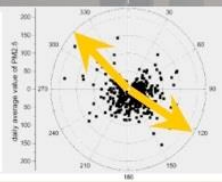
Results of the optimized scenario
The solar accessibility of the surrounding buildings has been increased until 15% with the new layout compared to the configuration in the initial scenario and the solar potential of the buildings in the site project has been maintain constant



Percentage of solar radiation on the Facade

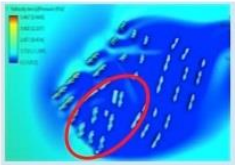
Air Pollution





Analysis

The wind from north-west and south-east bring more pollutant particles in the site project.



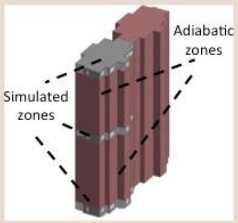
Advantages
- Comfort Zone
- Suitable for Green Roof
- More heat preservation in winter

Disadvantages
- Not well-ventilated
- Pollution
- Less heat dissipation in summer

Suggestions
- More plants
- Artificial water bodies
- New layout of the district

Wind

Building model

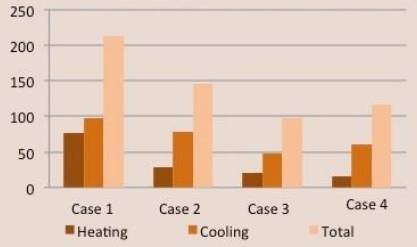


Improving Environmental Performance

1- Decrease the energy consumption for heating and cooling needs by 50% using passive strategies

2- Improve the comfort of indoor environment

- Case 1 - Initial
- Case 2 - Envelope upgrade
- Case 3 - Ventilation & shading
- Case 4 – Solar spaces



Green strategies

We need an integrated approach between sectors

Energy

Health

Sustainability

Water

Transport

Housing

Green structures

ICT

Waste

Economy

...

Urban & Regional Planners; Network Planners; Architects; Process Engineers; Power Engineers; Site Engineers; Installers; Technicians; Land Use Planners; Simulation Engineers; Structural Engineers; Supply Design Engineers; Landscape Planners; Automation Engineers; Facility Managers; HVAC Planners; Energy Strategy Developers; Component Designers; Automation Engineers; Energy Managers; Maintenance Engineers; Building Physicists; Stakeholder Process Managers; Environmental Engineers; ICT Engineers; Electro Planners; Consultants; Ecologists; Material Scientists; Waste & Water Engineers; Welders; Geotechnical Engineers; Forecasting Experts; Acoustic Engineers; Logistics Planners; Control Engineers; Fire Protection Engineers; System Analysts; Mobility Engineers; Optimisation Experts; Façade Engineers; Technology Developers; Policy Advisors; Production Engineers; Real Estate Managers; Master Builders; Economists; Interior Designers; Climate Scientists; Light Planners; Inspectors; Transition Experts…**and INTEGRATORS**

KPIs for Smart Liveable Cities

- High performance
- High quality
- Integrated solutions

Annemie.Wyckmans@ntnu.no

www.smartsustainablecities.org

EERA Conference, Birmingham, 24-25 November 2016

Session on Energy Systems

- System real-time monitoring and data management
- Smart Zero Emission Cities, from Data to Design
- System enhanced flexibility as a key factor to Renewables integration
- Energy Efficiency in food and drink manufacturing
- Energy Systems: An integrated effort by industry, public sector and research